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

Advanced Reactor Stakeholder Public Meeting

January 24th, 2024

Microsoft Teams Meeting
Bridgeline: 301-576-2978
Conference ID: 908 447 446#

Time	Agenda Topic	Presenter(s)
10:00 - 10:15 am	Opening Remarks and Advanced Reactor Program Highlights	NRC
10:15 - 10:30 am	Adv. Rx Integrated Schedule Demonstration	NRC
10:30 - 10:35 am	Upcoming NRC Workshop on Human Factors Considerations for Remote Operation of Nuclear Facilities	NRC
10:35 - 11:05 am	Gateway for Accelerated Innovation in Nuclear (GAIN)	DOE/INL
11:05 - 11:35 am	Advanced Reactor Demonstration Program (ARDP) Advanced Reactor Safeguards and Security program	DOE/SNL
11:35- 11:40 am	Closing Remarks	NRC
11:40 am	Adjourn	

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Opening Remarks and Advanced Reactor Program Highlights

Steve Lynch, Branch Chief, Advanced Reactor Policy Branch
Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission

Advanced Reactor Program

Advanced Reactor Program Highlights

Regulatory Framework Advancement

- RG 1.242, Revision 0, "Performance-Based Emergency Preparedness for Small Modular Reactors, Non-Light-Water Reactors, and Non-Power Production or Utilization Facilities" (ML23226A036) (November 13, 2023)
  - Guidance that supports the new emergency preparedness for SMRs and other new technologies rule

- "Emergency Preparedness for Small Modular Reactor and Other New Technologies" (ML23226A019)(November 16, 2023)
  - The final rule and associated guidance amended the regulations in 10 CFR Part 50, "Domestic Licensing of Production and Utilization Facilities," to include a risk-informed approach to emergency preparedness for SMRs and other new technologies

Advanced Reactor Program Highlights

Regulatory Framework Advancement Cont.

- Draft white paper "Guidelines for Risk Assessment and Severe Accident Information in a Light-Water Reactor Construction Permit Application" (ML23326A185) (November 29, 2023)
  - Provides guidance on the content of general and technical information for a preliminary safety analysis report (PSAR) to support the staff's review of probabilistic risk assessment (PRA) and non-PRA evaluations used in support of a construction permit application

Advanced Reactor Program Highlights

Licensing (Ongoing, Preapplication, and Future)

- In 2023, the staff completed reviews of:
  - 11 topical reports
  - 2 licensing actions
  - 29 white papers

- In the first calendar quarter of 2024, the staff will continue its reviews of:
  - 28 topical reports
  - 5 licensing actions
  - 12 white papers

Advanced Reactor Program Highlights

Licensing (Ongoing, Preapplication, and Future) Cont.
Non-Light-Water Reactors

- Kairos Hermes 1
  - On December 12, 2023, the Commission issued Commission Memorandum and Order CLI-23-05 (ML23346A068)
    - Authorized issuance of the Hermes 1 test reactor construction permit and the associated record of decision.
  - On December 14, 2023, the staff issued Kairos Power LLC Hermes Test Reactor Construction Permit No. CPTR-6 (ML23338A258) and the associated record of decision (ML23338A257).

Advanced Reactor Program Highlights

Licensing (Ongoing, Preapplication, and Future) Cont.

- Abilene Christian University Research Reactor
  - On December 21, 2023, the staff issued "Abilene Christian University – Transmittal of Requests for Additional Information" (ML23348A196)
    - Requested information pertaining to the application of American Society of Mechanical Engineers Boiler and Pressure Vessel Code, Section VIII, and surveillance procedures for materials degradation mechanisms.
    - Additionally, the staff communicated the intent to issue a revised schedule and level of effort estimate for the remainder of the review once responses are provided.

Advanced Reactor Program Highlights

Licensing (Ongoing, Preapplication, and Future) Cont.

- TerraPower, LLC
  - "TerraPower, LLC—U.S. Nuclear Regulatory Commission Staff Feedback Regarding White Paper: 'Preliminary Consensus Codes and Standards,' Revision 0 (EPID No. L-2023-LRO-0045)" (ML23319A338)(November 15, 2023)
    - Provided feedback to on the use of codes and standards that TerraPower intends to use for the Natrium reactor design.

  - "TerraPower, LLC—U.S. Nuclear Regulatory Commission Staff Feedback Regarding White Paper: 'Natrium Human Factors Engineering Concept of Operations,' Revision 0," letter and enclosure (ML23321A086, and ML23321A087 respectively) (November 17, 2023)
    - Provided feedback on the ways users interact with the human system interfaces and with one another to monitor, control, and maintain the Natrium plant.

Advanced Reactor Program Highlights

External Coordination and Communication

- In calendar year 2023, the staff held over **140 public meetings** on advanced reactor topics such as pre-application and licensing documents, staff-developed guidance, and industry-led guidance initiatives.

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Advanced Reactor Integrated Schedule Demonstration

Ossy Font, Project Manager
Advanced Reactor Policy Branch
Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission

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NRC Workshop on Human Factors Considerations for Remote Operation of Nuclear Facilities

January 31 & February 1, 2024

HYBRID MEETING

U.S. NRC HQ Auditorium & Microsoft Teams

Rockville, MD

Workshop Goals

1) Understand concepts of operations the nuclear industry is considering that may include elements of remote operation, and

2) Gain insights regarding how well-suited NRC's current guidance is for the human factors review of these concepts.

DRAFT AGENDA DAY 1

JAN 31, 2024
9:00 AM – 4:30 PM

TIME	TOPIC	SPEAKERS
9:00 AM – 10:00 AM	Workshop Opening and Introductions	• Niav Hughes Green & Stephanie Morrow, Workshop Coordinators, NRC • Scott Morris, Deputy Executive Director for Operations, NRC
10:00 AM – 10:15 AM	**BREAK**	
10:15 AM – 11:30 AM	Overview of NRC Ongoing Regulatory Development Areas	• David Desaulniers, NRC • Niav Hughes Green, NRC • Tom Ulrich, INL • Theresa Buchanan, NRC
11:30 AM – 1:00 PM	**LUNCH (On Own)**	
1:00 PM – 2:30 PM	Session 1: Industry Presentations on Remote Operation Concepts & Discussion*	• Nuria Bernal Cortes, Westinghouse eVinci • Chanson Yang, Radiant Nuclear • Christopher Poresky, Kairos
2:30 PM – 2:45 PM	**BREAK**	
2:45 PM – 4:15 PM	Session 2: Industry Presentations on Remote Operations Concepts & Discussion*	• Adam Smith, GE Vernova • DJ Hanson, Flibe Energy • Annie Paskavitch, NextEra
4:15 PM – 4:30 PM	Public Comments (Open to All)	• NRC/Public
4:30 PM	**Day 1 Adjourn**	

**Includes open discussion for questions from in-person and virtual participants.*

DRAFT AGENDA DAY 2

FEB 1, 2024
9:00 AM – 4:15 PM

TIME	TOPIC	SPEAKERS
9:00 AM – 9:15 AM	Day 2 Opening	• Niav Hughes Green & Stephanie Morrow, Workshop Coordinators, NRC
9:15 AM – 10:15 AM	Stakeholder Presentations & Discussion*	• Rick Paese, Sargent and Lundy • Cristina Corrales, EPRI • Daniel Odéen & Alexandra Fernandes, Halden Human Technology Organization (HTO)
10:15 AM – 10:30 AM	**BREAK**	
10:30AM – 11:00 AM	Human Factors Elements of a Licensing Application & Discussion*	• Brian Green, NRC
11:00 AM – 11:30 AM	Scalable Human Factors Engineering Reviews and Use of Human Factors Engineering Guidance & Discussion*	• David Desaulniers, NRC
11:30 AM – 1:00 PM	**LUNCH (On Own)**	
1:00 PM – 1:30 PM	Summary of Range of Concepts of Operations Discussed on Day 1	• Casey Kovesdi, INL
1:30 PM – 2:45 PM	Breakout Discussions of Concepts of Operations for Remote Operation**	• All In-Person Participants
2:45 PM – 3:00 PM	**BREAK**	
3:00 PM – 3:45 PM	Summary of Breakout Discussions & Key Takeaways	• NRC/INL
3:45 PM – 4:00 PM	Public Comments (Open to All)	• NRC/Public
4:00 PM – 4:15 PM	Day 2 Closing – End of Workshop and Next Steps	• Niav Hughes Green & Stephanie Morrow, Workshop Coordinators, NRC

**Includes open discussion for questions from in-person and virtual participants.*

***Breakout discussion activity from 1:30-2:45pm for in-person participants. Virtual participants will break until 3:00pm.*

Participating Organizations *(as of 1/16/24)*

- U.S. NRC
- Idaho National Laboratory (INL)
- Flibe Energy, Inc.
- General Electric Vernova
- Radiant Nuclear
- TerraPower
- Westinghouse
- X-energy
- Kairos
- Boston Atomics
- Nuscale Power, LLC
- NextEra (Florida Power and Light)
- Electric Power Research Institute (EPRI)
- Nuclear Energy Institute (NEI)
- Halden Human Technology Organization (HTO)
- Brookhaven National Laboratory (BNL)
- Sargent and Lundy

More Information

- Public meeting notice: https://www.nrc.gov/pmns/mtg?do=details&Code=20240019
- Virtual participation available via Microsoft Teams
- In-person participants must pre-register by emailing Niav Hughes Green (Niav.hughes@nrc.gov) with the following information:
  - Full Name
  - Affiliation (Company/Organization)
  - Contact phone number
  - Citizenship

GAIN Today

January 24, 2024
NRC Advanced Reactor Public Meeting

Christine King, GAIN Director

GAIN
Gateway for Accelerated Innovation in Nuclear

INL/MIS-18-50189

GAIN 2.0

GAIN is a nimble instrument of NE to find novel ways to ensure the assets of the DOE and national labs are used and useful in the pursuit of new nuclear tech

- Vouchers, legacy data, state engagement, commercialization research

As nuclear designs approach commercial markets, GAIN's audience has expanded to include the regions, states, and communities where these technologies will be considered and possible built.

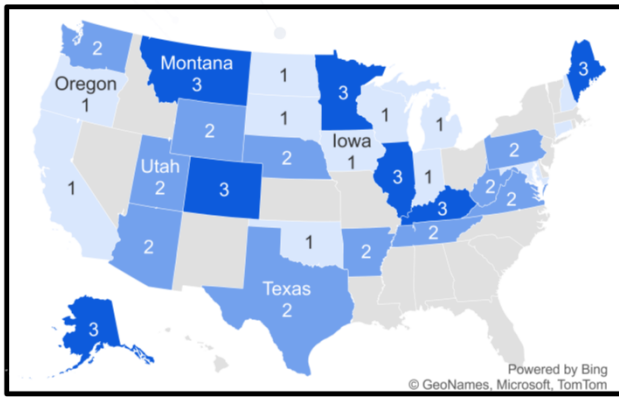
Mission is the same – the audience is expanding

…implementing small changes can have a significant impact... – little hinges swing on big doors.

SJ Scott

2024 Activities

GAIN Gateway for Accelerated Innovation in Nuclear



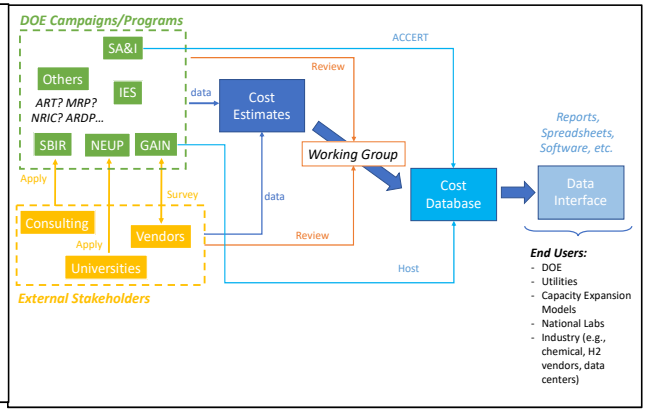
2023 State Level Outreach

- Policymakers, NGOs, Utilities, Regulators, Industrials, Commissioners
- Introduce Advanced Nuclear through direct conversation or testimony
- Help connect states to financial or technical resources across DOE complex
- Looking at state level regs

Advanced Reactor Cost

Project will update latest costs combining two approaches

- Use existing public nuclear cost data to develop advanced reactor cost ranges.
- Work with developers and utilities under NDA to collect cost projections to develop an anonymous advanced reactor cost ranges.



Industry Support

Chris Lohse, GAIN Innovation and Technology Manager
Holly Powell, GAIN Operations Manager
Jon Grams, GAIN Project Researcher

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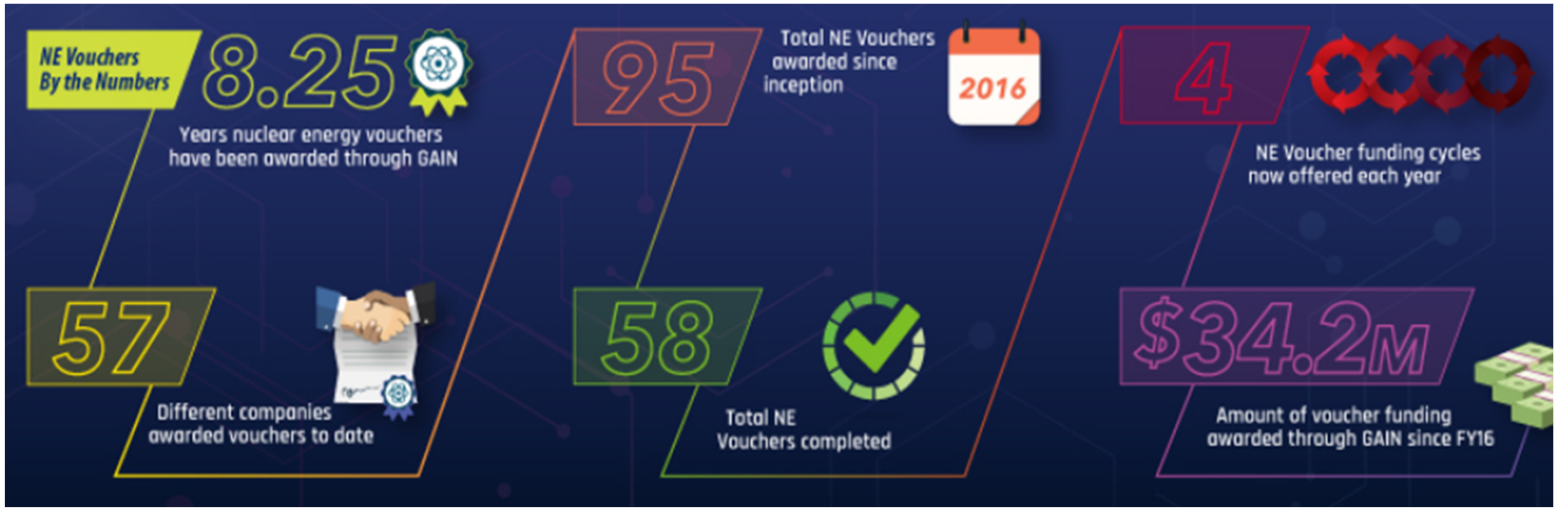
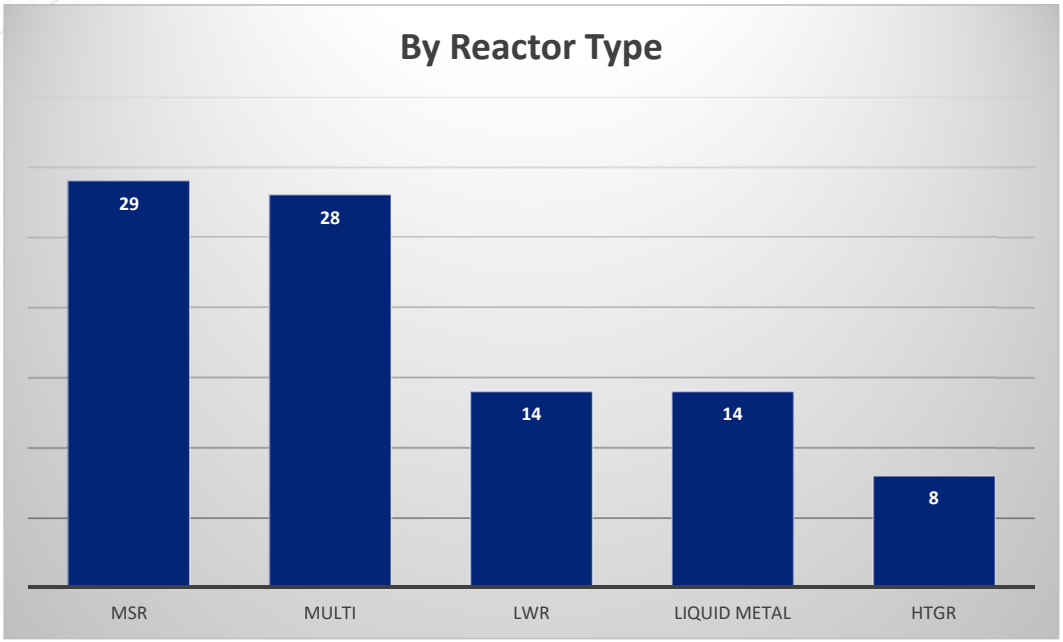
DOE-NE Vouchers

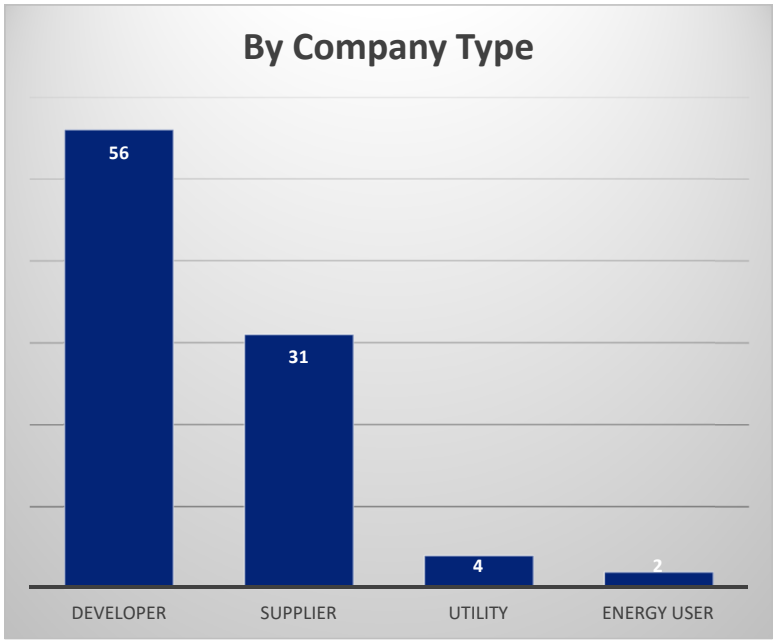
- Vouchers competitively award access to facilities and staff in the DOE national laboratory complex – NOT a financial award (Voucher value is ~$50K to $500K)
- Voucher recipient is responsible for 20% cost share
- Available to businesses that are majority (>51%) U.S. owned
- One-year Period of Performance
- Limit to one application per cycle
- Four cycles per year
- Standard CRADA



Voucher Award Statistics

GAIN Gateway for Accelerated Innovation in Nuclear

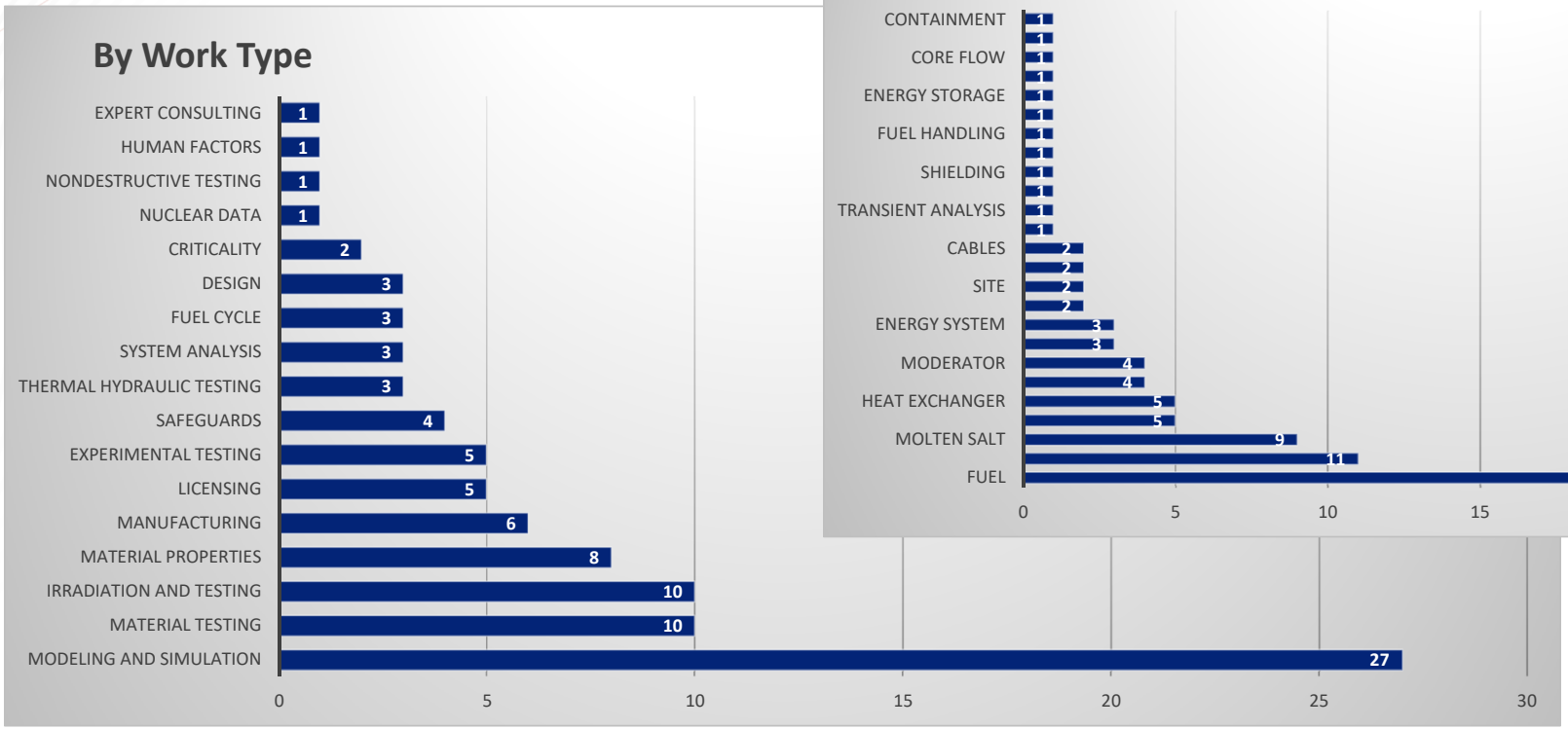




Both light and non-light water reactors seeking support;

Diversity increasing from developers to end users and supply chain

Voucher Award Statistics



Continue to see a focus on mod/sim, materials, and fuel.

GAIN Gateway for Accelerated Innovation in Nuclear

Rediscovering the past, to power the future

The Who

DOE-NE, OSTI, GAIN, the DOE laboratory complex, and industry partners

The What

A process to release export-controlled documents to industry partners

The Where

The process will happen at many locations simultaneously.

The When

Three test cases were completed over the summer 2022, full process roll-out slated for early 2023.

The Why

In the past, there has not been a way for a U.S. company to easily request and obtain access to export-controlled information.

National Lab and Regional Visits

- Curate a lab visit that highlights the capabilities directly related to advanced nuclear development
- Industry partners tour the lab and get time to meet the researchers and explore potential areas of collaboration
- GAIN visits local companies involved in the development of nuclear technology to understand their perspective and needs.
- Use our social media platforms to share the highlights of the visit

Advanced Reactor Cost

Chris Lohse, GAIN Innovation and Technology Manager

GAIN
Gateway for Accelerated Innovation in Nuclear

INL/MIS-18-50189

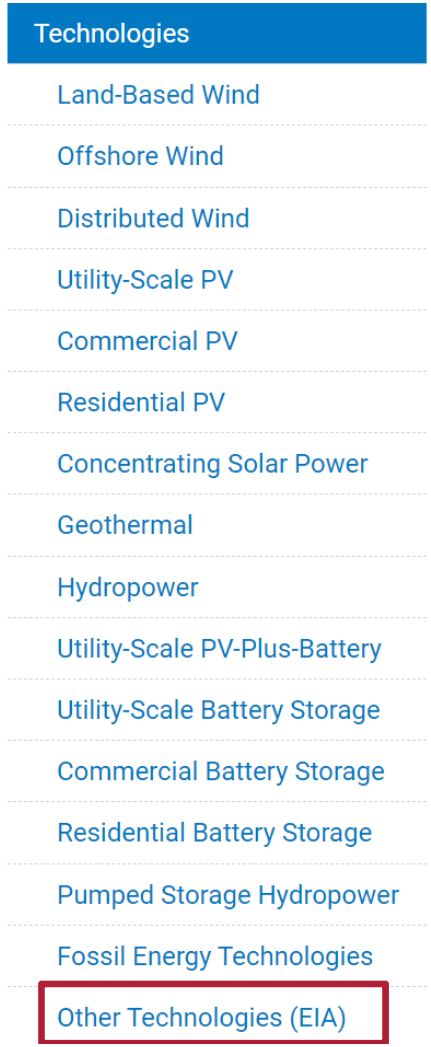
Advanced Reactor Costs

- Advanced nuclear costs are not well defined and are needed to support energy planning
- NREL ATB includes 2 options – AP1000 or 600 MWe SMR
  - Users left to search for other costs
- GAIN is using existing public nuclear cost data to develop advanced reactor cost ranges and other information to support energy planners (utilities, researchers, others)
- Report published ~March and work to include data in NREL ATB 2024 update – Published summer 2024.

What is NREL ATB

- https://atb.nrel.gov/
- The NREL Annual Technology Baseline (ATB) provides a consistent set of technology cost and performance data for energy analysis
- Used by: Utilities, Energy planners, Researchers, NGOs, Policy makers, etc.
- It's open source cost/performance data and is usually the first/only place people look for this data

GAIN Gateway for Accelerated Innovation in Nuclear



Nuclear data >

GAIN Supply Chain Assessment

Chris Lohse, GAIN Innovation and Technology Manager

GAIN
Gateway for Accelerated Innovation in Nuclear

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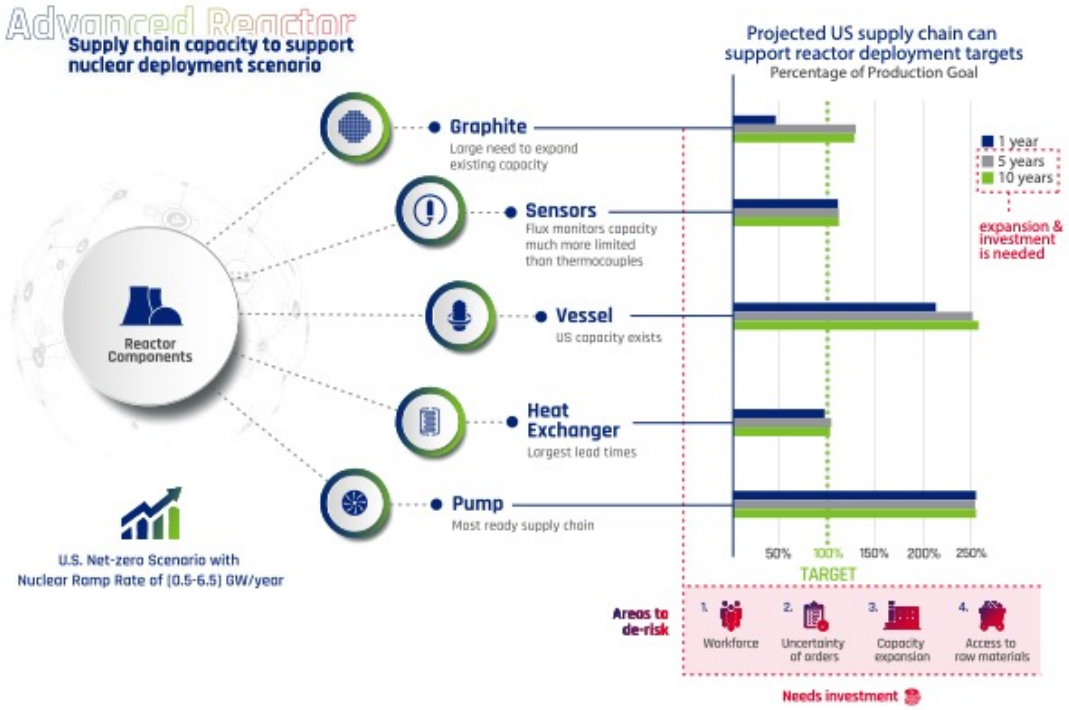
Overview of Supply Chain Assessment

- Builds on the prior DOE supply chain work.
- Assessed the capacity of certain critical nuclear components
- Mapped aggressive projections for nuclear deployments rates to component production targets
- Surveyed 20+ companies on abilities to meet production targets
- Initial findings:
  - We have an initial US capacity
  - Supply chain can ramp up with caveats…

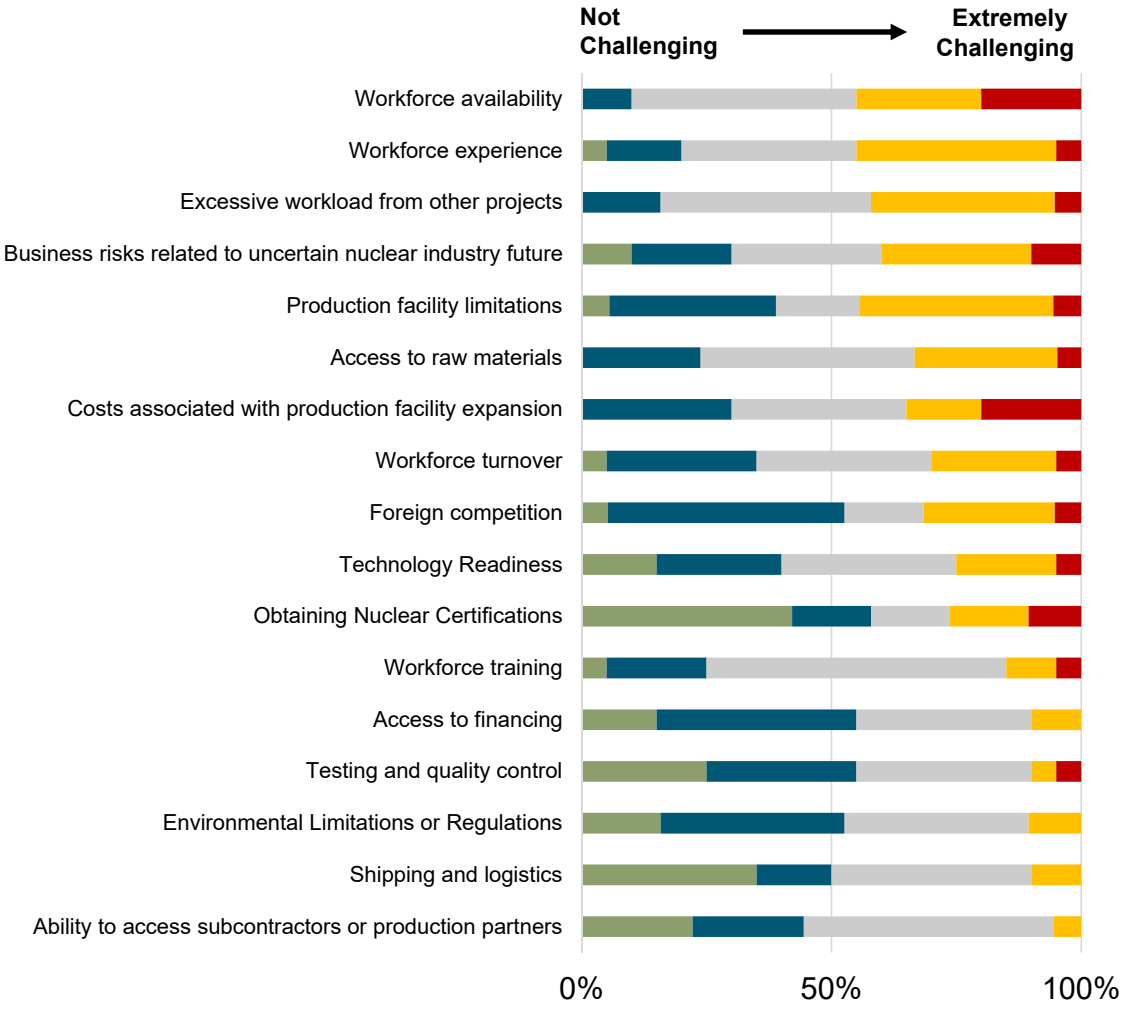


https://www.osti.gov/biblio/1973747

Some Concerns Noted

- Largest concerns are related to ***workforce*** issues:
  - Availability
  - Experience
  - Turnover
- Additional concerns include:
  - Uncertainty of demand
  - Other non-nuclear commitments
  - Production facility limits
  - Access to raw material
  - Cost of expansions/upgrades

1. Workforce
2. Uncertainty of orders
3. Capacity expansion
4. Access to raw materials



GAIN State Engagement

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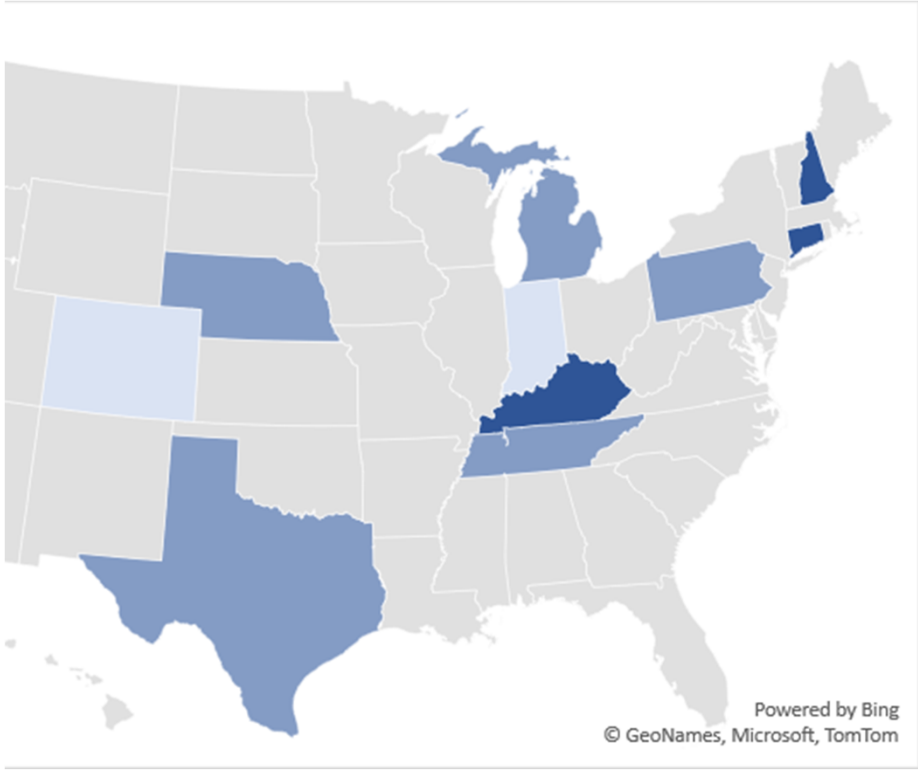
Advanced Nuclear Feasibility Studies

Completed Studies:

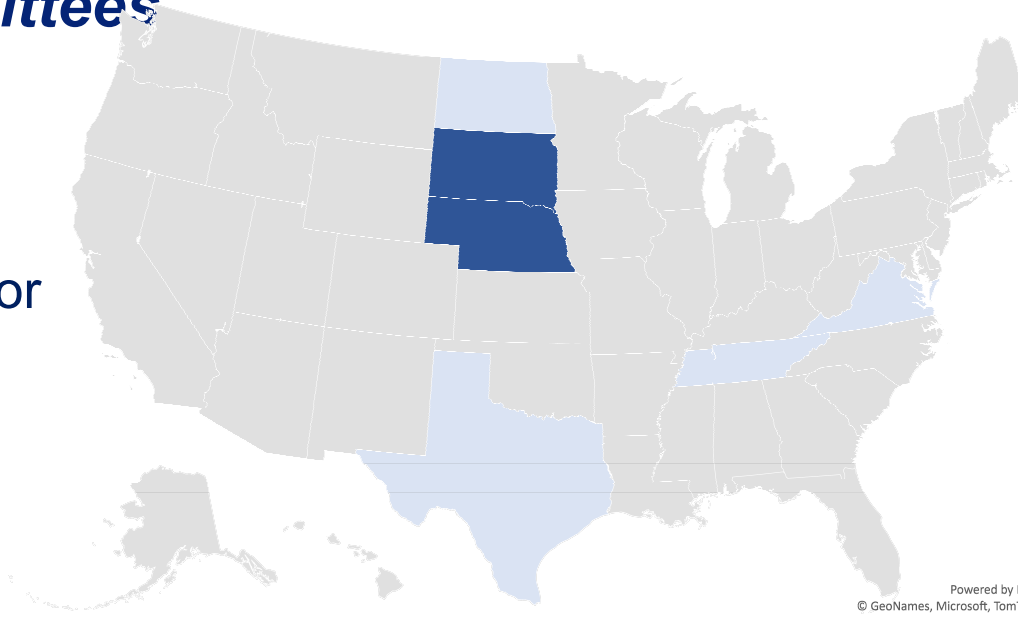
- Connecticut (H2 focus)
- New Hampshire
- Kentucky

Ongoing Studies:

- Pennsylvania (Jan 24)
- Michigan (Feb 24)
- Nebraska (Spring 24)
- Tennessee (Nov 24)
- Texas (Dec 24)
- Colorado (Summer 25)
- Indiana (expect to kick off in 2024)



State Level Working Group/Committees



Ongoing

- North Dakota
- Tennessee – mandated by Governor
- Texas – mandated by Governor
- Virginia – mandated by Governor

Completed

South Dakota

- did not establish coalition or working group

Nebraska

- drafting legislation to mandate the replacement of a decommissioning coal or natural gas plant with only other baseload technologies (very similar to Wyoming HB200).

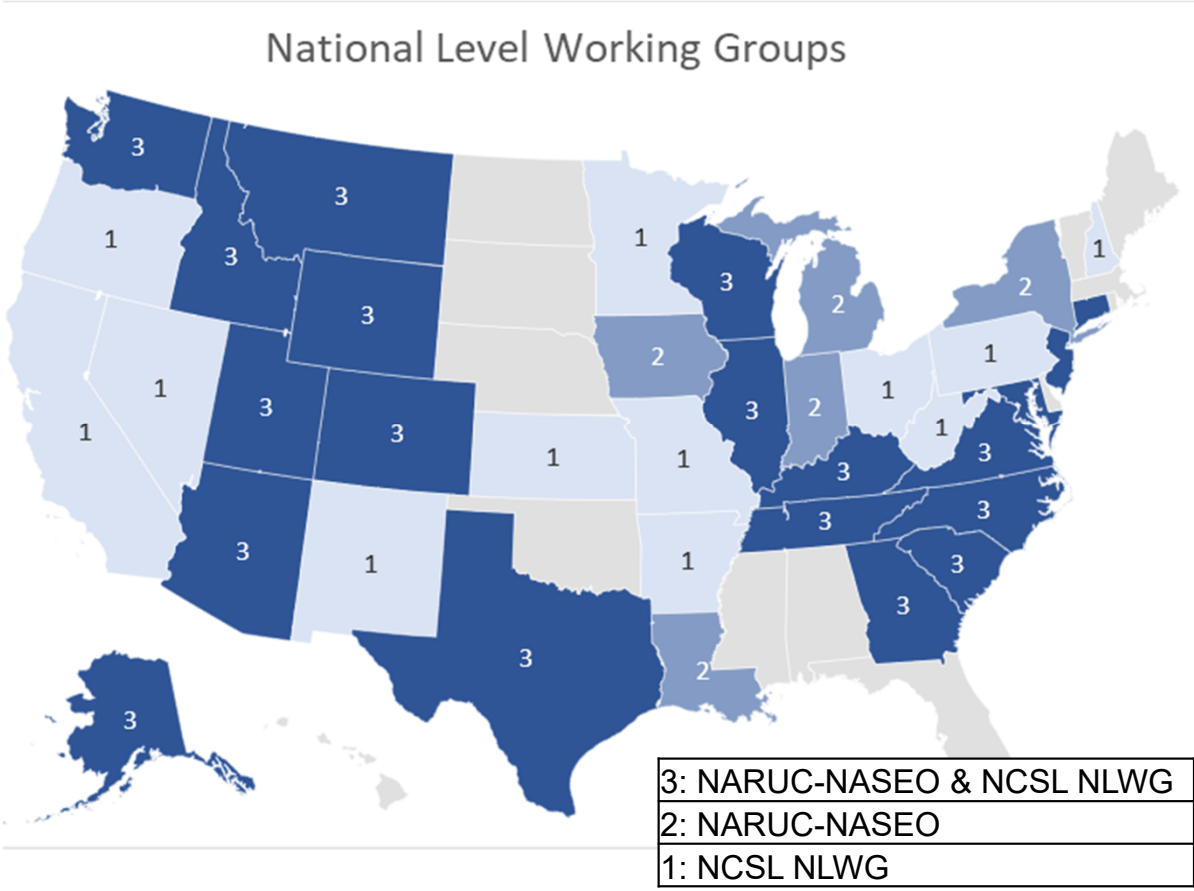
National Level Working Groups Peer to Peer Forums

NARUC-NASEO Advanced Nuclear State Collaborative

enhance collective understanding of the unique regulatory and policy questions surrounding the consideration and deployment of new nuclear generation

NCSL NLWG

The Working Group helps guide NCSL policies that serve as the basis for NCSL's advocacy before the federal government on behalf of state legislatures



GAIN Coal Transition Research

Emily Nichols, GAIN Project Coordinator

GAIN
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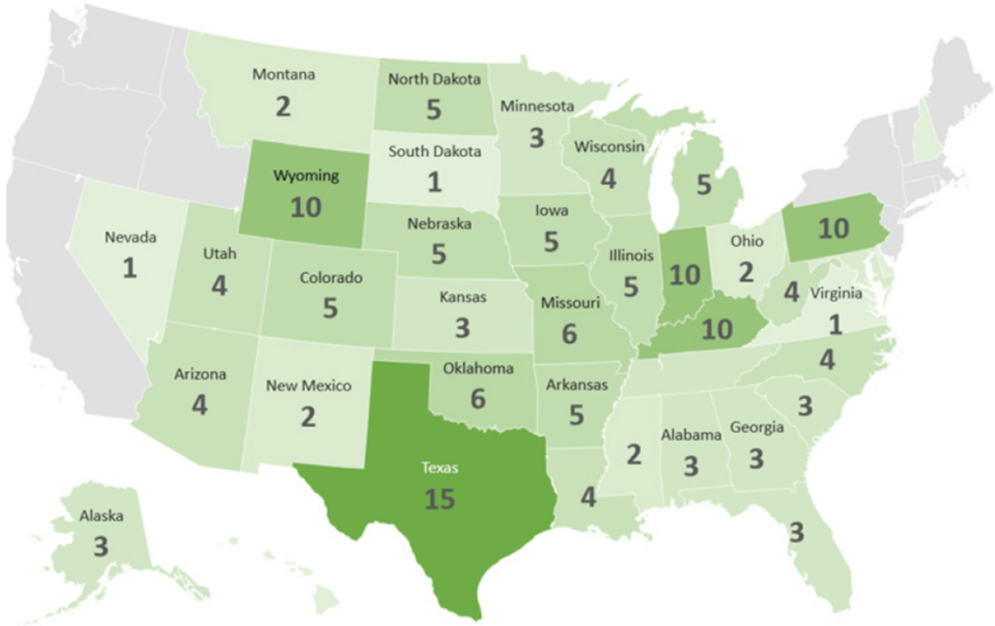
COAL TO NUCLEAR
ENERGY COMMUNITY TRANSITIONS

GAIN Gateway for Accelerated Innovation in Nuclear

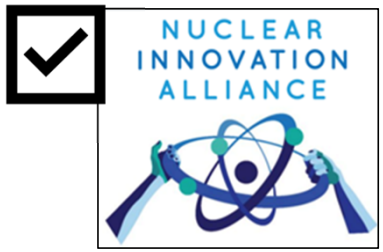
80% of Evaluated Coal Sites Suitable for

- **Primarily rural under-resourced communities affected**
- **Mixed models of ownership and desires**
- **Who should move first? Community or State or Utility**



ENVOY PUBLIC LABS

New Studies on coal transitions in U.S.



Overview of transition issues

Policy recommendations on early site permits

Practical guidebook coal-to-nuclear transition

Pilot Studies with Non-nuclear Utilities

Stakeholder guidebook on economic impacts, infrastructure, and licensing

Coronado Generating Station – Repurposing Study

Primary Objective: Assess the feasibility of transitioning from coal to nuclear; Learnings can be applied to other coal units within commuting distance from CGS

- Siting Evaluation (leveraging EPRI's Siting Guide)
  - Assess CGS site suitability
  - Identify strengths and weaknesses
  - Support selection of candidate nuclear technologies
- Nuclear Technology Assessment (leveraging EPRI's Nuclear Technology Assessment Guide)
  - Identify candidate nuclear technologies
  - Identify potential next steps
- Economic Impact Assessment
  - Evaluate economic outcomes and community impacts from:
    a) Coal plant retirement
    b) Introduction of a nuclear power plant
  - Publicly Available: https://gain.inl.gov/SiteAssets/Coal2Nuclear/StJohn_econ.impacts.pdf

Coronado Generating Station
Owned/Operated by Salt River Project
Located in Saint Johns, AZ

The GAIN Team


Director – Christine King
Deputy Director – Andrew Worrall


Senior Advisors
– Hussein Khalil
– Lori Braase

Operations Manager
Holly Powell

Innovation & Technology Manager
Chris Lohse

Administrator
Teresa Krynicki

Communications Liaison
Donna Kemp Spangler

Project Coordinator
Emily Nichols

Project Researcher
Jon Grams

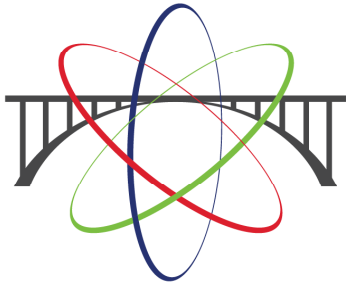
Voucher Principal Investigators

National Lab Technical POCs

Process Modernization
Rachel Taow

Regulatory Interface
Jim Kinsey

January 2024



GAIN

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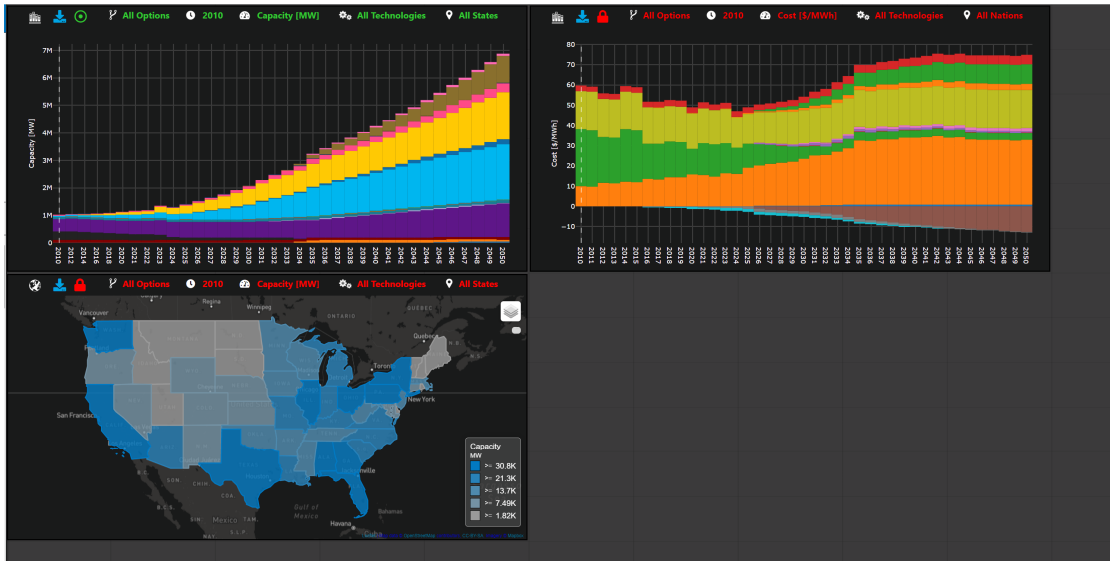
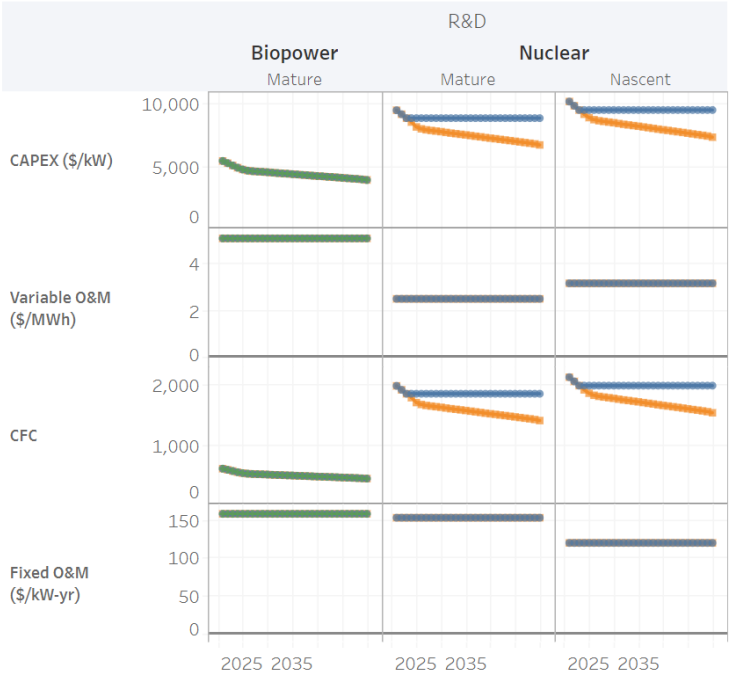
@GAINnuclear | gain.inl.gov

What is NREL ATB

- Data used to support utility planning and capacity expansion models
- Will go into NREL ReEDS Model and other models that people pull data from





Supply Chain Report Takeaways

Limitations

- Information is what suppliers believe they could expand to with investment
- Investment amounts were not quantified in this work and companies
- Does not help us understand the cost competitive nature of the suppliers with international competition
- Impact of other expanding markets may impact the projections
- Generic components were utilized for this work and reactor specific designs may limit number of suppliers based on specific capabilities
- Does not try to define the actual reactor mix that may be deployed

Key Findings

- Supply chain has some initial capacity to get started
- Assuming limitations are addressed, targets could be generally met across the various categories
- Expansion is required to meet larger targets and companies will expand operations if they can make the business case and have firm orders for the investment
- Estimated that ~5-year lead time required to expand industrial capacity
- Workforce is one of the biggest issues in the supply chain companies
- Current lead times range from 1 to 2 years based on the type of component

Kentucky Nuclear Development Working Group

Report submitted to the Governor and Legislative Research Commission on November 20, 2023.

Takeaways:

- Establishment of the Kentucky Nuclear Development Authority
- Natural gas combined-cycle plants have been replacing retiring coal plants, however, there is a large potential market for high-temperature process heat
- Paducah Gaseous Diffusion Plant could be a critical component in the new nuclear fuel cycle
- Financial and environmental (waste storage) barriers were among the chief concerns of the working group
- However, there are no insurmountable barriers to nuclear energy development in Kentucky

Link to report

New Hampshire Committee to Investigate New Nuclear

Report submitted to the Governor and legislative leadership on December 1, 2023.

Takeaways:

- New nuclear is an essential element in achieving a net-zero economy
- Cost efficiency and reliability of new nuclear is the primary driver of interest in the state
- There is considerable interest in the possibility of the reprocessing and recycling of nuclear fuel
- Deregulated energy markets, such as New Hampshire, will struggle in attracting FOAK reactor deployments
- Policy Options:
  - Designation of nuclear as a “clean” technology in the state
  - Additional state financial incentives for nuclear projects
  - Investment in nuclear supply chain capabilities

Link to report

ADVANCED REACTOR SAFEGUARDS & SECURITY

Lessons Learned in Physical Protection, MC&A and Cybersecurity

NRC Advanced Reactor Stakeholder Meeting

PRESENTED BY

Ben Cipiti Sandia National Laboratories

January 24, 2024

SAND2023-13942PE

Sandia National Laboratories is a multimission laboratory managed and operated by National Technology and Engineering Solutions of Sandia LLC, a wholly owned subsidiary of Honeywell International Inc. for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-NA0003525.

Sandia National Laboratories | U.S. DEPARTMENT OF ENERGY

ARSS Program Goal and Objectives

The ARSS program is addressing near term challenges that advanced reactor vendors face in meeting material control and accounting (MC&A), physical protection system (PPS), and cybersecurity requirements for reactors built in the U.S.

Material Control & Accounting	Physical Protection Systems	Cybersecurity
Systems Level PBR MC&A Approach MSR MC&A Approach Vendor Engagements International Coordination	**Systems Level** SMR PPS Design Approach Microreactor PPS Design Approach Vendor Engagements	**Systems Level** Cyber-Informed Engineering Defensive Cyber Architecture Vendor Engagements
Technology Level Measurement Technologies Process Monitoring Statistical Evaluations	**Technology Level** Advanced Intrusion Detection Advanced Delay Technologies Advanced Response Tech/Tactics	**Technology Level** Secure Elements/Tokens Supply Chain Control System Component Testing

Interface with Safety

Motivation and Outreach

Advanced reactor vendors have expressed interest in

- Reduced costs for physical protection systems (up front and operational)
- R&D support for MC&A requirements for pebble bed and liquid fueled reactors.
- Cybersecurity and control system design recommendations.

We're always happy to receive feedback on the R&D, approaches, and how to better use these results to improve the licensing process for vendors.

Program Contacts

UUR Reports will be posted to the program website:

https://energy.sandia.gov/ars

CUI Reports can be shared with vendors and NRC provided certain conditions are met to protect the information.

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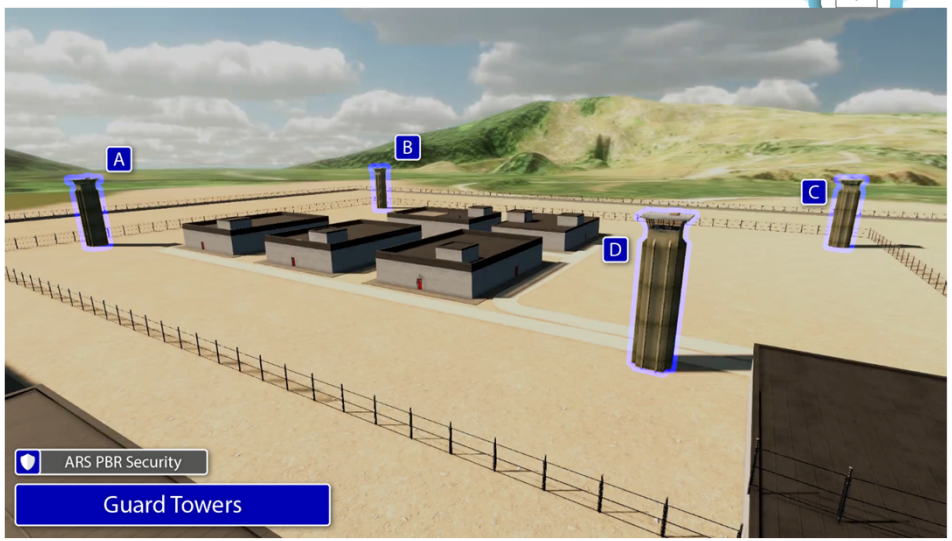
Physical Protection Systems

- The AR vendors would like to reduce the PPS footprint and number of on-site security staff
  - Cost aspect to keep overall plant economics competitive.
  - Marketing aspect to show that these reactors are smaller and safer.
- Systems level work has focused on minimum numbers of staffing required for different reactor types and where those minimum numbers may be reduced through exemptions/alternatives.



- Vendor engagements are being used to validate PPS design recommendations

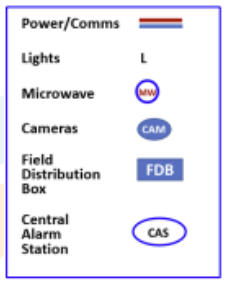
Initial Lessons Learned

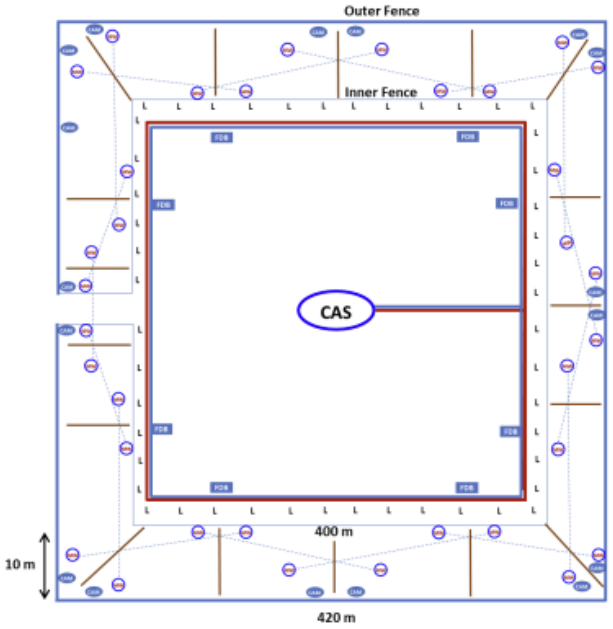
- Initial work examined the use of off-site response but has since moved away from that approach for several reasons:
  - Costs for agreements and training would be the same as on-site responders.
  - Response times lead to the need for significant delay (adding cost)
  - Questions about reliability
- Initial work was also focused on providing R&D to support potential changes in the Part 73 limited scope rulemaking and Part 53.
  - Challenges in those licensing processes have made this less of a focus, but we're still examining foundational R&D to support.
  - Seeing potential large differences in first-of-a-kind versus n^{th} of a kind.

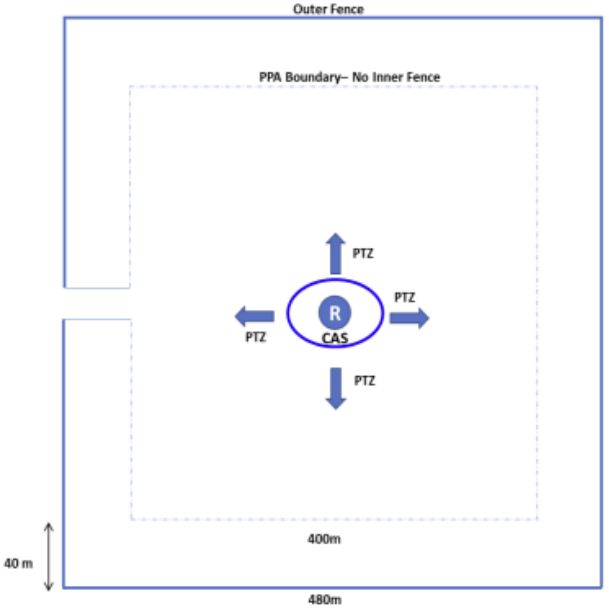
Traditional PIDAS Design versus DPIDS (DMA-enabled PIDS Design

Traditional

- PPA Boundary 400 m sides
- 17 Sectors
- 34 Microwaves
- 17 Cameras
- 8 FDBs (Field Distribution Boxes)
- 48 Lights/Light Poles
- Trenching for Power or Comms
- 8 Foot Security Fence
- Inner and Outer Fence, 3280m (10800 ft)
- 9 meter clear zone





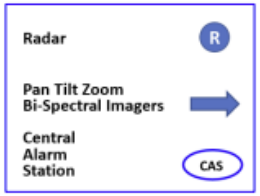


DPIDS

- PPA Boundary 400 m sides
- No Sectors
- No FDBs (Field Distribution Boxes)
- No Lights/Light Poles
- No Trenching for Power or Comms
- 8 Foot Security Fence
- Outer Fence, 1920m (6340 ft)
- 40 meter clear zone

Caveat Regarding "No Lights"

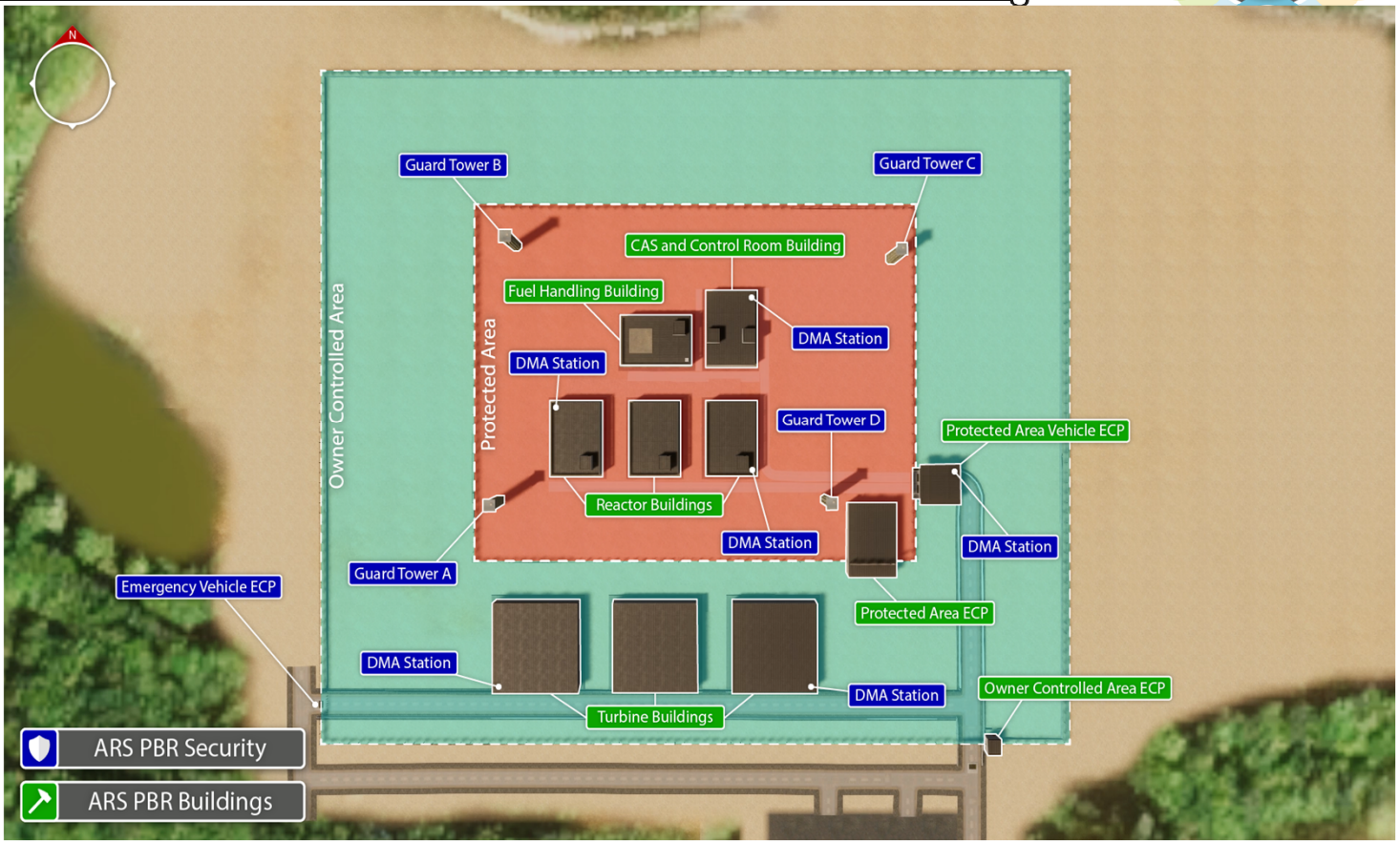
- No Lights on perimeter needed for intrusion detection
- Lights on/around the CAS
- Safety and Response Force may require lights



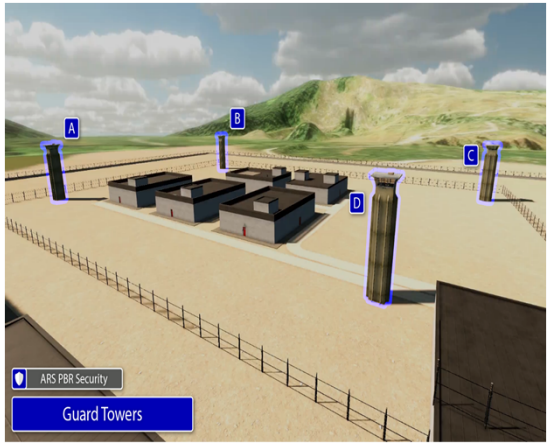
DPIDS Design is an estimated to cost 40% less than Traditional Design

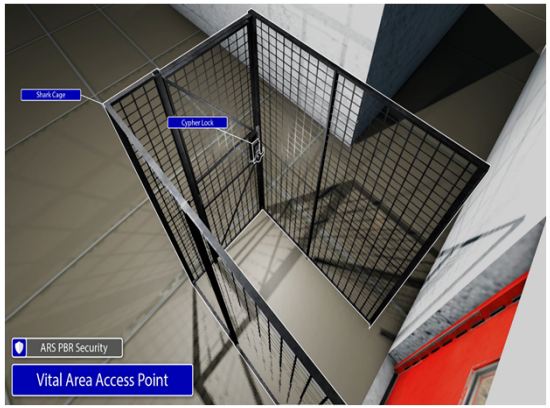
Generic Pebble Bed Reactor PPS Model

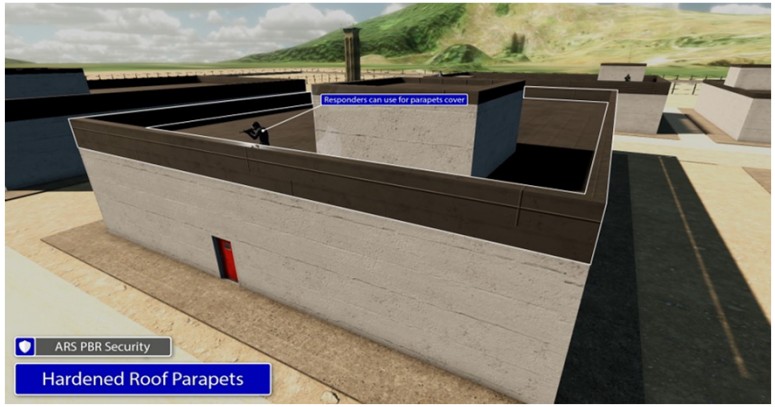
- Deliberate Motion Analytics → External Intrusion Detection
- Owner Controlled Area (OCA) Boundary in Blue
- Protected Area (PA) Boundary in Red
- 4 Response Towers
- 1 Roving Guard with Roof Access
- OCA entry control point for large vehicle searches
- PA entry control point for detailed vehicle inspections
- 6 Vital Areas



PBR PPS Attributes







PBR Staffing Plan

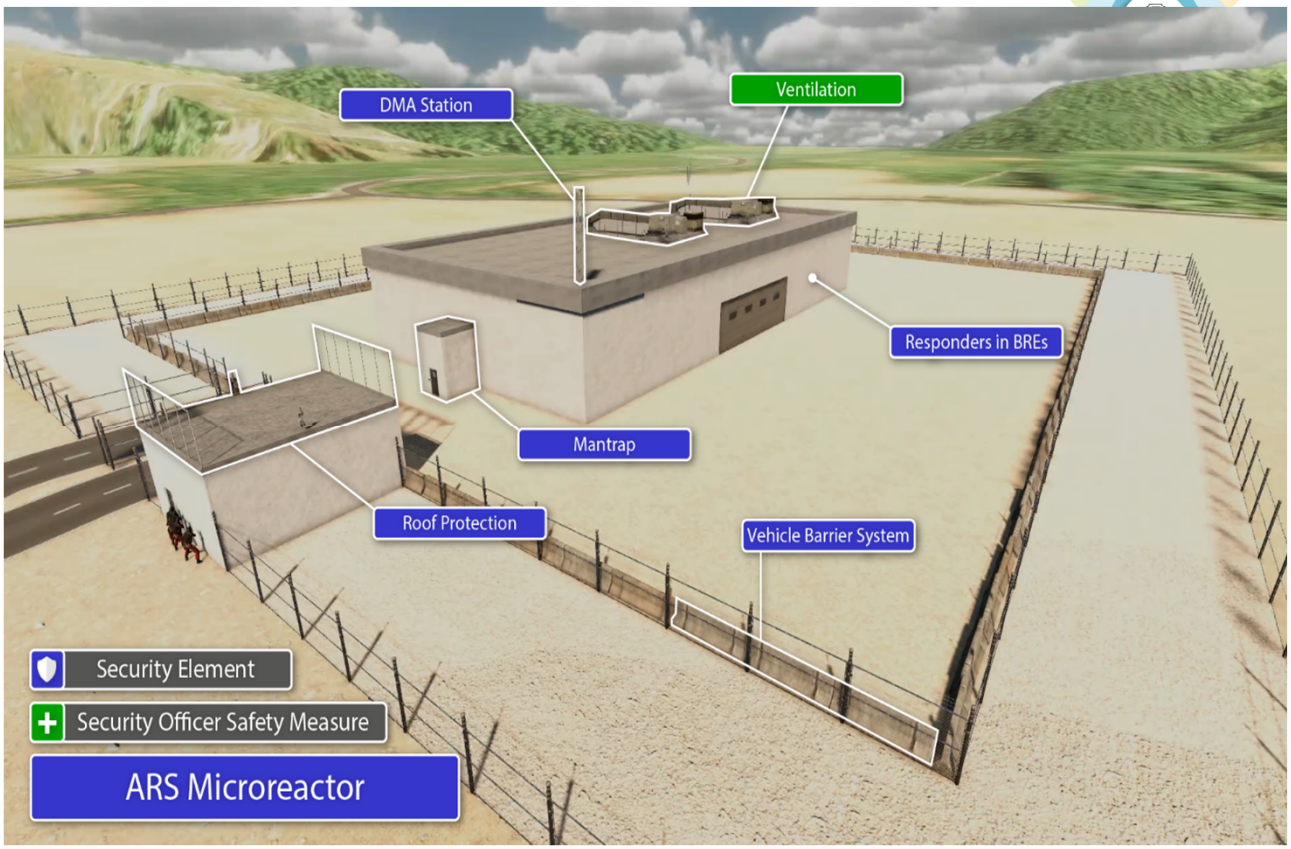
System Effectiveness Positions (Requiring Exemptions)

Position	24/7 12 hr. Rotating Shift	FTE
Security Shift Supervisor	1	4
Field Supervisors (One Response Team Leader)	2	8
Alarm Station Operators (CAS/SAS)	3	12
Armed Responders	6*	24
Armed Security Officers (Personnel, vehicle, and material processing)	3	12
Total	15	**60**

*Note that 6 responders is below the regulatory minimum of 10, but force on force adversary modeling found 6 to provide a >95% System Effectiveness for 4-7 adversaries.

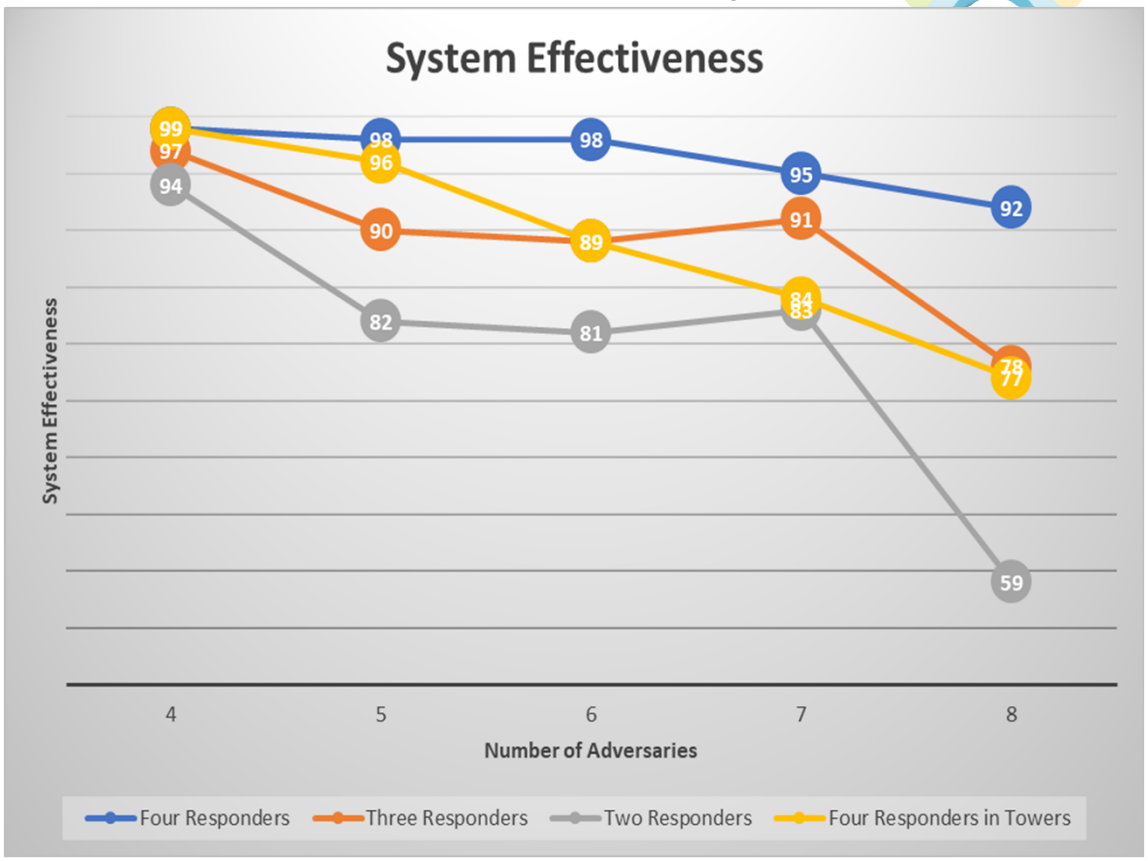
Generic Microreactor PPS Model

- Deliberate Motion Analytics → External Intrusion Detection
- Owner Controlled Area Boundary
- Protected Area Boundary
- 4 different scenarios analyzed
  - 4 internal responders
  - 3 internal responders
  - 2 internal responders
  - 4 responders in towers
- One Entry Control Point
- Two Vital Areas

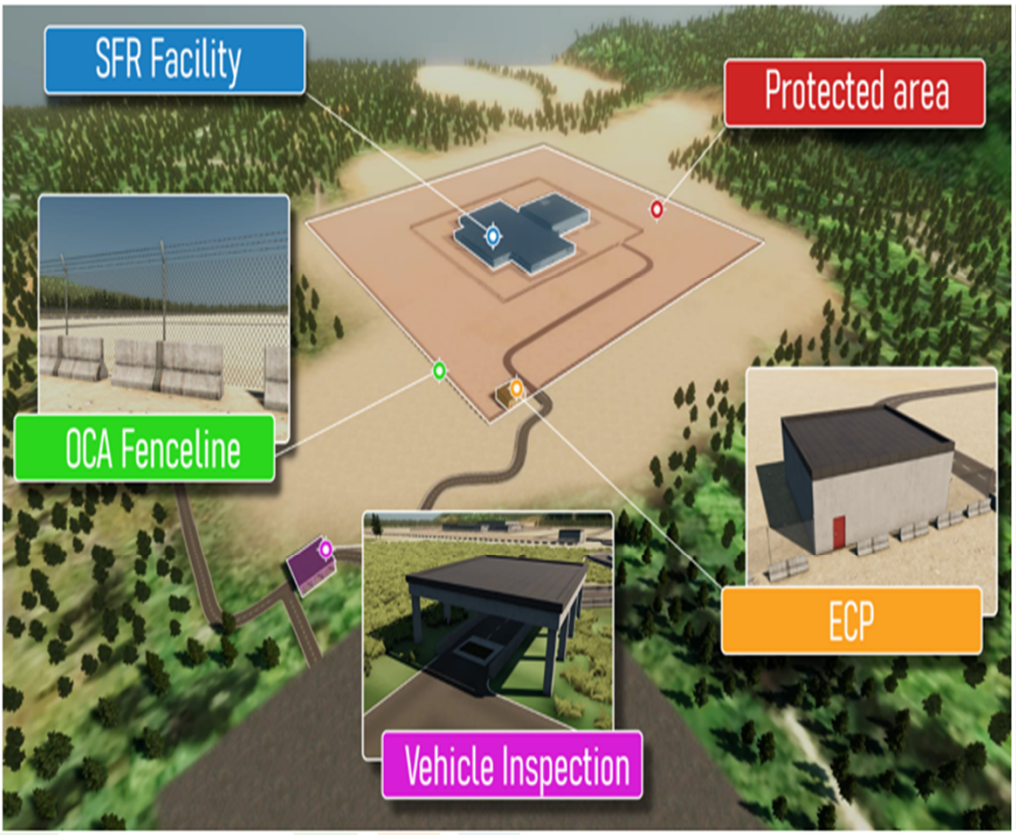


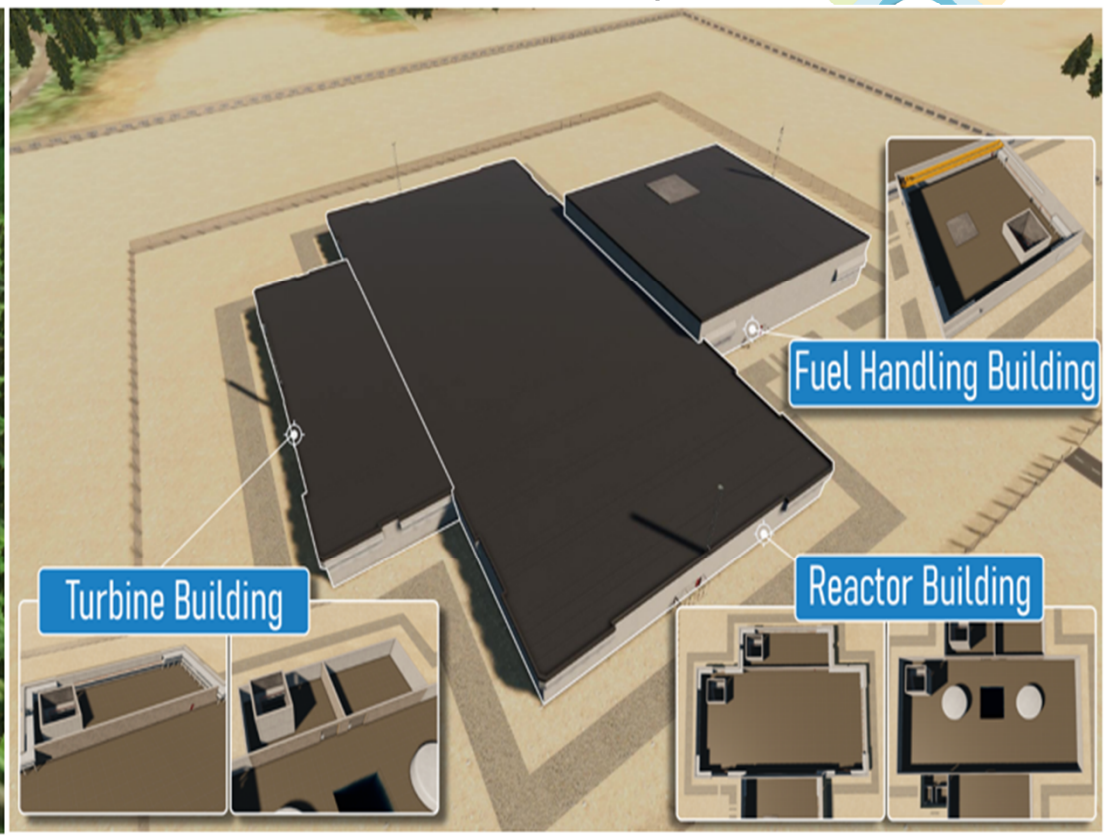
Microreactor System Effectiveness and Staffing Plan

Position	24/7 Rotating Shift	FTE
Security Shift Supervisor	1	4
Response Team Lead	2	8
Alarm Station Operators (CAS/SAS)	3	12
Armed Responders	5	20
Armed Security Officers (Personnel, vehicle, and material processing)	3	12
Total	14	56



Generic Sodium Fast Reactor PPS Model





Remote Operated Weapons Systems (ROWS) and Response Results

- 5 responders showed to be effective in all scenarios across all adversary ranges
  - Responders were able to engage externally and internally (neutralized most adversaries before entry into the building
- ROWS platforms only considered engagement interior to the building (fixed internal ROWS platforms)
  - A total of 8 ROWS platforms were required.
  - System effectiveness dropped to below 80% in some scenarios.

SFR Staffing Plans

ROWS Response Staffing Plan

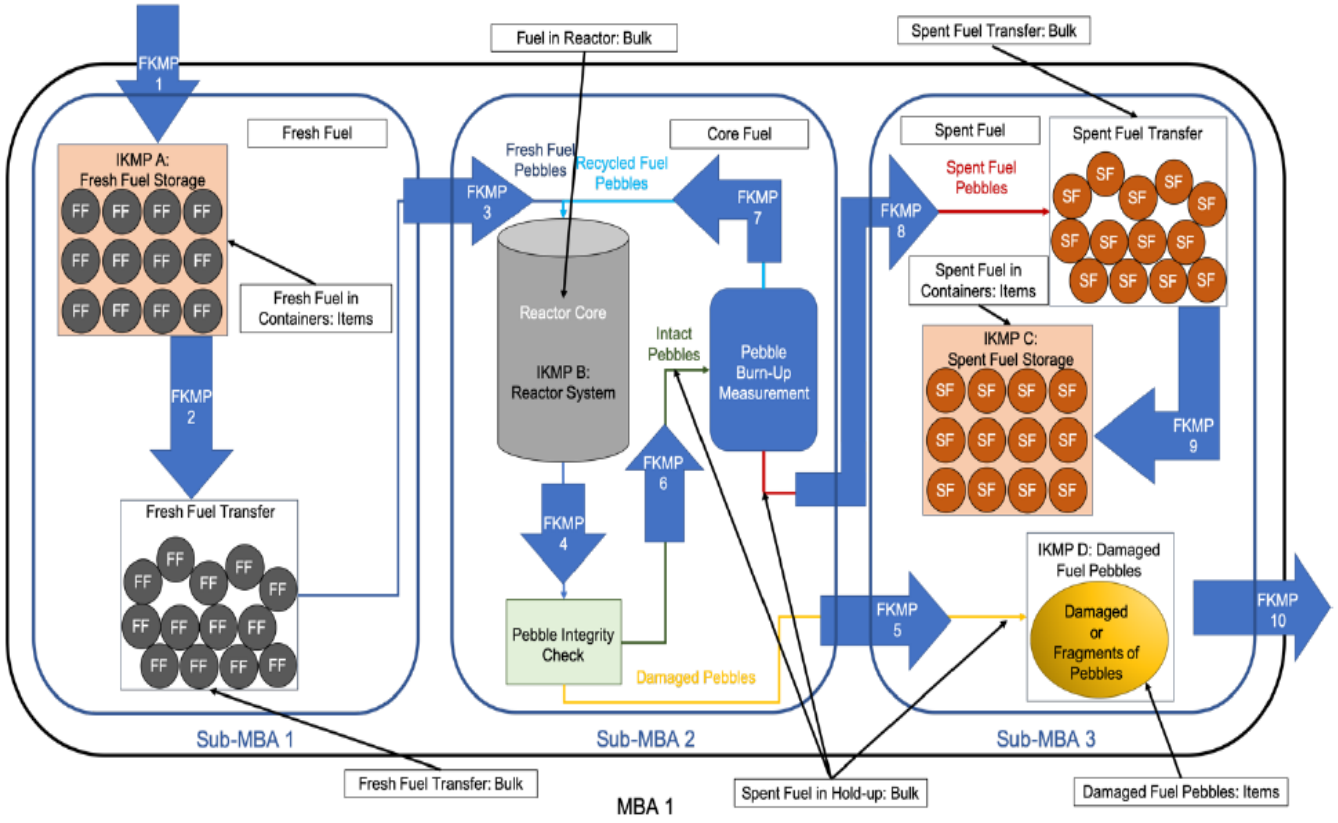
Position	24/7 12 hr. Rotating Shift	FTE
Security Shift Supervisor	1	4
Field Supervisor/RTL	2	8
Alarm Station Operators	3	12
ROWS Operators	4	16
Armed Security Officers (ECP, Vehicle Search, Escorts)	3	12
Total	13	52

Onsite Response Staffing Plan

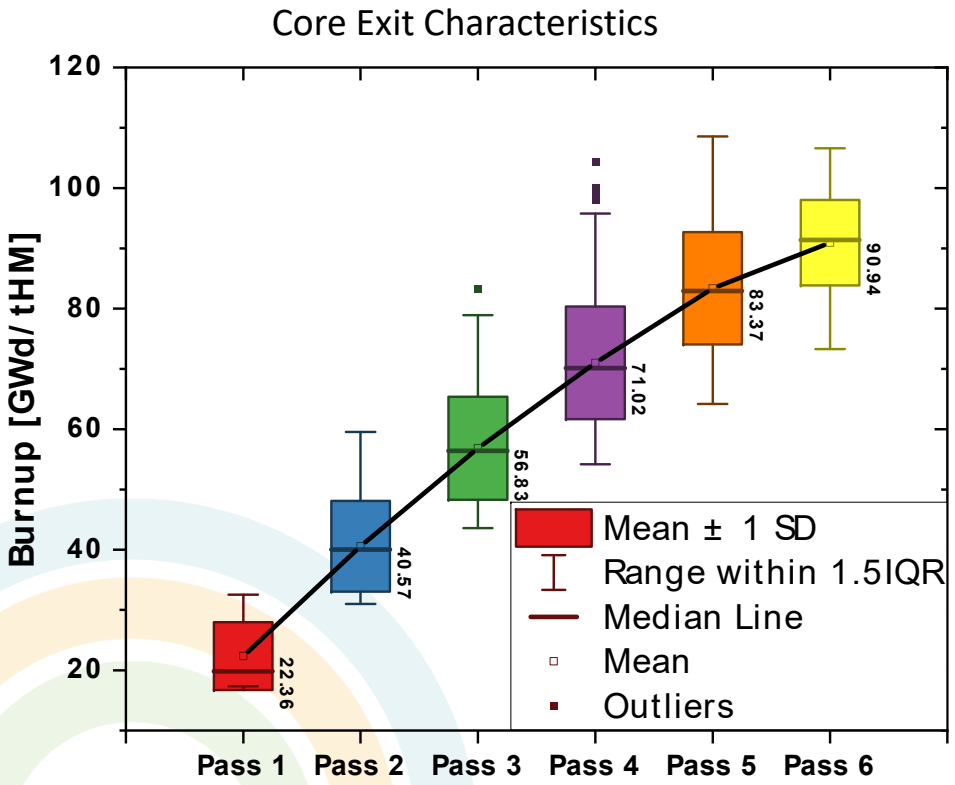
Position	24/7 12 hr. Rotating Shift	FTE
Security Shift Supervisor	1	4
Field Supervisor/RTL	2	8
Alarm Station Operators	3	12
Armed Responders	6	24
Armed Security Officers (ECP, Vehicle Search, Escorts)	3	12
Total	15	60

MC&A for Pebble Bed Reactors

- Completed a milestone report on the MC&A approach for PBRs.
- Item accounting on fresh and spent fuel canisters.
- Fuel handling system consists of pebble counters, pebble integrity check, and burnup measurements.
- The burnup measurements can inform actinide content in spent fuel canisters.



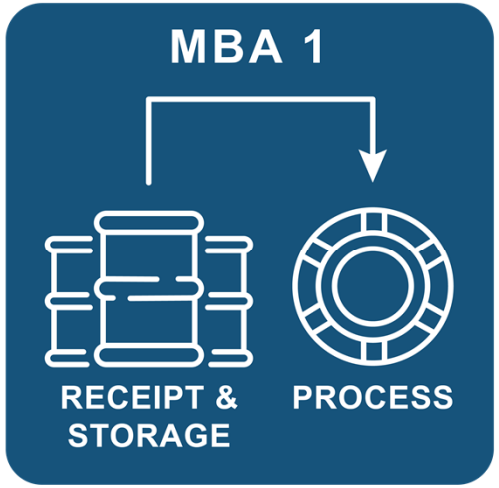
MC&A for Pebble Bed Reactors



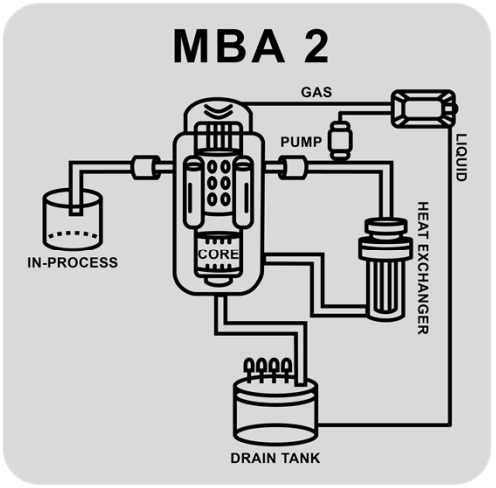
- The analysis on the left shows the range of burnup values achieved based on the pass.
- Based on a PBMR-400 model, the largest additional burnup achievable is 16.8 GWD/MT, so if the burnup limit is 100 GWD/MT, pebbles could need to be ejected once greater than 83.2 GWD/MT.
- ARSS is supporting an NDA measurement campaign on spent TRISO fuel and also looking into machine learning algorithms to improve the burnup measurement.

MC&A for Liquid Fueled Molten Salt Reactors

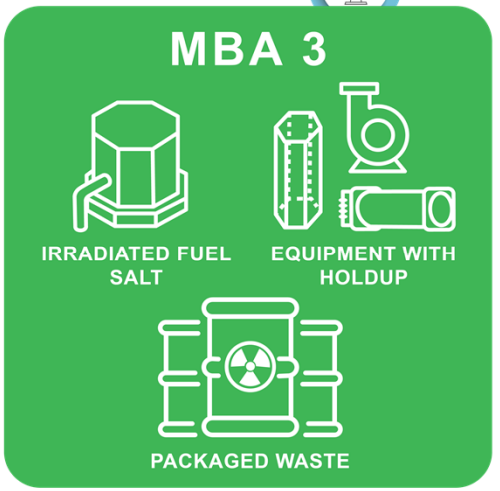
- MSRs are bulk facilities and will very likely need to submit an FNMC plan.
- Item accounting at front end and back end, with diversion monitoring for the reactor loop.



Periodic inventories performed, IDs and SEIDs calculated
(follows Part 74 requirements)



Monitoring performed in specific locations to detect diversion



Periodic inventories performed, IDs and SEIDs calculated
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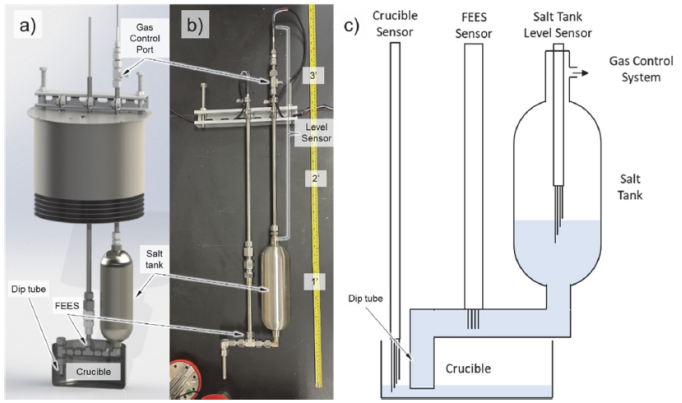
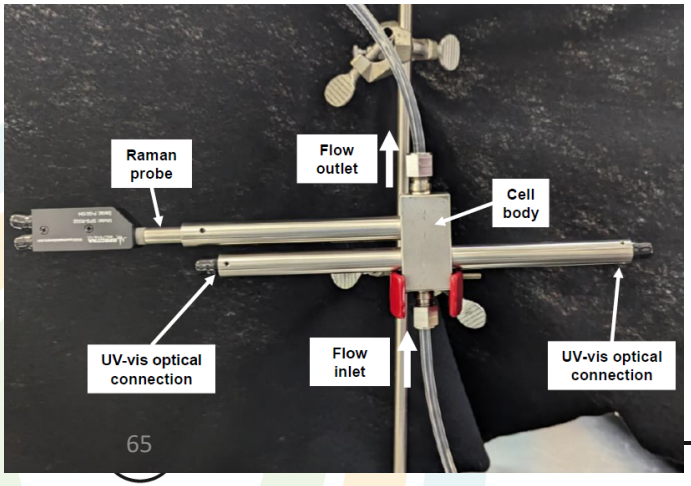
MC&A for Liquid Fueled Molten Salt Reactors





- Continuing to develop both voltammetry and spectroscopy techniques for measuring actinide content in molten salts.
- Laboratory work is moving toward more actinide species and more complex molten salt solutions.
- Work will transition toward piloting with vendors and gathering lessons learned about deployment, maintenance, and performance.

Cybersecurity R&D

- One program goal is to define a Defensive Cyber Security Architecture for each class of advanced reactor.
- The DCSA is used to develop the network design, system components, and flow of information.
- The goal here is not to design the system for the vendors, but rather provide recommendations and develop the technical basis for components that may be used.

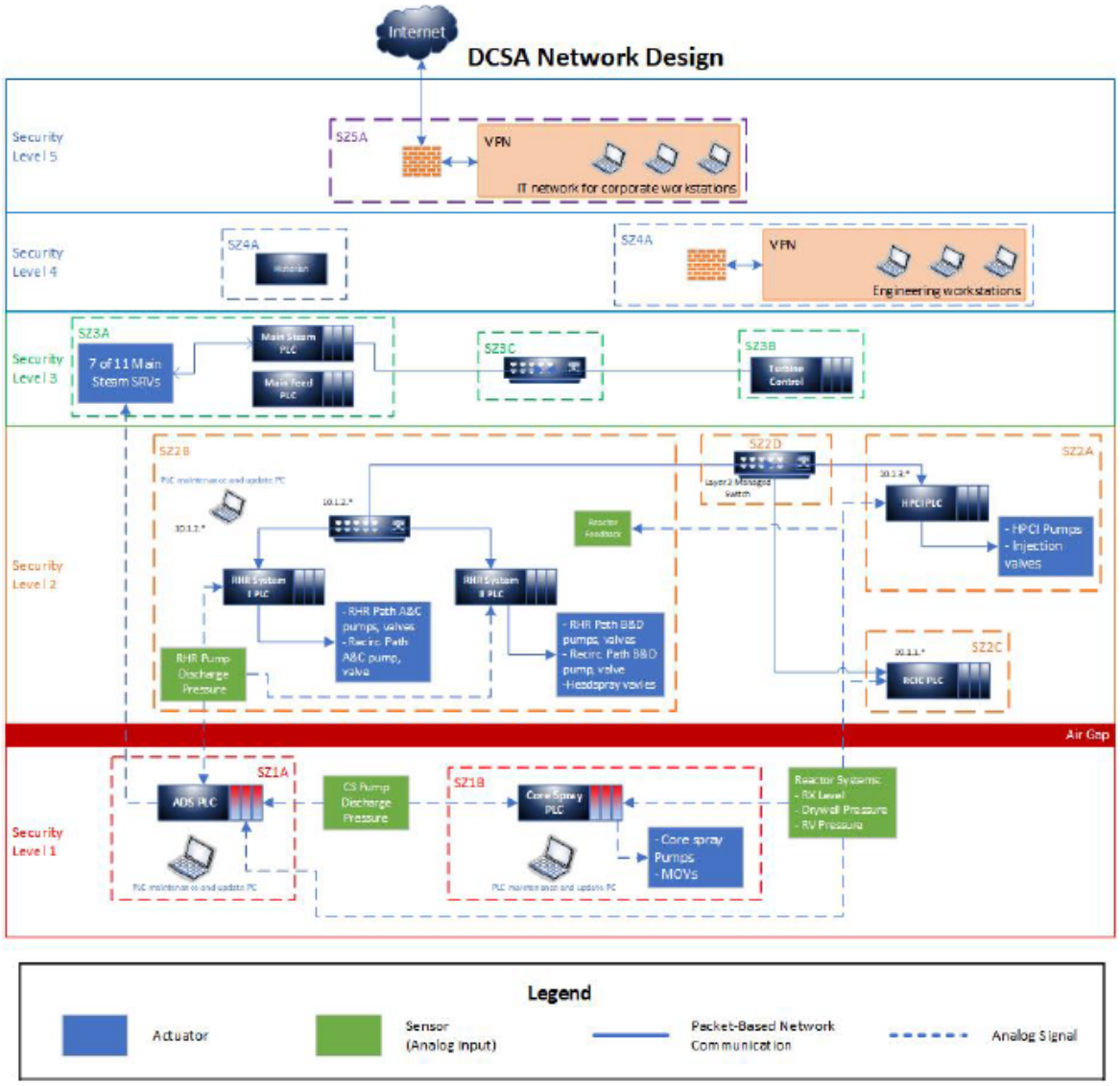
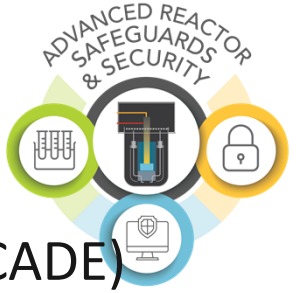


Figure 7. DCSA design of RHR System

Cybersecurity R&D



- Advanced Reactor Cyber Analysis and Development Environment (ARCADE)
  - Modeling environment that connects physical plant models to control system emulations to support cyber security testing and evaluation
- Development and evaluation of security techniques for control systems
  - Identify performance characteristics and requirements for using security techniques (e.g., encryption and authentication) in control systems
  - Secure Elements – Explore use of smart chips in control system components for supply chain security and embedded encryption and authentication
  - Integrity guaranteeing protocols – Evaluate alternatives to encryption to ensure integrity in control systems
- Wireless Cybersecurity
  - Develop requirements for secure wireless applications
  - Develop testing and evaluation protocols to support use of wireless in new applications

Discussion & Conclusions

- Response forces for SMRs and microreactors may be reduced below current regulatory requirements and still reach high system effectiveness. Additional staff reductions may be possible for sites with very limited maintenance and visits.
- We need to understand better the consequences of full core release which could have a significant impact on physical and cybersecurity design.
- Major milestone reports are available soon on the MC&A approach for PBRs and liquid fueled MSRs.
- The cybersecurity R&D is focusing on design recommendations for vendors and moving increasingly into performance testing in the future.
- We expect to see more integrated 3S work as the program progresses.

How Did We Do?

- Click link to NRC public meeting information:

  https://www.nrc.gov/pmns/mtg?do=details&Code=20231097

- Then, click link to NRC public feedback form: