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Public Meeting on Advanced, Non-light water Reactor Regulatory Reviews

Office of New Reactors

October 25, 2016

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Public Meeting

- Telephone Bridge

  (888) 570-6344

  Passcode: 3222936
- Opportunities for public comments and questions at designated times
- Please mute phones

  *6 – Self Mute/Unmute

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Agenda

- Morning
  - Vision and Strategies
    - Implementation Action Plans
      - ADAMS Accession No. ML16294A181
  - Draft Regulatory Review Roadmap
      - ADAMS Accession No. ML16291A248
  - DOE Update
- Afternoon
  - Nuclear Infrastructure Council
  - Nuclear Innovation Alliance
  - Nuclear Energy Institute

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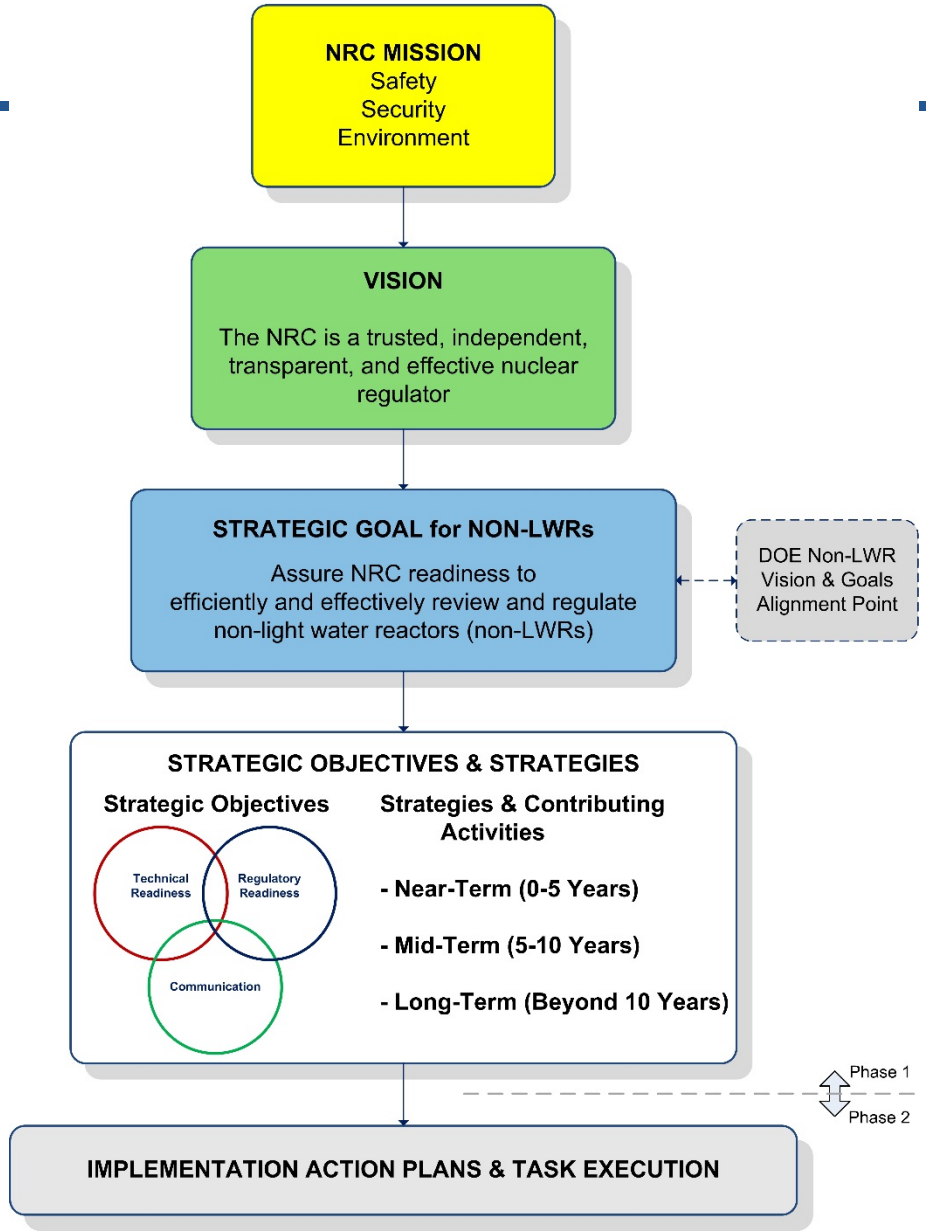
NRC Non-LWR Mission Readiness Roadmap



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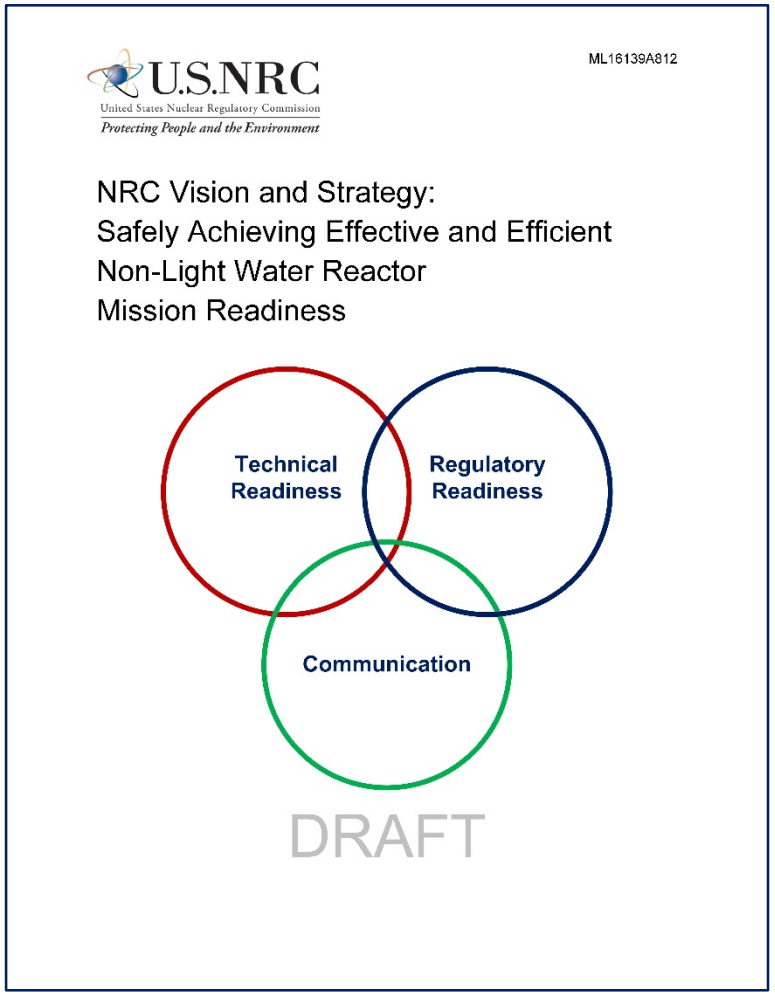
Non-LWR Vision and Strategy



- Draft NRC Vision & Strategy made public at DOE-NRC Workshop on June 7-8, 2016 (ML16139A812)
- Public comment period on the V&S document closed 09/19/2016
- Staff is currently reviewing and incorporating public comments as appropriate.
- Draft near-term Implementation Action Plans (IAPs) were completed on 09/30/2016 and have received management approval

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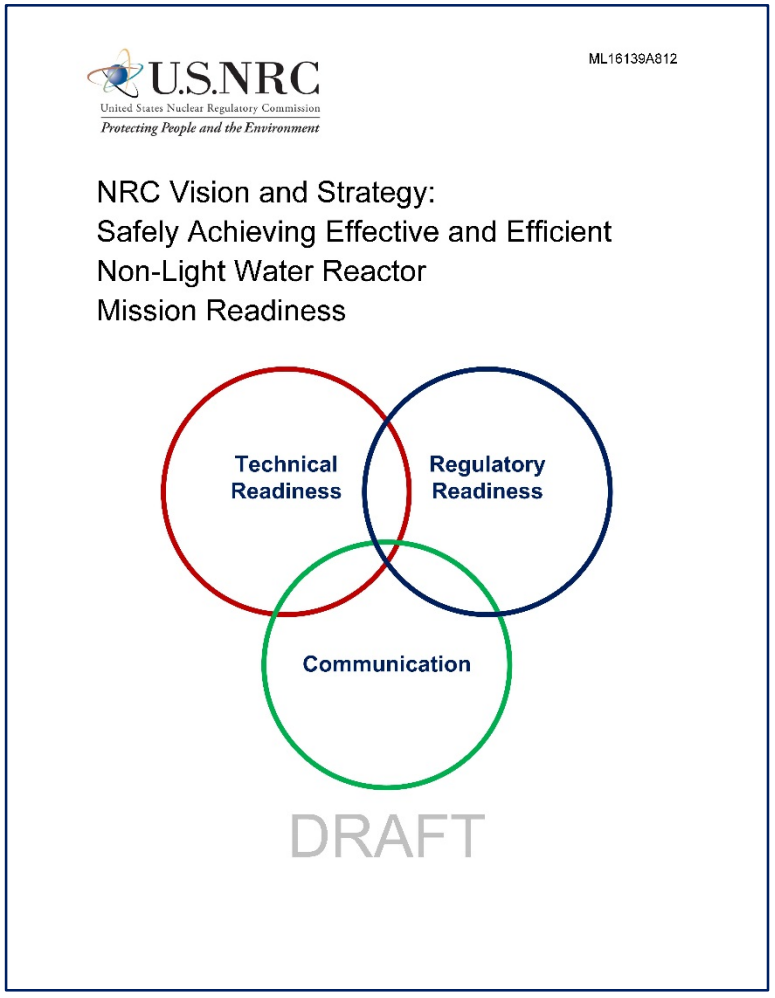
Non-LWR Vision and Strategy



- Public comment themes included:
  - Schedules for NRC readiness activities are too long.
  - The document should identify specific opportunities for public and stakeholder engagement and input.
  - The document should add discussion of the front-end fuel cycle issues for non-LWRs.
  - Clarify the schedule and strategy for prototype and test reactor licensing.

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Implementation Action Plans (IAPs)

- Development of the NRC's non-LWR readiness strategy consists of two phases:
  - Phase 1 – Vision & Strategy
  - Phase 2 – Implementation Action Plans (IAPs)

- The IAPs are planning tools that describe:
  - Work to be done to achieve non-LWR readiness,
  - Resources needed to accomplish the work,
  - How the work should be sequenced,
  - How to prepare the workforce to do the work, and
  - Considerations for organizing work execution for maximum effectiveness and efficiency

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Implementation Action Plans (IAPs) (cont'd)

- Draft near-term IAPs are intended to cover a timeframe of 0-5 years.
- Actual start dates and priorities of the activities shown in the IAPs will be dependent on a range of factors, including NRC work prioritization, actual funding appropriations, industry maturity and application readiness, and similar factors.
- The IAPs are organized by Strategies, Contributing Activities, and Supporting Tasks.
- Refer to the Draft IAP Volume 1 report for additional background information.

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Near-Term Strategies

1) Acquire/develop sufficient knowledge, technical skills, and capacity to perform non-LWR regulatory reviews
2) Acquire/develop sufficient computer codes and tools to perform non-LWR regulatory reviews
3) Develop guidance for a flexible non-LWR regulatory review process within the bounds of existing regulations, including the use of conceptual design reviews and staged-review processes
4) Facilitate industry codes and standards needed to support the non-LWR life cycle (including fuels and materials)
5) Identify and resolve technology-inclusive policy issues that impact the regulatory reviews, siting, permitting, and/or licensing of non-LWR nuclear power plants (NPPs)
6) Develop and implement a structured, integrated strategy to communicate with internal and external stakeholders having interests in non-LWR technologies

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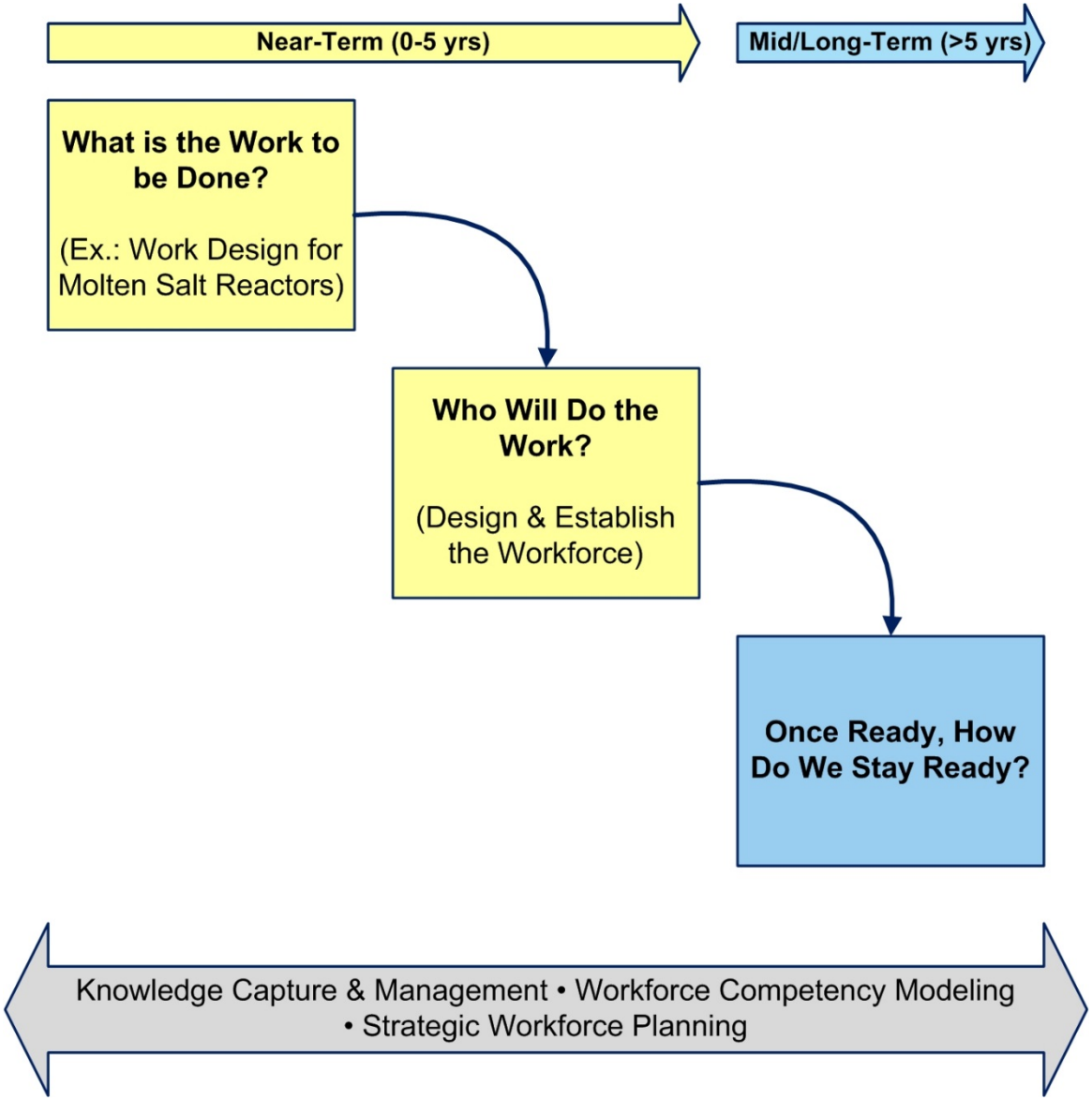
Strategy 1: Technical Skills



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Strategy 2: Computer Codes & Tools

- Philosophy – NRC will not independently develop non-LWR codes and tools unless other acceptable approaches are not available.
- Contributing Activities are organized by functional areas:
  - Reactor kinetics and criticality
  - Fuel Performance
  - Thermal – fluid phenomena
  - Severe accident phenomena
  - Offsite consequence analysis
  - Materials & component integrity

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Strategy 3: Review Processes

- To Be Discussed Later During the Meeting

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Strategy 4: Codes & Standards

- In line with current practice, it is expected that the use of codes and standards will be an integral part of the NRC's strategy to improve its readiness to regulate non-LWR technologies.

- As shown in the IAP for this strategy, the staff intends to enhance the NRC's technical readiness for possible non-LWR designs by applying its established process for incorporating codes and standards into its regulatory framework.

- The NRC will work with standards development organizations (SDOs), non-LWR designers, and other stakeholders to identify and facilitate new codes needed for non-LWR development. The NRC maintains its independence during participation with SDOs by reserving the right to apply conditions on codes and standards used in its regulatory process to ensure that they will meet the NRC's requirements to protect the public health and safety and the environment. The need to impose conditions may, however, be reduced by attempts to resolve outstanding issues through meetings with SDOs and other stakeholders, and active participation during the codes and standards development process.

- Codes and standards that could be applied to a range of non-LWR designs are likely to be identified beginning in the near-term (0-5 years) as candidates for facilitation and development.

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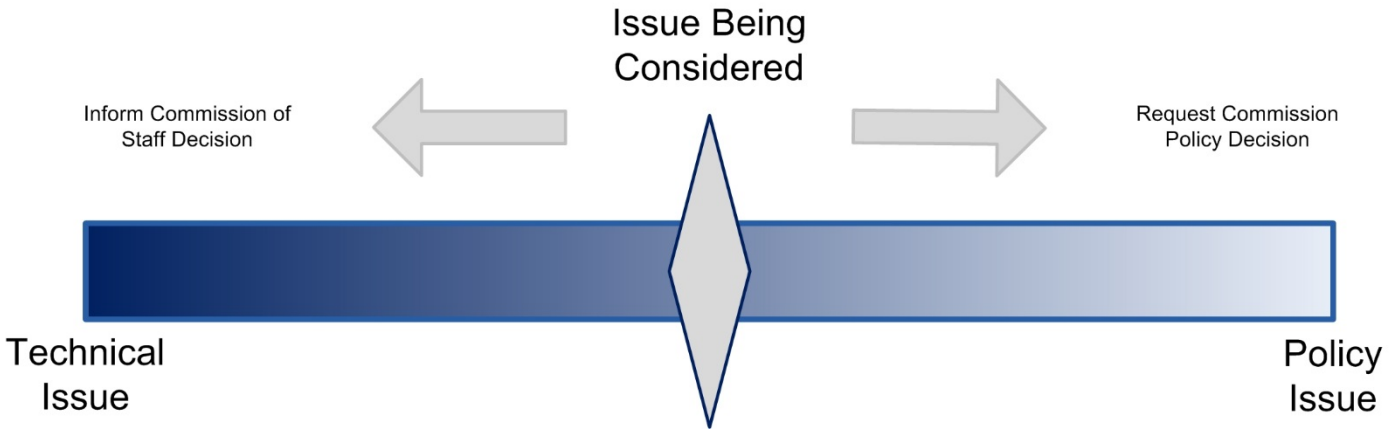
Strategy 5: Policy Issues

- Early identification and resolution of policy issues provides regulatory certainty to stakeholders and helps to achieve the agency's strategic objectives for non-LWRs.
- Technology-inclusive issues have the broadest applicability for the non-LWR regulatory framework.
- The range of issues for non-LWRs can range from strictly technical problems to broadly applicable issues of policy. There is a continuum of factors that must be identified and considered as a particular issue of interest is classified. The following figure illustrates this continuum.



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Strategy 6: Communications

As shown in the NRC's non-LWR vision and strategy document, the strategic objective for optimizing communications is:

"The NRC will optimize its communication with non-LWR stakeholders by disseminating clear expectations and requirements for non-LWR regulatory reviews and oversight. These expectations and requirements will be expressed using multiple channels of communication appropriate to different stakeholder interests. NRC messaging will be consistent and tailored to audiences for maximum communications effectiveness. Stakeholder feedback paths to the NRC will also be optimized to ensure that feedback is received, considered, and addressed in a timely manner, as appropriate."

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Regulatory Roadmap

- Draft Regulatory Roadmap
  - ADAMS Accession No. ML16291A248
- Regulatory Effectiveness IAP (Strategy 3)
  - Establish criteria necessary for regulatory findings
  - Determine appropriate design bases and event selections
  - Identify and resolve gaps in regulatory framework
  - **Develop regulatory review roadmap reflecting design development lifecycle and appropriate interactions**
  - Develop prototype reactor guidance
  - Engage with technology- or design-specific licensing project plans and develop risk-commensurate regulatory approaches

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Regulatory Roadmap

- Design Processes (Critical Decisions, DOE model)
  - Preconceptual design process
  - Conceptual design process
  - Preliminary design process
  - Final design process
  - Construction
- Align with Technology Readiness
  - Research and development
  - Licensing project plans
- Other options available but desire to center around an approach to support common understandings

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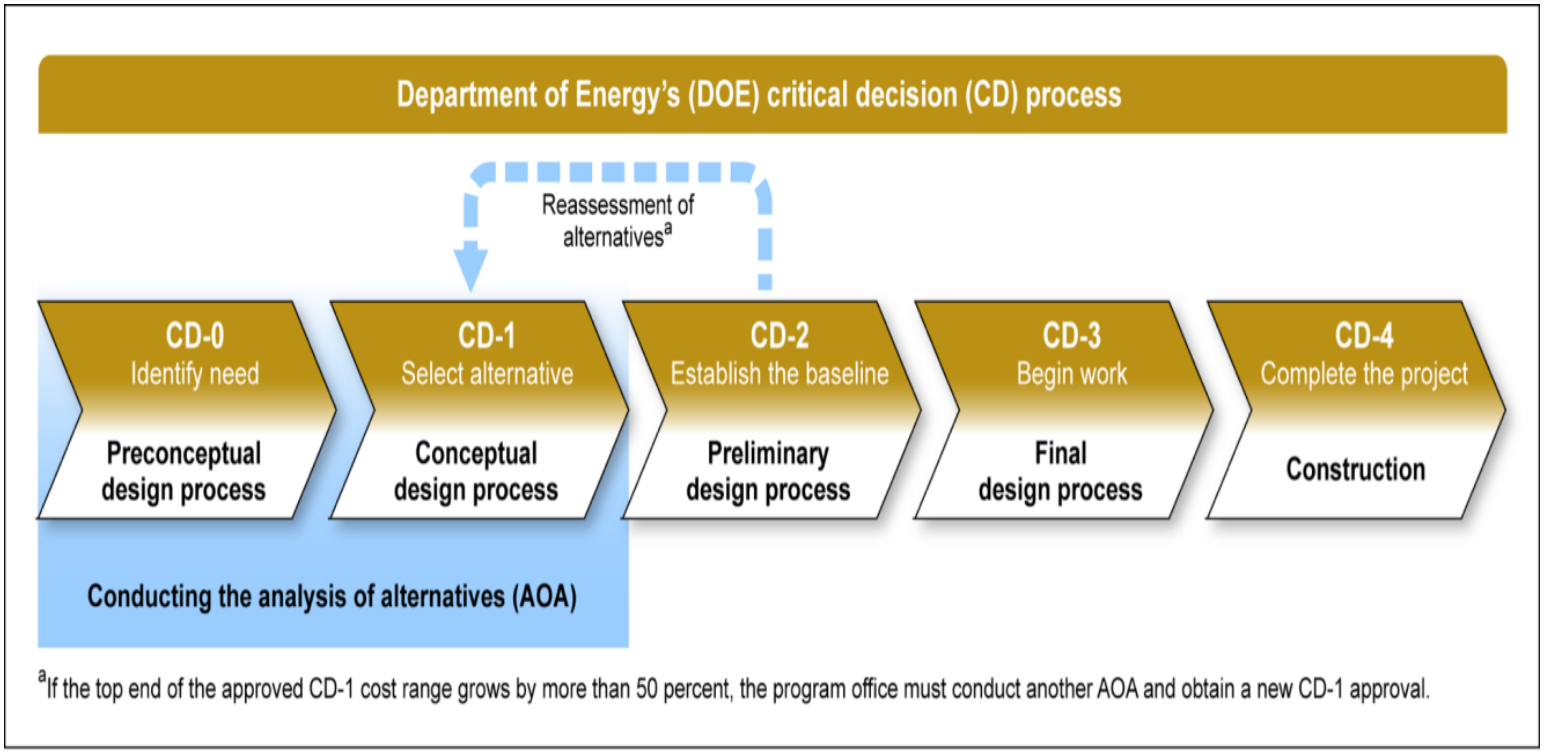
DOE Critical Decision Process



Source: GAO analysis of DOE's Order 413.3B. | GAO-15-37

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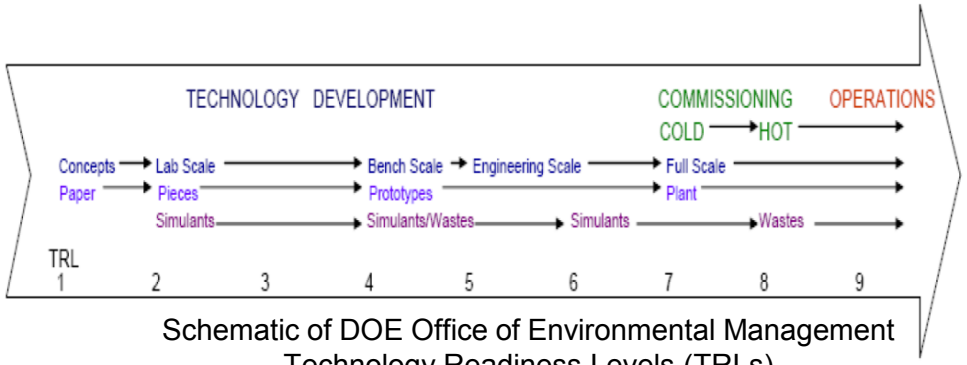
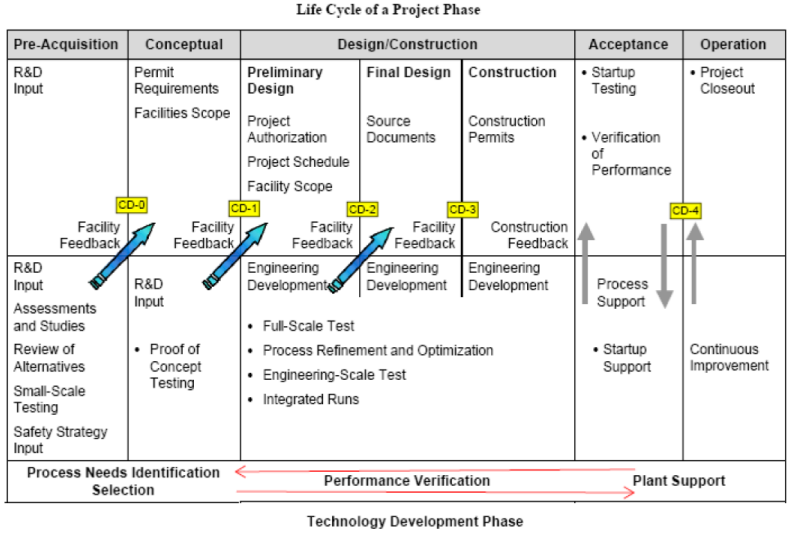
DOE Critical Decision Process

- Aligning design, project management, research, technology readiness to support overall program and licensing project plan



Schematic of DOE Office of Environmental Management Technology Readiness Levels (TRLs)

Technology Development Integration with Project Management



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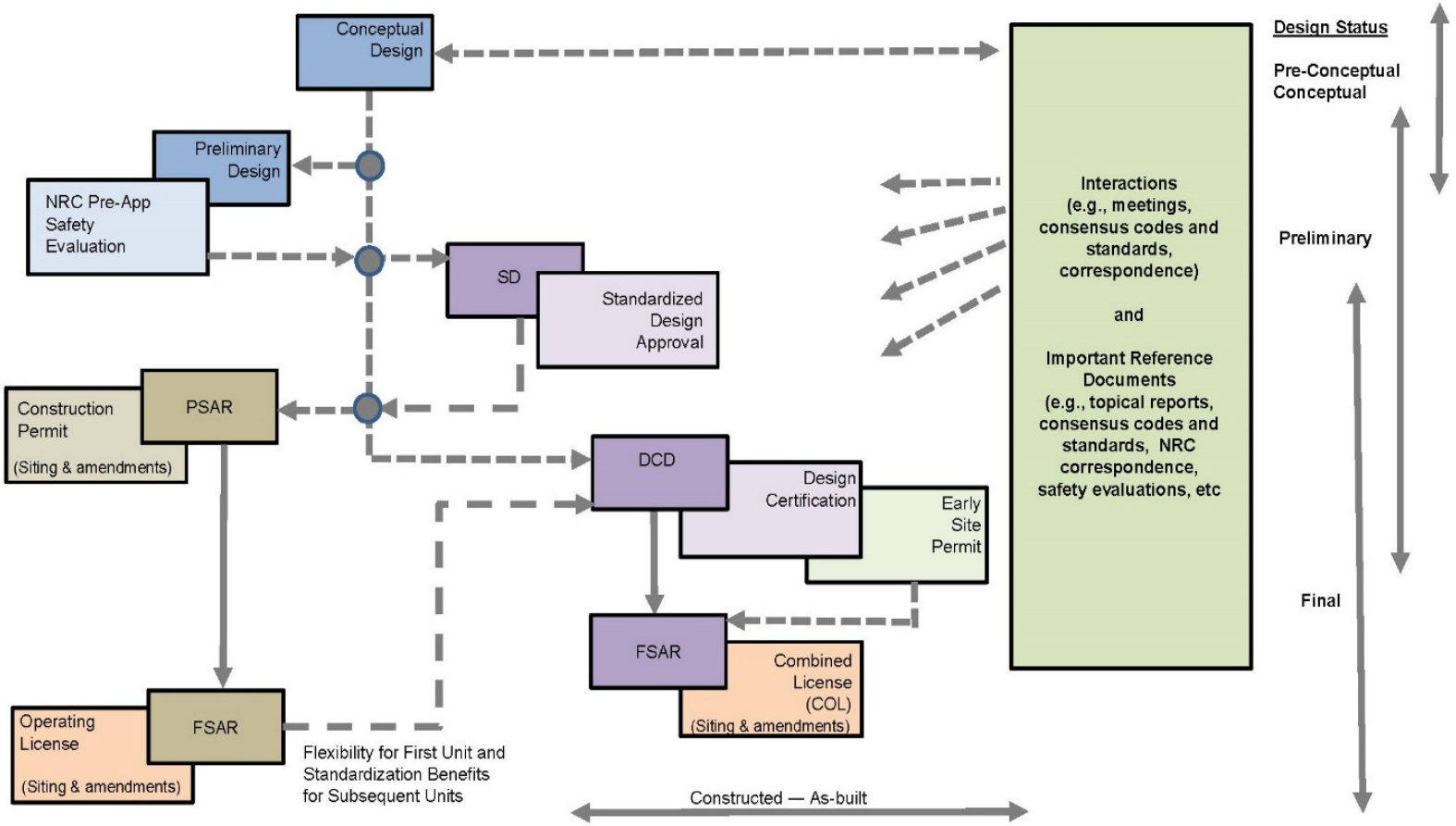
NRC Licensing-related processes



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Outcomes

- Information exchange
- Initial feedback
- Conditional staff findings
- Conclusive staff findings
- Final agency position

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Interactions

- Meetings
- Correspondence
- White papers
- Technical reports
- Topical Reports
- Consensus codes and standards
- Rulemaking and regulatory guidance
- Research plans
- Other supporting documents/programs

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Conceptual Design

- Early consideration and selection of various key alternatives that will define the fundamental design features and general principles of operation, key risk insights
- Supports development of a licensing project plan, including identifying those matters needing early regulatory interactions to support coordination with other aspects of the overall program
- Information exchanges, initial feedback, conditional findings and conclusive findings on specific issues in response to submittals of white papers and topical reports. Possible final agency positions via SECY papers, rulemakings
- Resource constraints may require prioritization of key topics and could impact expected regulatory outcomes
- Terminology preferences?

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Preliminary Design

- Preliminary or preapplication design documents can be provided to the NRC for information or to solicit feedback on testing programs, safety analysis approaches, or the overall feasibility of licensing a design
- Preapplication safety evaluation reports used for design documents submitted by DOE following the issuance of the NRC's advanced reactor policy statement (1990s)
- Available combinations of preapplication interactions, creation of reference documents, and standard design approval is sometimes referred to as a staged licensing process
- Terminology preferences?

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Standard Design Approval

- Standard design for a major portion of a nuclear power plant to the NRC for review
- SDA documents conclusive staff findings, involves ACRS reviews, and provides a reference for subsequent applications (Duration – 15 years, no provisions for renewal)
- Defining a major portion of a design for the purpose of an SDA may be challenging given the relationships between various plant systems and the contributions of safety and non-safety systems to plant risk
- Licensing project plans and other interactions between a designer and the staff will need to include a rationale for which parts of a plant will be included in the application and which portion(s) can be excluded from the review or addressed though concepts similar to the “conceptual design information”
- Establish expectations in terms of outcomes, resources, and schedules and periodic meetings to monitor progress and costs

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Construction Permit and Operating License

- Construction Permit
  - Focus on the preliminary design of a nuclear plant and the suitability of the site before authorizing construction of the plant
  - Can reference SDA and other reference documents
  - Environment reviews, ACRS reviews, NRC staff safety evaluation
  - Mandatory public hearing is conducted by the Atomic Safety and Licensing Board (ASLB)
  - Some advantages to the “design-as-you-build” approach, but also introduces some licensing risks near the end of the final design/construction phase
- Operating License
  - Final safety analysis report and updated environmental report, including references to topical reports, other key documents
  - Environmental reviews, ACRS reviews, NRC staff safety evaluation
  - Opportunity for public hearing

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Design Certification

- Certify a reactor design for 15 years through the rulemaking process, independent of a specific site
- Essentially complete nuclear power plant design
- Application must provide sufficient information for NRC to reach a final conclusion on all safety questions associated with the design before the certification is granted
- ACRS reviews, Commission decisions on rulemaking establish final agency positions
- Reference for combined license application
- Provisions to renew certification

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Combined License

- Combined license to authorize construction and operation of a nuclear power plant
- Essentially same information as application for an operating license
- Mandatory hearing (ASLB on contested matters)
- Verify completion of required inspections, tests, analyses and acceptance criteria (ITAAC)
- Hearing opportunity related to ITAAC completion
- Finding that acceptance criteria met (52.103(g)) prior to plant operation

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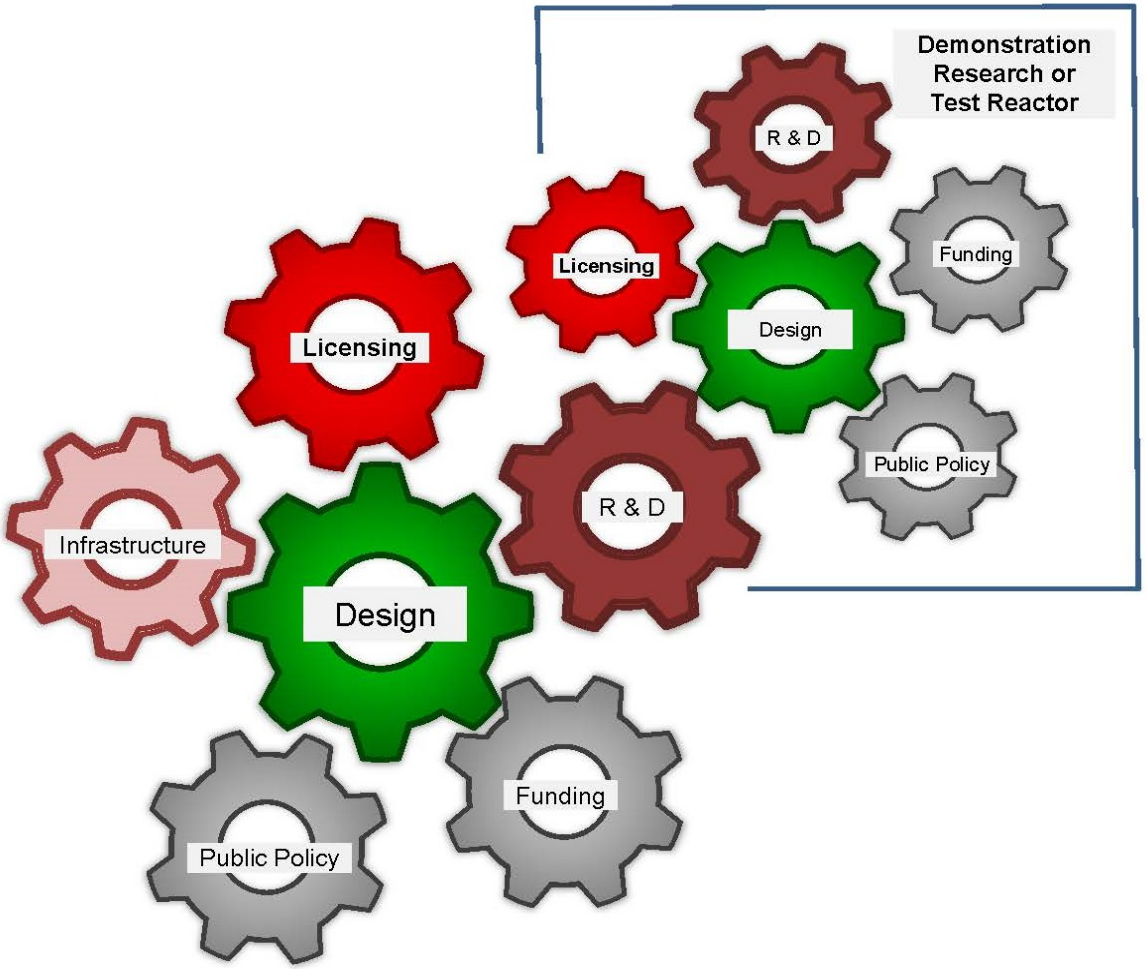
Licensing as Subpart of Overall Development Program



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Licensing Project Plans

- Numerous possible plans and combinations of interactions and submittals that could be included in a licensing project plan during the conceptual or preliminary design processes
- Proposed licensing project plans would include consideration of the designer's and NRC's capabilities and resource availability as well as how the licensing project plan supports overall program
- Licensing project plans allow the designer and NRC staff to prioritize issues and optimize interactions to address design alternatives or address issues most important to the overall program

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Licensing Project Plans

- Licensing project plan is an early step in the overall program to develop and deploy a new reactor technology
- Reflects the technology readiness level of the reactor design, including innovative features, and the related research and development activities
- Mutual agreement on the desired outcomes of defined interactions and estimated costs and schedules for defined reviews
- Particular attention to near-term activities needed to support the critical decision process (see DOE figure)
- Longer-term licensing and construction strategies for commercial units can be useful to include in the licensing project plan, but recognize uncertainties and dependencies

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Initial Interactions

- Important to familiarize NRC staff with design concepts and to familiarize designer with NRC's regulatory processes
- Early meetings usually involve designer providing presentations and available design documents
- Initial interactions followed by more specific discussions supporting licensing project plan and related NRC review plan
- Licensing project plan identifies key interactions and submittals, including important reference documents (e.g., topical reports, SDA)
- Coordination of licensing project plan with research and development and other parts of the overall program (including expected need for research or test reactor, prototype testing, other licensed facilities, etc.)

- Terminology preferences (demonstration, prototype)

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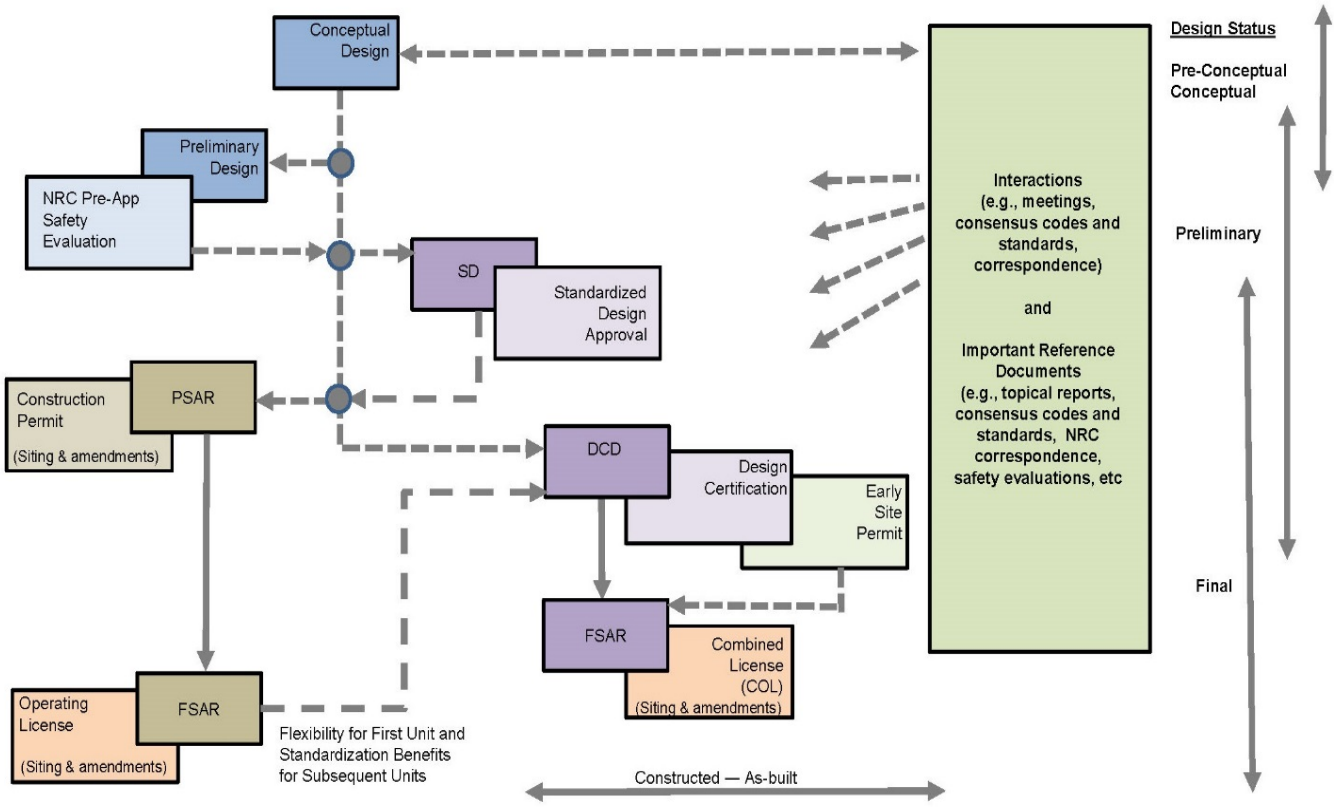
Discussion/Questions



- Specific examples or issues to address ?

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DOE Update

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DOE Vision and Strategy for the Development and Deployment of Advanced Reactors

Secretary of Energy Advisory Board Report on the Future of Nuclear Power

Craig Welling
Chief of Nuclear Safety
Office of Nuclear Energy

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Advanced Non-Light Water Reactors Overview

There has been increasing interest in advanced Non-light water reactors and benefits they can provide toward clean energy and energy security needs.

- **DOE initiatives have included:**
  - Development of a vision and strategy for advanced reactors
  - Establishment of the Gateway for Accelerated Innovation in Nuclear (GAIN)
  - Providing cost shared support for reactor concepts.
  - Conduct of a Test/Demonstration Advanced Reactor Planning Study
- **These initiatives support the need for new nuclear capacity in the 2030 to 2050 time frame.**

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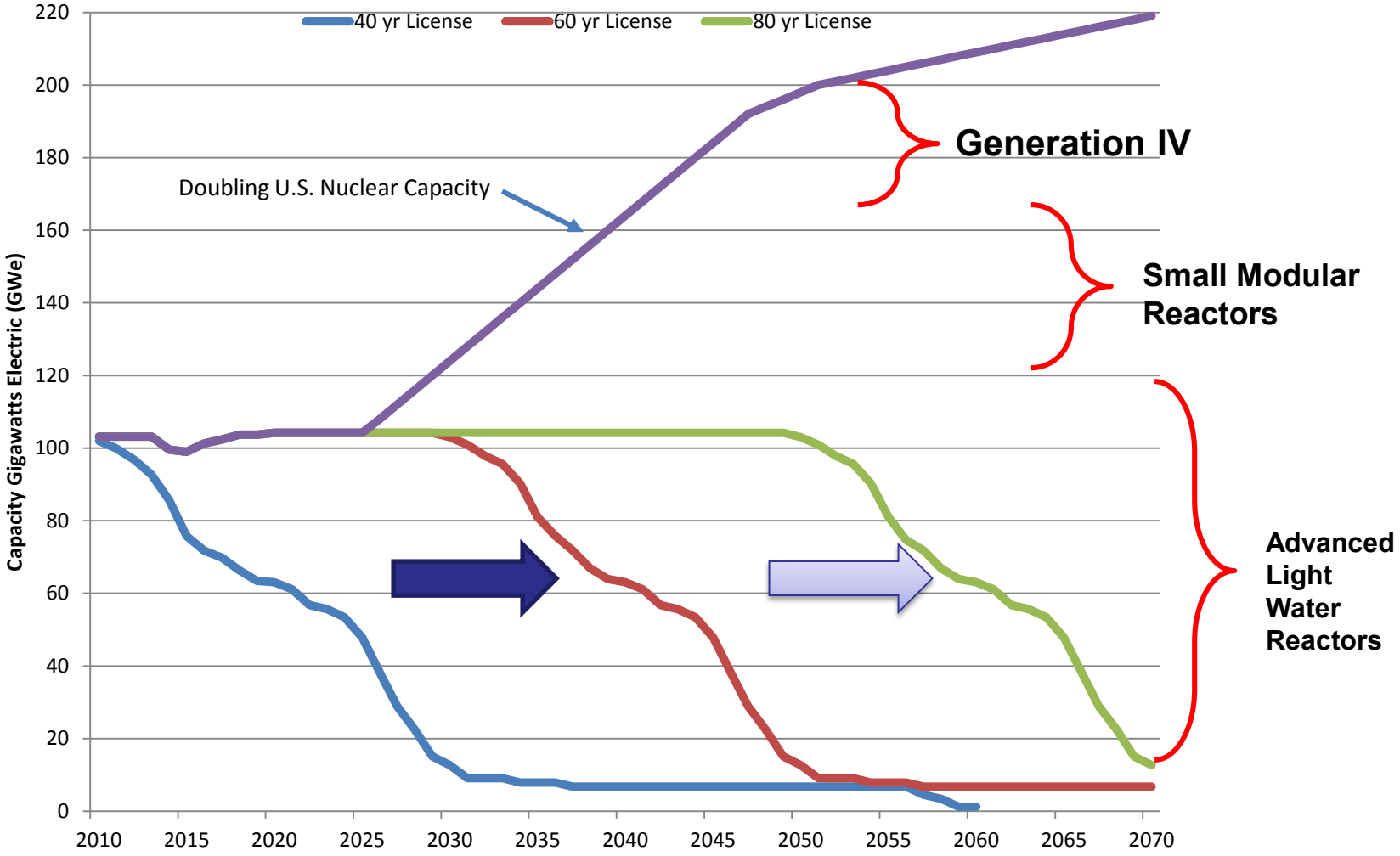
Nuclear Power Capacity needed to meet Clean Power Goals



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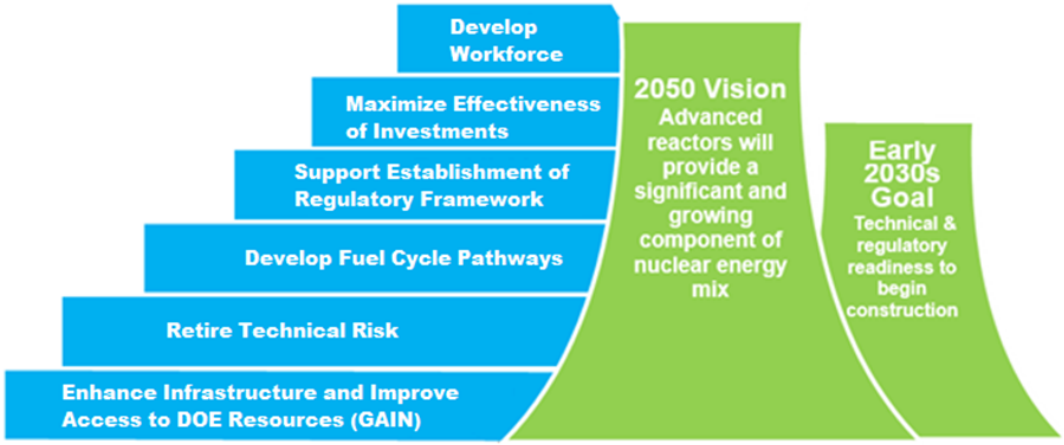
Vision and Strategy for Advanced Reactors

- **To meet the challenge, DOE has developed the *Vision and Strategy for Development and Deployment of Advanced Reactors***
  - Final draft publically available at http://energy.gov/ne/downloads/draft-vision-and-strategy-development-and-deployment-advanced-reactors
- **The Vision and Strategy will complement DOE efforts to:**
  - Support the current Light Water Reactor fleet
  - Pursue the construction/operation of Generation III+ reactors
  - Support the development/licensing/deployment of Small Modular Reactors



Vision and Strategy for Advanced Reactors

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Vision and Goal

VISION

By 2050, advanced reactors will provide a significant and growing component of the nuclear energy mix both domestically and globally, due to their advantages in terms of improved safety, cost, performance, sustainability, and reduced proliferation risks.

GOAL

By the early 2030s, at least two non-light water advanced reactor concepts have reached technical maturity, demonstrated safety and economic benefits, and completed licensing reviews by the U.S. Nuclear Regulatory Commission (NRC) sufficient to allow construction to go forward.

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Strategic Objectives

1. Enhance the innovation infrastructure for nuclear technologies and vastly improve access to DOE expertise and capabilities through the Gateway for Accelerated Innovation in Nuclear (GAIN) initiative
2. Demonstrate performance and retire technical risks for advanced reactors
3. Support the development of fuel cycle pathways for advanced reactors
4. Support the establishment of an efficient and reliable regulatory framework for advanced reactors
5. Maximize the effectiveness of public/private sector resources and policy incentives to aid the private sector in accelerating advanced reactor deployment
6. Address human capital and workforce development needs

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Enhanced Nuclear Innovation Infrastructure and Improved Access

- **Continue to enhance experimental, testing, and simulation capabilities while vastly improving access to DOE expertise and facilities.**
  - Implement the Gateway for Accelerated Innovation in Nuclear (GAIN)
    - Provide greater access to experimental, testing, and modeling and simulation capabilities
    - Facilitate use of the DOE nuclear technology database
    - Promote broader engagement with industry to understand technical needs. (Technology Centered Workshops)
    - Facilitate interaction between industry and the NRC
  - Restart the Transient Reactor Test Facility (TREAT)

TREAT Facility

GAIN Gateway for Accelerated Innovation in Nuclear

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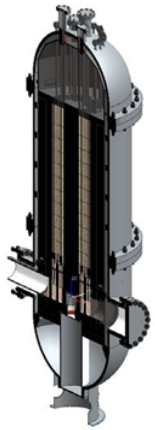
Retiring Advanced Reactor Technical Risk

- **DOE will pursue a multifaceted set of efforts to retire technical risks associated with advanced reactors including:**
  - Conducting Laboratory directed R&D
  - Supporting cost-shared, industry-led R&D for concept-level development and conduct research on advanced reactor technologies
  - Pursuing relevant research projects selected through the DOE's Nuclear Energy University Program
  - Potential consideration to develop a test/demonstration reactor(s) to further enhance testing capabilities and support the timely deployment of advanced reactors
  - Pursuing technical solutions to support the changing role of nuclear energy as part of a diverse electricity generation mix and for non-electric uses

Mechanisms Engineering (Sodium) Test Loop at ANL



High Temperature Test Facility at Oregon State University

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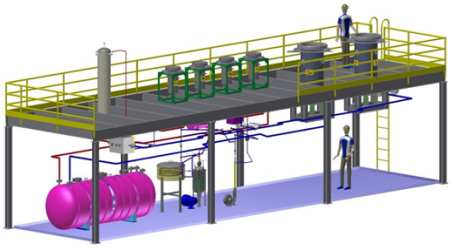
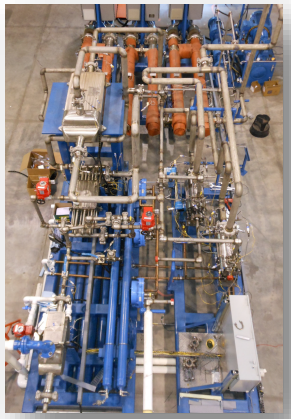
Advanced Reactor R&D - Laboratory directed R&D

- **R&D focused on Advanced, Small and Modular Reactor Concepts**
  - Fast Reactor Technologies
    - Current focus on sodium cooled reactors
  - High Temperature Reactor Technologies
    - Current focus on helium gas- and Fluoride High Temperature Reactors (FHRs) liquid salt-cooled reactors (Fluoride, Lithium, Beryllium salts)
  - Advanced Reactor Generic Technologies
    - Common design needs for advanced materials, decay heat removal systems and modeling methods



Sodium Test Loop at ANL

- **Supercritical Transformational Electric Power (STEP) Initiative:**
  - Investigating commercialized Supercritical Carbon Dioxide (sCO2) Brayton cycle energy conversion system



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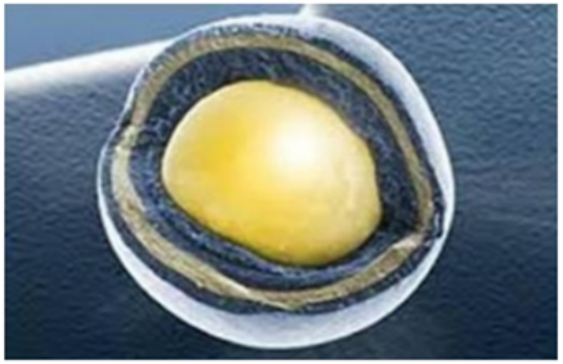
Fuel Cycle Pathways for Advanced Reactors

- **DOE will pursue R&D to develop improved fuels for existing reactor technologies and suitable fuels for advanced reactors. Working with industry, these efforts will likely focus on:**
  - TRISO-coated particle fuel for high temperature reactors, metallic fuel for fast reactors, and transmutation fuels for longer-term applications
  - Identifying and characterizing fuels and separations/enrichment technologies.
    - DOE would assess the need for and/or provide for the deployment of fuel cycle facilities.
  - Addressing the back end of the nuclear fuel cycle
    - DOE is pursuing R&D to develop the technologies and capabilities needed to enable the safe storage, transportation, and disposal of used nuclear fuel and wastes generated by existing and future nuclear fuel cycles



TRISO coated particle fuel

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Supporting Regulatory Framework Development for Advanced Reactors

- **DOE and its stakeholders will collaborate with the NRC as the NRC develops a regulatory framework for advanced reactors. Potential efforts include:**
  - Providing assistance to the NRC as it develops
    - design criteria for advanced reactors
    - potential staged licensing and preliminary licensability review processes
  - Assisting the NRC in
    - resolving key policy issues
    - co-hosting joint workshops
    - modifying existing guidance (such as the Standard Review Plan) to accommodate advanced non-light water reactor designs

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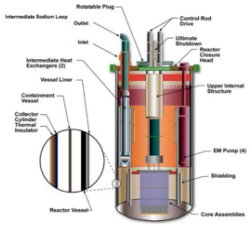
Maximizing the Effectiveness of Public and Private-Sector Investments to Accelerate Advanced Reactor Deployment

- **DOE will explore new ways to work with the private sector to accelerate advanced reactor deployment and support further development of advanced reactor concepts.**
  - DOE would use public-private partnerships and technology-specific working groups to identify opportunities for government investment that could help advance multiple reactor concepts
  - DOE and the Administration will explore the use of other appropriate policy or financial incentives to support advanced reactor deployment

- PWR
- BWR

- AP1000
- ESBWR

- NuScale
- B&W mPower
- Holtec SMR-160
- Westinghouse SMR



- Sodium Fast Reactor
- High Temperature Gas Reactor
- Lead Fast Reactor
- Gas Fast Reactor
- Molten Salt Reactor

GEN II	GEN III +	SMR	GEN IV Advanced Reactors
Leveraged Support	NP 2010	SMR Licensing Technical Support	Cost Shared and Potential Future Support for Advanced Reactors

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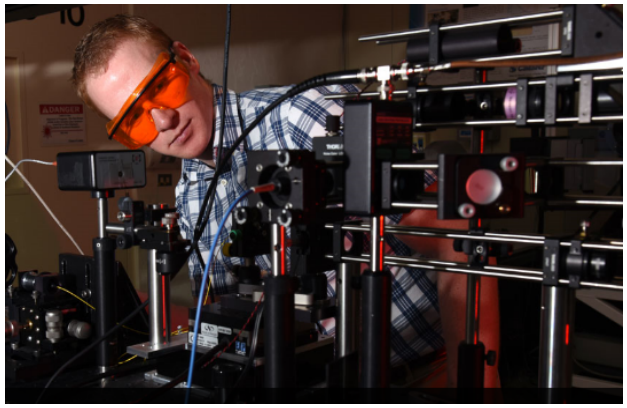
Developing the Nuclear Energy Workforce of the Future

- Continue funding nuclear-related research projects and scholarships and fellowships through its Nuclear Energy University Program (NEUP) and Integrated University Program (IUP)
- Promote advanced reactor technology training opportunities through workshops, curriculum development, and joint laboratory, university, and industry projects
- Seek opportunities to engage academic institutions in enhancing research efforts relevant to the development of advanced reactor technologies

NEUP Nuclear Energy University Program
U.S. Department of Energy



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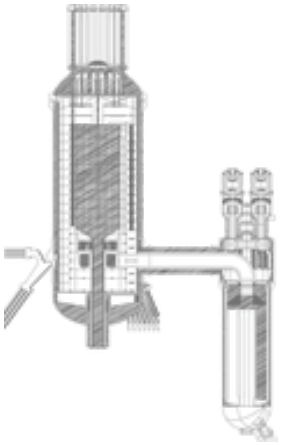
Industry Collaboration – Cost Shared support for reactor concepts

- **DOE made multiple awards totaling $16.5M in FY 2013 and FY 2014 for cost shared industry-led R&D to address specific technical R&D needs of advanced reactors.**

- **With FY15 funding DOE is providing $12.5M for cost-shared further development of two performance based advanced reactor concepts. Awardees are:**
  - X-Energy (Pebble Bed High Temperature Gas Reactor)
  - Southern Company Services (Molten Chloride Fast Reactor).

- **These awards reflect DOE's interest in collaborating with industry and Congressional support for advanced reactor development.**



X-Energy Xe-100

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Advanced Test/Demo Planning Study

- **FY15 Omnibus Spending Bill**
  "$7,000,000 is for an advanced test/demonstration reactor planning study by the national laboratories, industry, and other relevant stakeholders of such a reactor in the U.S. The study will evaluate advanced reactor technology options, capabilities, and requirements within the context of national needs and public policy to support innovation in nuclear energy."
- **The objective of the study is to provide options for a test and or demonstration reactor(s) to be built to support innovation and long term commercialization**
- **The Nuclear Energy Advisory Committee is examining test reactor needs.**

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Summary for Vision and Strategy

- **Achieving our vision of a substantial role for nuclear power for a clean energy future and in support of national security requires:**
  - The continued long-term operation of the existing fleet of nuclear power plants
  - The deployment of new nuclear plants, including a mixture of
    - Large LWRs
    - SMRs
    - Advanced Reactors
- **Through the Vision and Strategy for Development and Deployment of Advanced Reactors, GAIN and other initiatives DOE will work with key stakeholders, the NRC, and the private sector to continue to support light water reactors and lay the foundation for advanced reactor deployment.**

U.S. DEPARTMENT OF ENERGY | Nuclear Energy

Secretary of Energy Advisory Board
Task Force on
the Future of Nuclear Power
Draft Report

U.S. DEPARTMENT OF ENERGY
Nuclear Energy

SEAB Draft Report on the Future of Nuclear Power

- Secretary Moniz charged the Task Force to describe a new nuclear power initiative that would lead to a situation in the period 2030 to 2050 where one or more nuclear technologies are being deployed at a significant rate.
- The principal motivation for this initiative is the vital contribution that nuclear power and other technologies can make worldwide to reduce carbon dioxide emissions, slowing global average temperature increase.
- Four factors explain the private sector's current reluctance to invest significantly in U.S. nuclear power:
  - Absence of an established price for carbon emission;
  - Significant technical, cost, and regulatory uncertainties;
  - Projected market conditions;
  - Unanticipated intervening events internal or external to the project with effects that exceed the time horizon of private investors.

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SEAB Draft Report on the Future of Nuclear Power – Key Findings

- **The Task Force believes that significant market restructuring is a prerequisite for the success of any nuclear power initiative.**
- **The Task Force Recommends a Four-Phase Advanced Nuclear Reactor Program:**
  - The first phase (technology down select) of the initiative involves conducting the technology development, engineering, and systems analysis necessary to establish technological readiness, estimated capital costs, and LCOE of the candidate technologies.
  - This second phase (subsystem development and reactor demonstration preparation) is devoted to obtaining subsystem development and validation, front-end engineering design, and NRC demonstration plant licensing.
  - The third phase (demonstration plant operation) is devoted to construction and operation of a demonstration plant and preparing a detailed design for a FOAK commercial plant.
  - The fourth phase (FOAK reactor plant operation) consists of construction and operation of a FOAK commercial-scale plant.

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SEAB Draft Report on the Future of Nuclear Power – Key Findings

- **Cost** - the Task Force midpoint estimate is that such a four-phase program would require about 25 years and $11.5 billion. The Federal Government would share these costs; the proportion paid by each partner would vary according the project risk.
- **Safety and Licensing -** The NRC must be involved in all four phases of the advanced nuclear reactor initiative.
- **International Linkage -** United States' ability to influence decisions internationally will inherently depend on the country's involvement in the development of advanced nuclear technology.
- **Program Management - The Task Force recommends that a quasi-public corporation be established.**
- **On Sep 23, 2016 the SEAB voted to send the draft report forward to the Secretary.**

NRC Plan for Licensing Non-Light Water Reactors

Jeffrey S. Merrifield

Chairman, Advanced Reactors Task Force

U.S. Nuclear Infrastructure Council

Partner, Pillsbury Winthrop Shaw Pittman

USNRC Commissioner (1998-2007)

October 25, 2016

Overview

- NIC commends the staff of the Nuclear Regulatory Commission for organizing this meeting
- We believe this meeting provides a meaningful and timely forum to share views
- For over five years, NIC has advocated on behalf of the safety and economic advantages represented by these innovative Advanced Reactor technologies
- Given the growing recognition of the clean, non-carbon emitting benefits of nuclear power, it is vital that the NRC provides a predictable and efficient means to license these designs
- NIC has testified before both the Senate EPW and House E&C Committees regarding the need for NRC reform and modernization
- NIC believes that the NRC is continuing to make progress in preparing to license non-light water technologies

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Overview (2)

- NIC is also heartened that a bi-partisan support in both the House and Senate for the types of reforms that NIC has advocated over the last few years
- Specifically, NIC continues to believe that a pre-licensing design review process similar to that in Canada is appropriate and that some developers would welcome a design review process which is phased in a manner appropriate to the financial abilities of the individual developers
- The recent NRC meeting on Advanced Reactor Design Criteria was productive and demonstrated the willingness of the NRC to recognize the enhanced safety principles represented in these designs
- We look forward to continuing to work with the Agency to identify ways to enable the deployment of Advanced Reactors through a timely, risk-informed, performance-based licensing process consistent providing adequate protection to the public
- NIC has been working to identify sources of higher levels of enriched LEU for the use of Advanced Reactors and encourages the NRC code efforts to recognize this development
- NIC also strongly supports efforts to provide sufficient off-the-fee-base funding for the NRC's Advanced Reactor activities including the $5 million requested for FY17

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NRC Vision and Strategy – Mission Readiness

- NIC recognizes the NRC believes it "could review and license a non-LWR design today, if needed."
- While that may be technically accurate, NIC believes the NRC's regulatory framework could be enhanced to better address Advanced Reactors.
- Among the challenges that NIC believes need to be addressed:
  - The Agency does not currently possess sufficient financial or technical resources to efficiently license these designs
  - The licensing process could be faster, more efficient and more risk informed
  - Longstanding policy issues must be addressed to appropriately license Advanced Reactor technologies
  - The timelines for Agency action could be shortened particularly given the speed with which some Advanced Reactor designs have moved forward

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NRC Vision and Strategy – Mission Readiness (2)

- As an advocate of a pre-licensing design review process, NIC is encouraged by the willingness of the Agency to review pre-licensing methodologies
  - NIC continues to believe the Agency should seek to identify a regulatory model equivalent to the Canadian Nuclear Safety Commission – Pre-Licensing Design Review
- We believe it is positive that the staff has indicated that it will consider developing new guidance for a conceptual design assessment and staged regulatory review
- For innovative technology developers, it is critical that early indications regarding of the viability of their designs be provided to guide future investment decisions
- On page 7 of the Mission Readiness document, the staff states that it "must have policy decisions in place to govern the acceptability of non-LWR designs" including "emergency preparedness requirements for high-safety, low-consequence designs, and commercial concerns such as NRC fees and insurance requirements."
- NIC concurs with the view that the Commission needs to act on policy issues
- NIC further believes the staff needs to reduce its hesitation to raise these policy concerns to the Commission in the absence of a specific design

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NRC Vision and Strategy – Mission Readiness (3)

- NIC recognizes that the NRC has a delicate balancing act in preparing itself to license a currently unknown number of Advanced Reactor designs
- NIC appreciates the strategies that the NRC has listed in its "Mission Readiness Document"
- While it is understandable that the Agency desires to "prioritize the non-LWR technologies most likely to achieve review readiness" – including inputs from DOE and others – The Atomic Energy Act requires the Agency to license those designs that are submitted to it as long as it can determine they are safe
- Ultimately, one or two reactor designs will be the first to move forward, and the Agency should remain flexible in the methods it uses to license these designs
- Regardless of which designs are submitted first, the Agency needs to possess sufficient technical skills to be prepared to review a variety of designs and its technical capabilities should be aligned to meet this goal
- The Agency should possess the ability to license categories of Advanced Reactors (molten salt, high temperature gas, sodium fast reactors, lead bismuth, etc.)

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NRC Vision and Strategy – Mission Readiness (4)

- Timing is critical in the continued advancement of these designs
- The NRC staff and senior management should reassess policy issues identified during the NGNP review and raise as many as possible, as quickly as possible, and reverse its insistence that they require a specific application to provide resolution
- Overall, the activities in the roadmap seem logical
- Given the desire of some Advanced Reactor technologies to deploy full-scale Advanced Reactors in the 2020's, the timelines for Mid and Long Term Strategies need to be accelerated by 7-9 years
- If the strategy timelines outlined in pages 28-29 of the Mission Readiness document are driven by financial and staff resources, the Agency must clearly articulate and be transparent about what is needed to accelerate the schedule

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NRC Vision and Strategy – Near Term Action Plan

- Strategy 1 – (Knowledge and Technical Skills)
- Overall appears to be a logical approach
  - While it claims not to be "constrained by budget or other agency mission priorities" (p.3), it order to meet developer needs, it needs further acceleration
  - If molten-salt reactors are utilized as the "example non-LWR technology" for the Strategy 1 Planning effort, the Agency must act quickly to acquire the needed knowledge base
- Strategy 2 – (Computer Codes and Tools)
- While the Agency needs to be able to review non-LWR designs in an independent manner – it needs to be flexible in its use of computer codes
  - "NRC can maintain its independence by developing expertise in the codes' phenomenological modeling, numerical schemes, and verification and validation process. The NRC will also participate in the development process to the degree that resources allow."(p.10)
  - It is unclear what this means. NIC advocates the use of existing codes and not seeking to have a new set of codes prepared for NRC use
  - Plan for codes needs to be resolved promptly and efficiently

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NRC Vision and Strategy – Near Term Action Plan (2)

- Strategy 3 – (Flexible non-LWR Regulatory Review Process)
- Flexibility of adapting licensing approached is welcome
  - However, creation of a predictable model similar to the Canadian Pre-Licensing Design Review – provides a transparent option for investors to monitor progress in the licensing of individual Advanced Reactor designs
  - Each technology developer will "come to the table with a different set of needs and expectations" – adaptable approach is welcome
- Strategy 4 – (Industry Codes and Standards)
- Strong engagement with industry codes and standards organizations is positive
  - However, licensing activities should not be held back waiting for development of codes and standards to catch up with Advanced Reactor deployment
  - Strong Agency engagement to resolve concerns within the code process is needed

NRC Vision and Strategy – Near Term Action Plan (3)

- Strategy 5 – (Resolve Technology-Inclusive Policy Issues)
- NIC strongly believes that the Agency Staff and Management need to move on this strategy
  - The sooner policy issues can be elevated to the Commission for decision-making, the more uncertainty is removed from the Advanced Reactor development process
  - NGNP provides a wealth of information on potential opportunities for moving forward
- Strategy 6 – (Communication with External Stakeholders)
- Presence of NIC and NIA at this meeting is indicative of a changing environment
  - Advanced reactor technologies have attracted a large group of non-traditional NGOs who strongly support nuclear power and whose voices have not been heard previously. The views of the "public" are not represented just by traditional voices
  - ClearPath, Breakthrough Institute, Third Way and the Nuclear Innovation Alliance
  - While the industry has a collaborative view – there is no "one voice" on Advanced Reactors

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NRC Vision and Strategy – Near Term Action Plan (4)

- 3.0– (Near-Term Prioritization)
- While NIC agrees with the importance of Communications - that issue should be listed separately from other policy issues
- ARDC development is appropriately prioritized as this is a vital matter
- As stated previously, NIC believes the elevation of near-term policy issues should be a higher priority
- Given parallel developments in Canada, appropriate interactions should be factored into the plan
- However, NIC does not advocate the waiting for international approach to Advanced Reactor licensing – time does not allow this approach

Roadmap for Non-Light Water Reactors

- There is a significant amount of information to be digested in these materials
- As we have only had the document for a short period of time, we have not had a chance to fully vet it with the members of NIC
- On Page 3, it quotes the IAEA Specific Safety Requirements SSR-2/1
  - "2.8 – To achieve the *highest level of safety that can reasonably be achieved in the design of a nuclear power plant*, measures are required to be taken to do the following"…
  - "To ensure that…the *radiological consequences of such an accident would be mitigated to the fullest extent possible*."
- These two phrases in the document appear to be inconsistent with U.S. law including the Adequate Protection Standard
- References to the IAEA standard should be removed to avoid confusion

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Roadmap for Non-Light Water Reactors (2)

- The interactions listed on pages 9-12 do provide for a flexible process, but decision-making needs to be simplified and streamlined given the significantly reduced risks posed by these reactor designs
- We will hear later from the Technology-Inclusive Regulatory Framework Team regarding risk-informed, performance based decision-making – NIC supports this effort
- Agency needs to recognize that the timing and cost of licensing review activities must to be proportionate to risk
- Previous timelines for topical report, white paper and other reviews are unacceptable
- Agency needs to establish clear performance matrices for Advanced Reactor reviews
- Agency needs to appropriately manage RAIs to provide discipline and predictability – this is not referenced in the document
- The Agency needs to develop a predictable framework for the budgeting of its reviews. A running meter is not an acceptable outcome. Do not repeat NGNP process.

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Summary

- NIC appreciates the opportunity to participate
- We look forward to our continuing involvement in these meetings
- Advanced Reactor progress is a national priority and while the NRC must independently license these designs, it shouldn't be an impediment.
- U.S. needs to continue to be a global trailblazer in safe nuclear energy
- Window of opportunity is finite – these technologies can and will go abroad
- Ramped-up programmatic, funding and regulatory commitment is vital to promote innovation along with investment in infrastructure

United States NIC Nuclear Infrastructure Council

For more information visit www.usnic.org

U.S. Nuclear Infrastructure Council
1317 F Street, NW – Suite 350 – Washington, DC 20004
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About the USNIC

- Leading business consortium advocating for increased U.S. nuclear use and global deployment of U.S. nuclear technologies and services
- Represents over 80 member companies encompassing wide representation of the nuclear energy supply chain and key movers
- Member of the Civil Nuclear Trade Advisory Committee, ANS International Committee and the U.S. Industry Delegation to the IAEA
- Strongly supports Gen 3+ reactors, small modular reactors and advanced reactors moving in parallel paths

Feedback on NRC Non-LWR Vision and Strategy and Supporting Documents

NRC Public Meeting

October 25, 2016

Ashley Finan
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617.733.5458

Key Regulatory Challenges to Commercialization

- Regulations designed for light water technologies do not easily fit advanced reactors, requiring major revisions to requirements, exemptions, and high costs and long time periods interacting with the regulator.

- The current licensing process is requires a major investment of time and money, without transparent interim steps that provide concrete feedback.

- Some innovators need to build a prototype or demonstration reactor, and the regulatory process is not well-charted territory.

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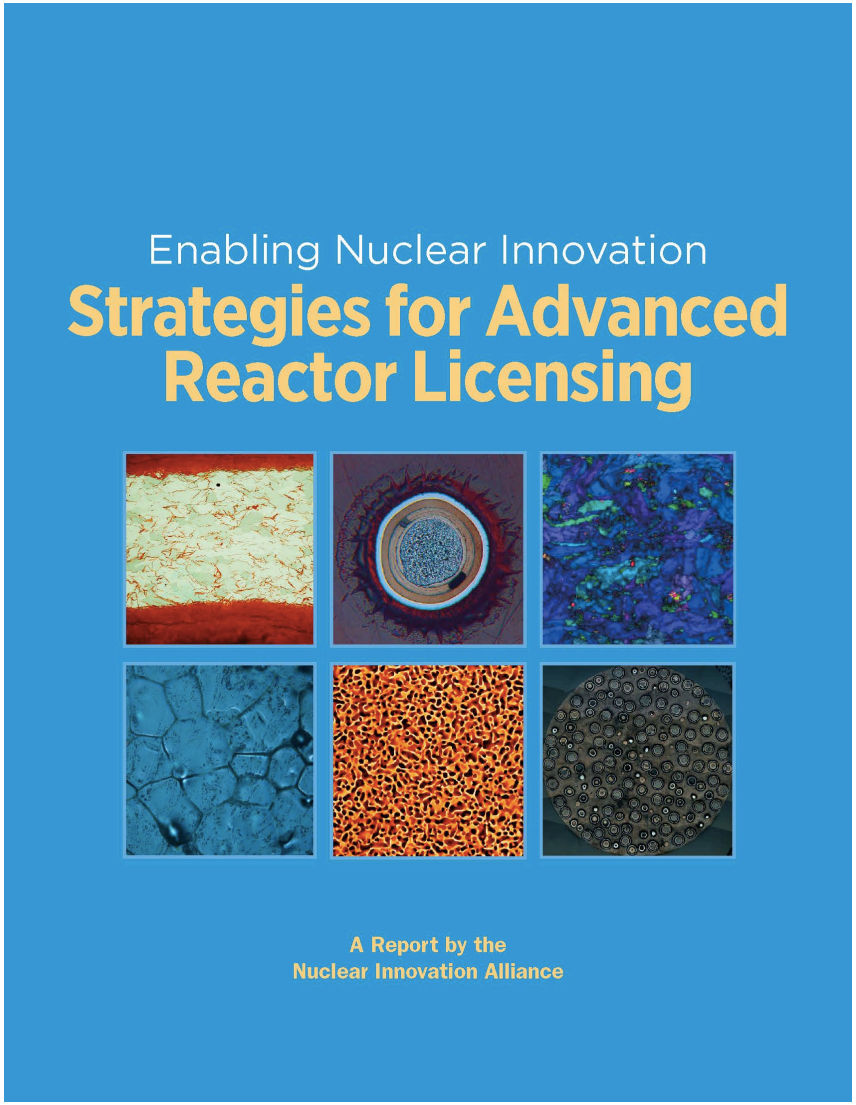
NIA Report Issued April 2016



Download the Report at:
www.nuclearinnovationalliance.org

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Regulatory Recommendations

- Staged licensing, using a licensing project plan, topical reports, and standard design approval
- A statement of licensing feasibility process to structure pre-licensing and provide early feedback
- Resolution of policy issues and more risk-informed performance based evaluation techniques
- Development of a technology inclusive framework
- Development of guidance for advanced reactor demonstrations
- Expansion of NRC expertise in advanced reactors

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Policy Recommendations

- Revise the NRC's budget structure so that licensees and applicants reimburse it for activities related to their regulation, with Congress funding other agency-related activities
- Appropriate funds for the NRC to prepare for advanced reactor licensing
- Fund DOE to competitively award grants for early efforts to license advanced reactors

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Industry Recommendations

- Coordinate and deliver a consistent message about technology-inclusive advanced reactor priorities.
- Inform the NRC as early as possible of prospective applicants' intent to request review.
- Take a more active role in communicating on the challenges and opportunities associated with various advanced reactor designs.
- Pursue the development of codes, standards and conventions for advanced nuclear power, working with the appropriate research and standards organizations.

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We intend these recommendations to serve as a foundation for appropriate deliberation and, soon after, decisive action to improve the regulatory pathway for advanced nuclear energy technologies. This is critically important work that will enable society to capture the immense future benefits of advanced nuclear power.

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NIA Feedback on NRC Non-LWR Vision and Strategy

- The vision and strategy is an excellent foundation for the NRC's non-LWR mission readiness efforts
- NIA supports the overall direction and the bulk of the details in the document.
- NIA is concerned that the NRC's readiness timeline is driven primarily by the DOE vision and strategy, which does not represent private sector efforts.
- NIA encourages the NRC to move forward with developing procedures and guidance in the conduct of conceptual design assessment and development of a staged regulatory review process. In particular:
  - To be most useful, a CDA needs to provide more structure and concrete outcomes based on bounded inputs than the current pre-application process. Balancing this with the difficulty of defining a single product cost and schedule will be a challenge, but the NRC should work with stakeholders to try to strike the right balance
  - The standard design approval will be more usable when there are guidelines available to describe what a "major portion" of the design might include.

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NIA Feedback on NRC Non-LWR Near-Term IAPs

- NIA strongly supports each of the 6 strategies
- NIA recommends completing within the first two years:
  - Strategy 3: "Develop guidance for a flexible non-LWR regulatory review process within the bounds of existing regulations, including the use of conceptual design reviews and staged review processes."
- NIA recommends commencing work immediately on:
  - Strategy 5: "Identify and resolve technology-inclusive policy issues that impact the regulatory reviews, siting, permitting, and/or licensing of non-LWR nuclear power plants."
    - As the IAP report notes on page 15, "The identification and resolution of policy issues within the purview of the NRC contribute directly to regulatory certainty, effectiveness, and efficiency." Thus it is critical to begin immediately.
- NIA recommends expanding Strategy 2, "Acquire/develop sufficient computer codes and tools to perform non-LWR regulatory reviews."
  - More effective use of modeling and simulation could accelerate the fuel qualification process, and make it more efficient and conducive to innovation. This may require the development of new approaches to using modeling and simulation at the NRC, not just the development of codes and tools.

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NIA Feedback on NRC Regulatory Review Roadmap for Non-LWRs

- Citation of IAEA standards is confusing – it would be preferable to reference applicable NRC standards.
- Overall the roadmap is useful, but could be more useful if:
  - The conceptual design assessment was further defined
  - The potential use of the SDA was discussed with some examples of what constitutes a “major portion” of the design.

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NIA Feedback Summary

- NIA applauds the efforts of the NRC staff in developing the vision and strategy and supporting documents.
- NIA supports the strategies laid out by the NRC.
- NIA offers some suggestions for improvement. Highlights:
  - Mission readiness timelines should consider private sector as well as DOE visions.
  - Staged licensing should be a very near-term priority.
  - Addressing technology-inclusive policy issues should begin as soon as possible.
- More effective use of modeling and simulation for fuel qualification could enable accelerated innovation. This will require coordinated action among the industry, DOE, SDOs, and the NRC.

NUCLEAR INNOVATION ALLIANCE

Thank you

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NUCLEAR INNOVATION ALLIANCE

NIA Mission

The NIA leads advanced nuclear energy innovation.

NUCLEAR INNOVATION ALLIANCE

NIA Modes of operation

- ***We assemble companies, investors, experts, and stakeholders to advance nuclear energy innovation and enable innovative reactor commercialization through favorable energy policy and funding.***

- ***We research, develop, and advocate policies that enable the efficient licensing and timely early-stage demonstration of advanced reactor technologies.***

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NIA Strategic Priorities

- Top priorities:
  - A staged and more technology-inclusive licensing process
  - A test bed & demonstration platform where nuclear innovators in the private sector can demonstrate advanced technologies
- Next tier priorities:
  - Cooperation to provide for international commercial testing, demonstration, and deployment of advanced technologies.
  - Financial support for early stage technology development and early commercial deployment.

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NEI Advanced Reactor Regulatory Task Force Activities

Advanced Reactor Regulatory Task Force

October 25, 2016 • NRC

ARRTF Focus Areas

- Staged Application Review & Approval
- Technology-Inclusive Risk-Informed Performance-Based Regulatory Structure
- Policy
- Demonstration Reactor

Staged Application Review & Approval

- Regulatory Engagement Planning Guidance
  - Develop a user's guide for any prospective reactor designer/licensee to plan for NRC engagement
  - Provide examples of successful "how-to" as a complement to NRC's Regulatory Review Roadmap "what-to"
- White Paper/Technical Report Guidance
  - Expectations for categorizing submittals
  - Forms of NRC feedback

Modernization of Technical Requirements for Licensing of Non-Light Water Reactors

Amir Afzali

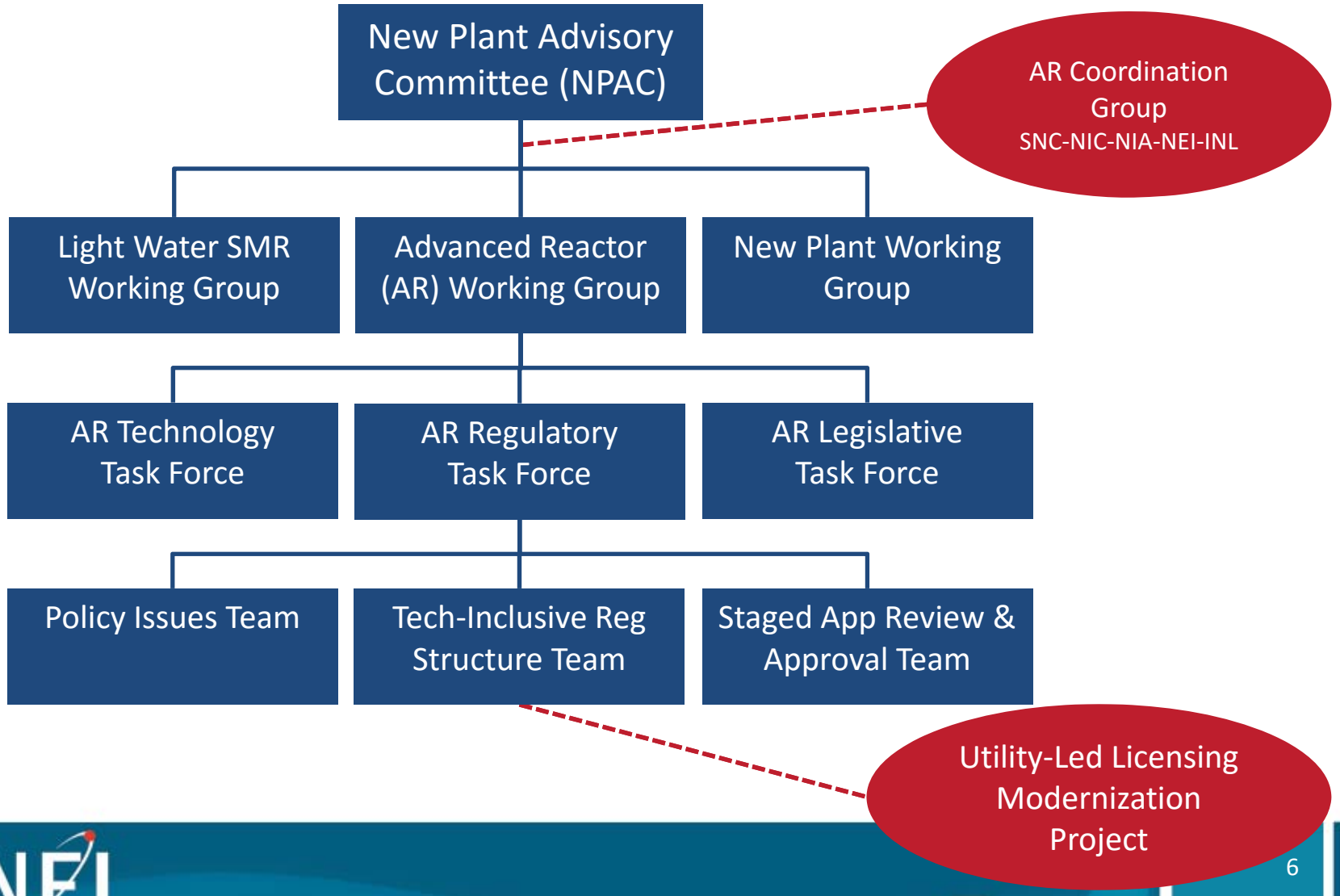
Licensing and Policy Director - Next Generation Reactors,
Southern Nuclear and NEI ARRTF Co-Chair

Southern Nuclear

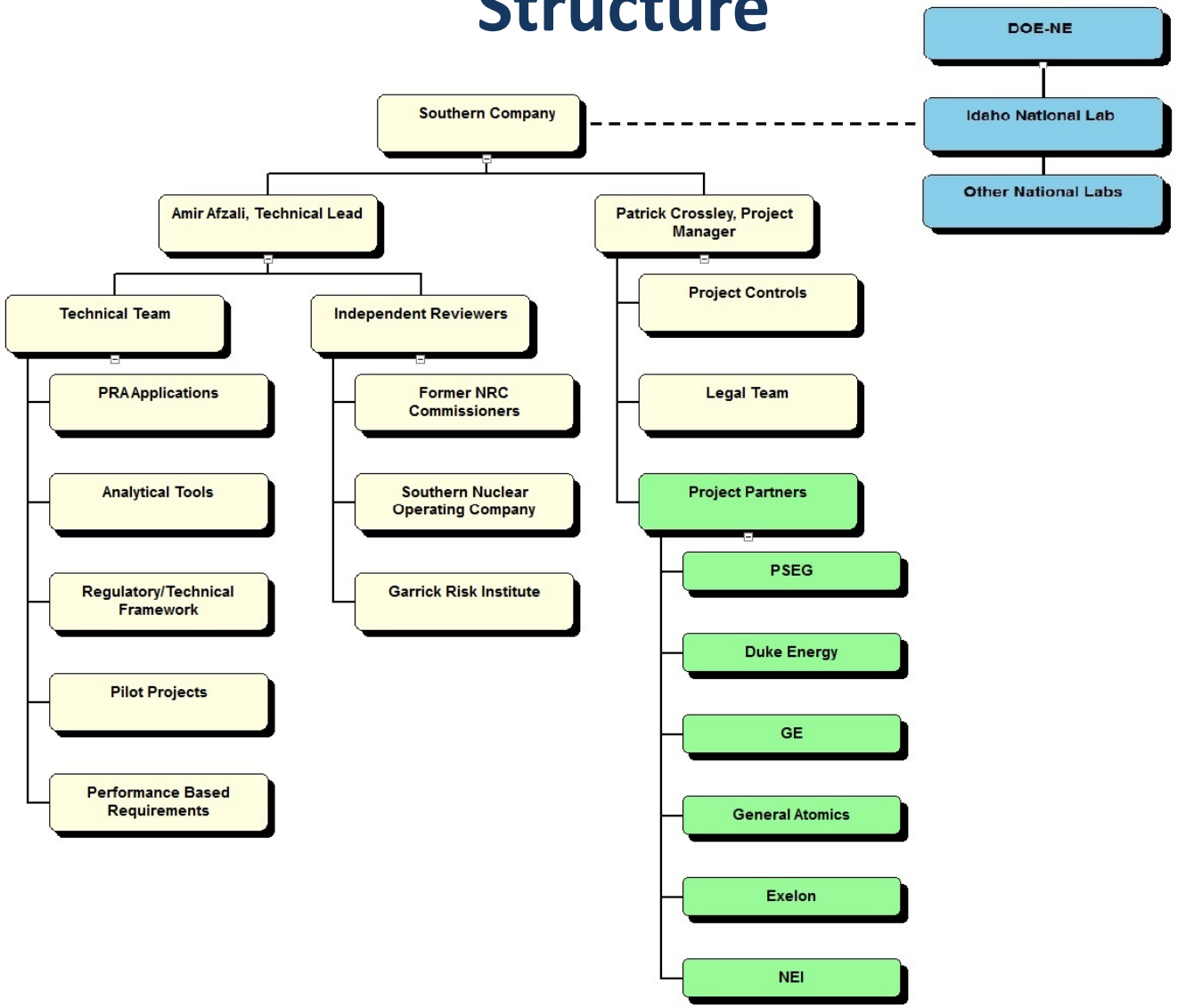
Introduction

- Modernization of current requirements is necessary
  - Current framework primarily LWR-based
  - Inherent/passive safety → significantly different characteristics
  - Risk-informed and performance-based (RIPB) → realization of enhancements in safety
- Process attributes
  - Technology-inclusive (TI)
  - RIPB
  - Collaborative development
  - Build on substantial precedent and recent NRC *Vision and Strategy*

Industry Interfaces



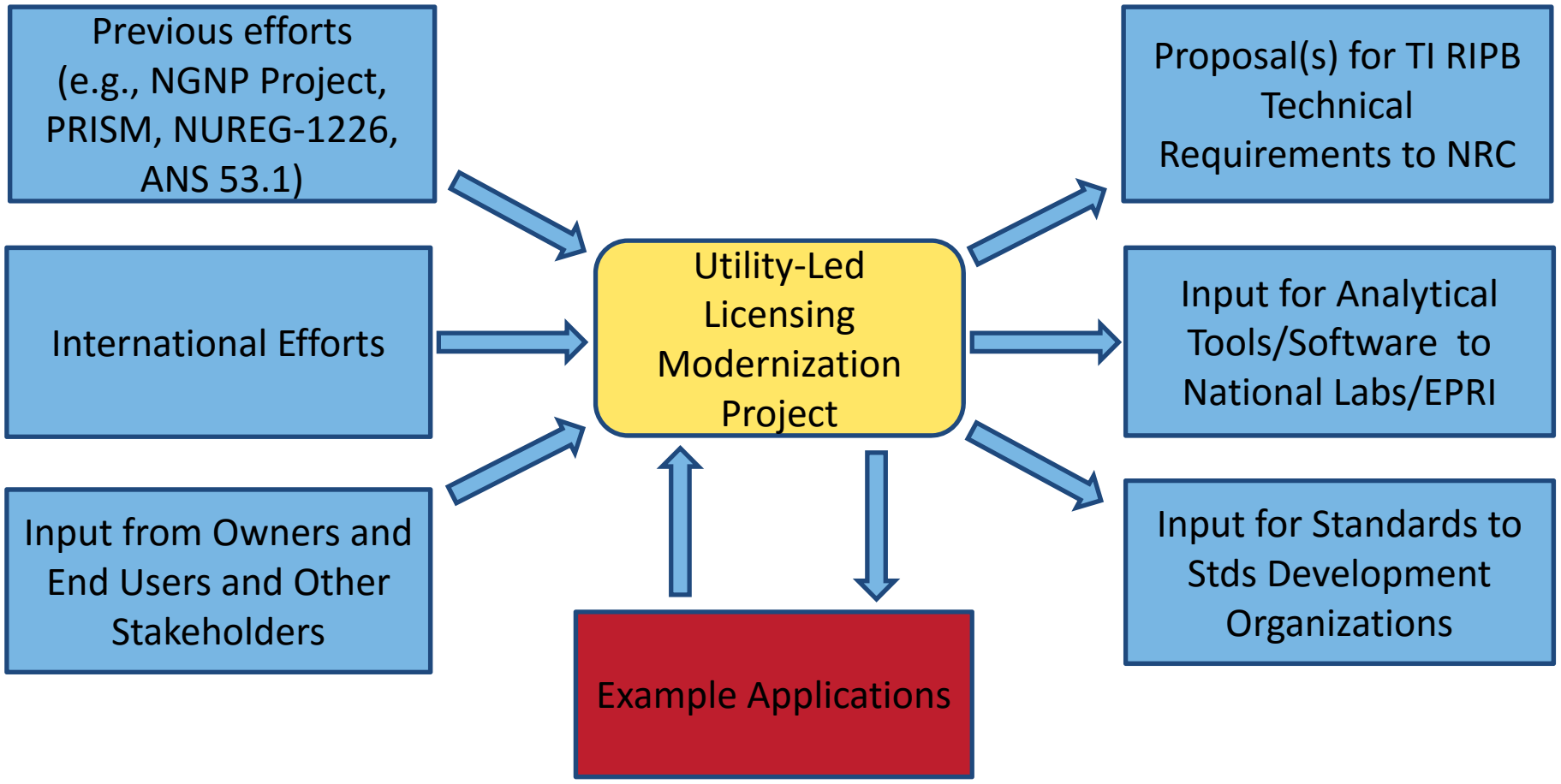
Utility-Led Licensing Modernization Project Structure



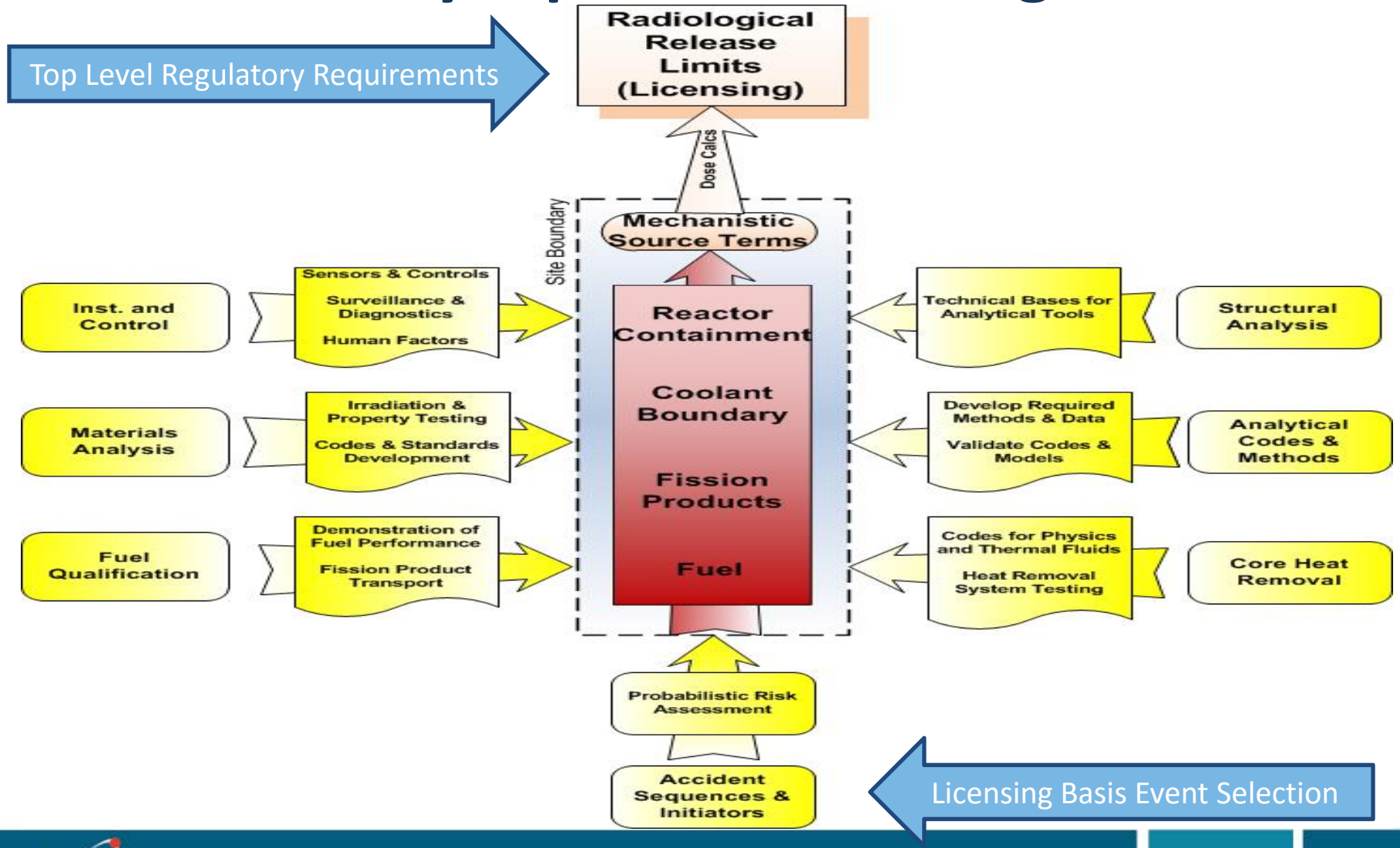
Project Objectives

- Technology-inclusive, risk-informed, performance-based
- Propose/clarify topics with potential significant impact on:
  - Research and development
  - Design
  - Defining/addressing licensing requirements
  - Defining/clarifying need for Commission action
- Continue prior progress from NGNP development with more substantial regulator feedback
- Alignment with NRC readiness as outlined in NRC's *Advanced Reactor Vision and Strategy* draft document
- Support communication of path forward to internal and external stakeholders

Project Inputs and Products



Key Input for Licensing



Draft NRC's IAP for Improving Its Regulatory Readiness for Non-LWR Designs

- Contributing Activities
  1. Establish the criteria necessary to reach a safety, security, or environmental finding for non-LWR technologies
  2. Determine appropriate licensing bases and accident sets for non-LWR technologies
  3. Identify and resolve gaps in current regulatory framework

Alignment of Products with RIPB Approach

- What must be met
  - Top Level Regulatory Criteria (TLRC)
- When TLRC must be met
  - Risk-informed Licensing Basis Events (LBEs) selection
    - LBE Process White Paper projected completion 2Q CY2017
    - PRA Technical Adequacy for LBE and Road Map projected completion 3Q CY2017
- How TLRC must be met
  - Process for Safety Functions Determination and SSC Classification - Design specific based on design features; to be addressed by advanced reactor designers
    - PRA Technical Adequacy for RIPB Decision Making projected completion 4Q CY2017
  - Safety Design Criteria (General and Regulatory Technical Requirements)-
    - Expanded TI Gap Analysis of SDC projected completion 4Q CY2016
    - Performance Based White Paper projected completion 2Q CY2017
- How well TLRC must be met
  - Quantitative SSC Design Criteria- Not within the scope of this project.
  - Regulatory Special Treatment – Not within the scope of this project.
  - Risk-Informed Decision Making (systematically addressing “adequate safety”)
    - RI-DM White Paper projected completion 1Q CY2018

Top Level Regulatory Criteria for the Public

- 10CFR20 annualized offsite dose guidelines
  - 100 mrem/yr total effective dose equivalent
  - Measured on a cumulative basis annually at the EAB of the site
  - For normal operation and anticipated operational occurrences
- 10CFR50.34 (10CFR52.79) accident offsite doses
  - 25 rem total effective dose equivalent
  - Evaluated at the site EAB at 2 hr and at the site LPZ at 30 day
  - Design basis for off-normal events
- EPA-400-R-92-001 Protective Action Guides (PAGs) offsite doses
  - 1 rem total effective dose equivalent for sheltering (as design objective)
  - Evaluated at the proposed site EPZs based on design and site characteristics
  - Emergency planning and protection during off-normal events
- 51 Federal Register (FR) 130 individual fatality risks
  - Prompt and latent Quantitative Health Objectives (QHOs) of $5x10^{-7}$/yr and $2x10^{-6}$/yr Evaluated at 1 mile for prompt and 10 miles for latent
  - Overall assurance of negligible cumulative risks during normal operation and off-normal events

Top Level Regulatory Criteria or Objective

- Generic, technology-inclusive and independent of plant site
- Quantitative
- Direct statements of acceptable consequences or risk to the public

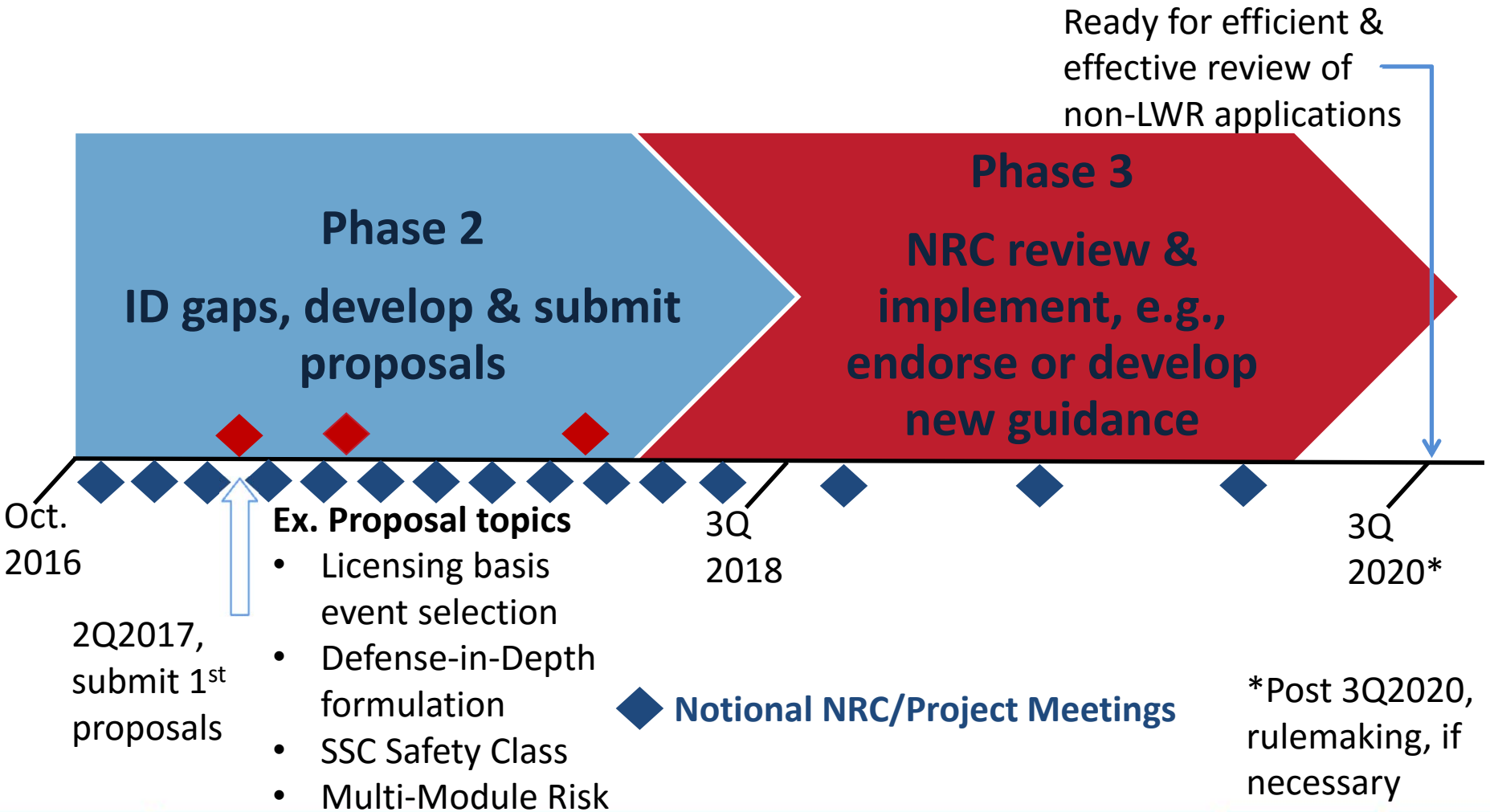
Risk-Informed and Performance-Based Licensing Basis Event Selection

- Why address first-
  - It is integral to the design process at all stages of development and central to NRC safety assessment process
  - It forms the underlying foundation for the safety assessment & license application
  - The current process for setting licensing basis events is design specific, ad hoc, and retrospective

Risk-Informed and Performance-Based Licensing Basis Event Selection

- How the work will be performed-
  - Starting point is the 30-year-old process developed for mHTGR extended to the most recent NGNP work and will be made technology inclusive
  - NRC RAIs on the NGNP proposed process will be reviewed and utilized in further defining a TI-RIPB framework
  - The proposed process will be sample piloted with at least two designs
- What would be the final product - A documented recommendation of a process that can be reviewed by the staff and used by the industry for LBE selection.

Utility-Led Licensing Initiative Timeline



Expected NRC Interactions

- Proposal Development Phase
  - Industry team and NRC work to align needs and priorities consistent with supporting advanced reactor development and licensing timelines
  - Industry team proposes processes and technical bases to NRC for modernized technical regulatory structure
    - Regular interactions with the project team prior to submitting proposals
- NRC Review Phase
  - NRC review of submittals
  - Industry team response to RAIs and closure on proposed processes
- NRC Guidance Phase
  - NRC develops/issues regulatory guidance as appropriate (e.g., ISG, SRP/DSRS, RG)
- Possible follow-up rulemaking as appropriate

Other NEI Advanced Reactor TF Activities

- Fuel enrichments above 5%
- Research and Test Reactor (RTR) licensing of non-power demonstration facilities
- Industry involvement in standards development

Fuel Enrichments Above 5%

- Upcoming meeting to identify front end of the fuel cycle issues and challenges to support the use of uranium with enrichments above 5%
  - Needs of the industry
  - Commercial enrichment and fabrication infrastructure
  - Transportation infrastructure
  - Regulatory framework and guidance

Licensing Non-power Demonstration Facilities

- Seek understanding of basis for *testing facility* definition in 10 CFR 50.2
  - Test reactor distinction from research reactor at power >1 MWt based on liquid fuel
- Language gaps between current NRC guidance for non-power reactor licensing and liquid fueled technologies
  - Possible need for Interim Staff Guidance (ISG) augmenting NUREG-1537 similar to that for licensing radioisotope production facilities and aqueous homogeneous reactors

Industry Involvement in Standards Development

- Plan to promote industry involvement in standards development organizations (SDOs)
- Interest in NRC's plans for interaction with SDOs

Questions