

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	

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 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 Sodium reactor design.
 - “TerraPower, LLC—U.S. Nuclear Regulatory Commission Staff Feedback Regarding White Paper: ‘Sodium 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 Sodium 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.



Advanced Reactor Integrated Schedule Demonstration

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



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

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

TIME	TOPIC	SPEAKERS
9:00 AM – 10:00 AM	Workshop Opening and Introductions	<ul style="list-style-type: none"> 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	<ul style="list-style-type: none"> 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*	<ul style="list-style-type: none"> 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*	<ul style="list-style-type: none"> Adam Smith, GE Vernova DJ Hanson, Flibe Energy Annie Paskavitch, NextEra
4:15 PM – 4:30 PM	Public Comments (Open to All)	<ul style="list-style-type: none"> NRC/Public
4:30 PM	Day 1 Adjourn	

DRAFT AGENDA DAY 2

FEB 1, 2024
9:00 AM – 4:15 PM

**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.*

TIME	TOPIC	SPEAKERS
9:00 AM – 9:15 AM	Day 2 Opening	<ul style="list-style-type: none"> Niav Hughes Green & Stephanie Morrow, Workshop Coordinators, NRC
9:15 AM – 10:15 AM	Stakeholder Presentations & Discussion*	<ul style="list-style-type: none"> 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*	<ul style="list-style-type: none"> Brian Green, NRC
11:00 AM – 11:30 AM	Scalable Human Factors Engineering Reviews and Use of Human Factors Engineering Guidance & Discussion*	<ul style="list-style-type: none"> 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	<ul style="list-style-type: none"> Casey Kovesdi, INL
1:30 PM – 2:45 PM	Breakout Discussions of Concepts of Operations for Remote Operation**	<ul style="list-style-type: none"> All In-Person Participants
2:45 PM – 3:00 PM	BREAK	
3:00 PM – 3:45 PM	Summary of Breakout Discussions & Key Takeaways	<ul style="list-style-type: none"> NRC/INL
3:45 PM – 4:00 PM	Public Comments (Open to All)	<ul style="list-style-type: none"> NRC/Public
4:00 PM – 4:15 PM	Day 2 Closing – End of Workshop and Next Steps	<ul style="list-style-type: none"> Niav Hughes Green & Stephanie Morrow, Workshop Coordinators, NRC

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 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.

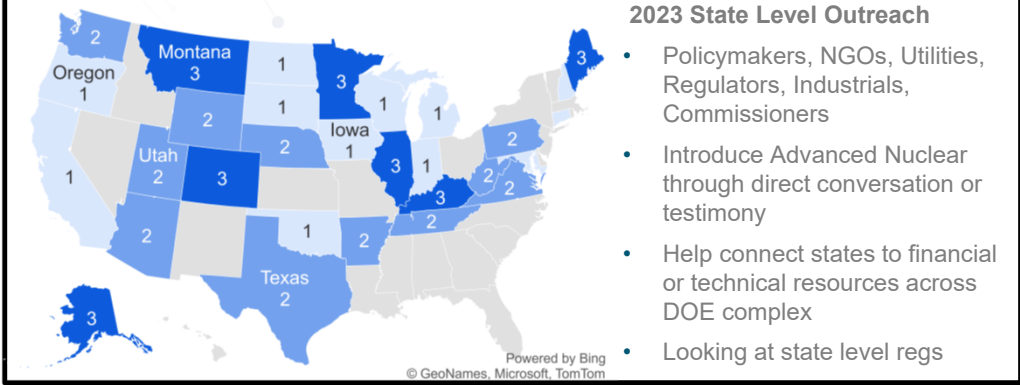
Mission is the same – the audience is expanding



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

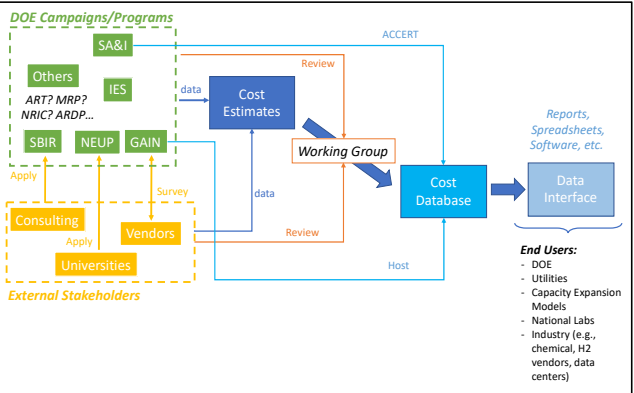
SJ Scott

2024 Activities



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.



ADDING NUCLEAR TO THE MIX WORKSHOP

NOVEMBER 14 & 15, 2023

MORGANTOWN, WEST VIRGINIA

A workshop designed to gather those interested in exploring the expansion and integration of nuclear power alongside existing energy sources.

Hear about the latest research recommendations, updates from early movers, utility and community perspectives of repowering projects.

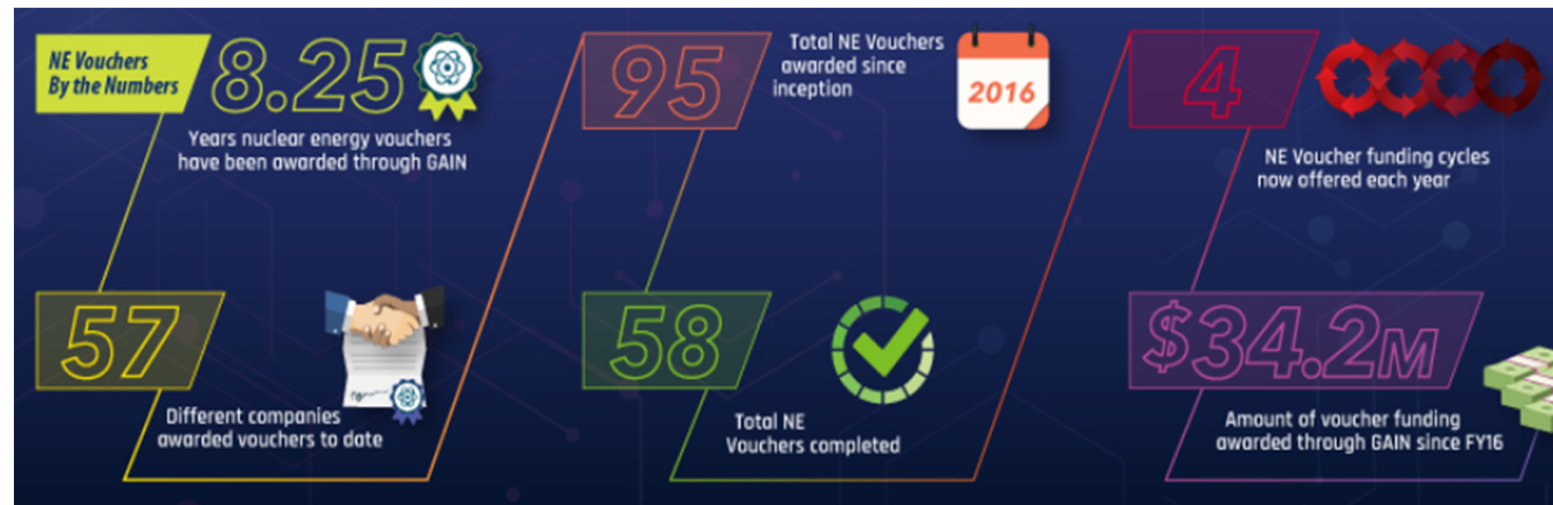
Industry Support

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

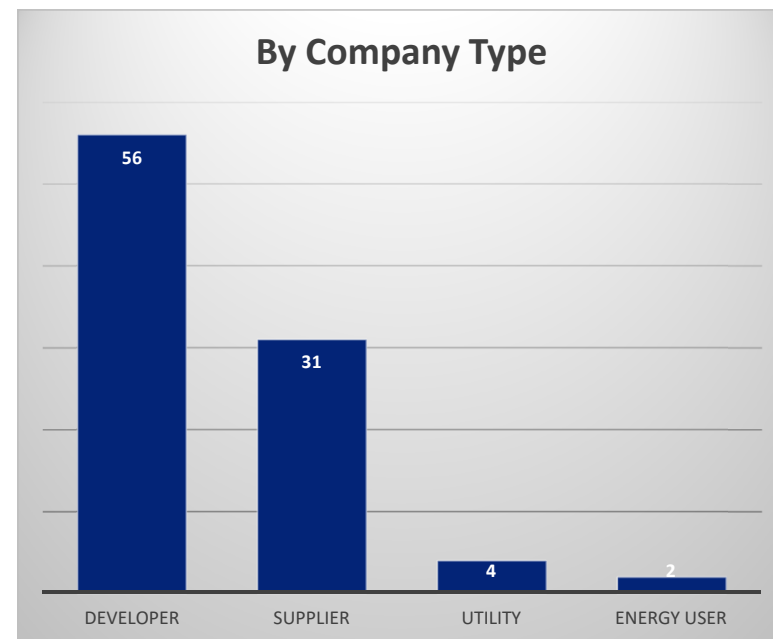
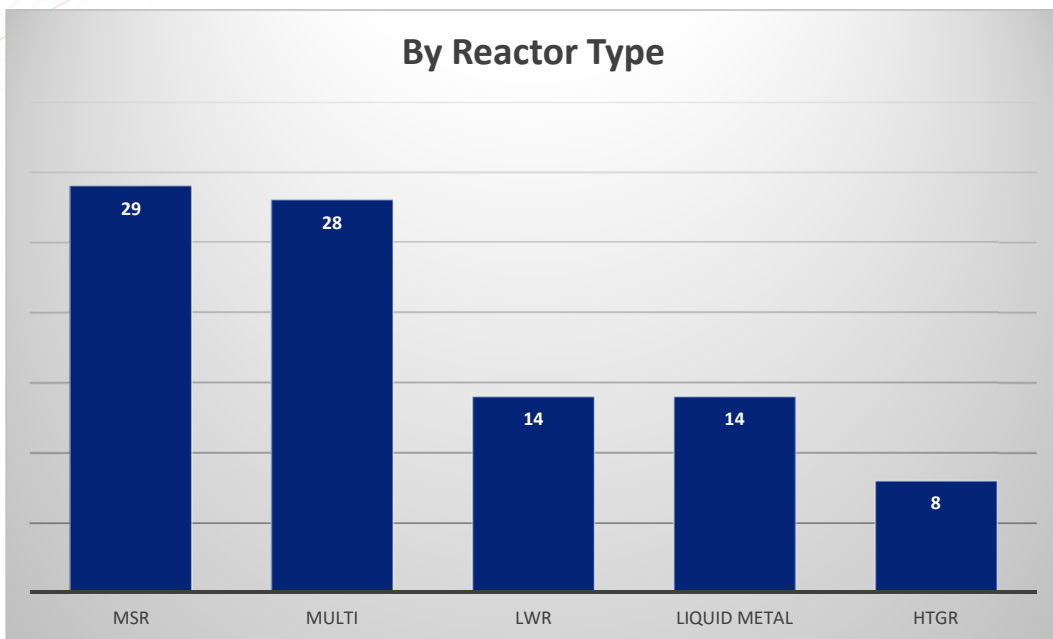


DOE-NE Vouchers

- 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

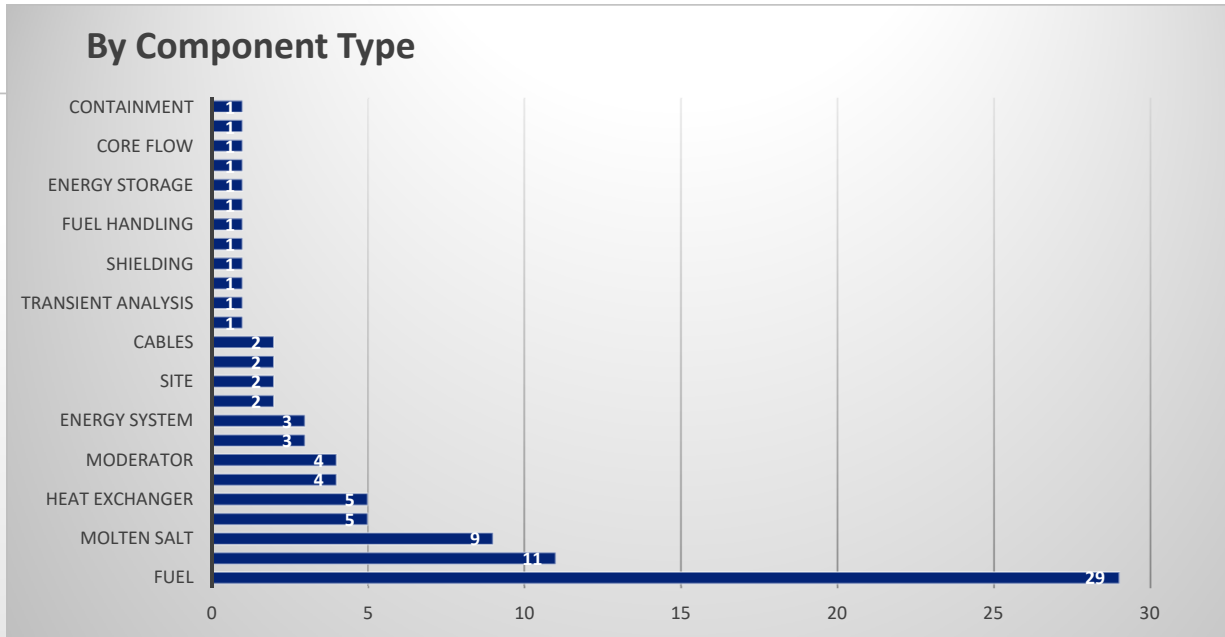
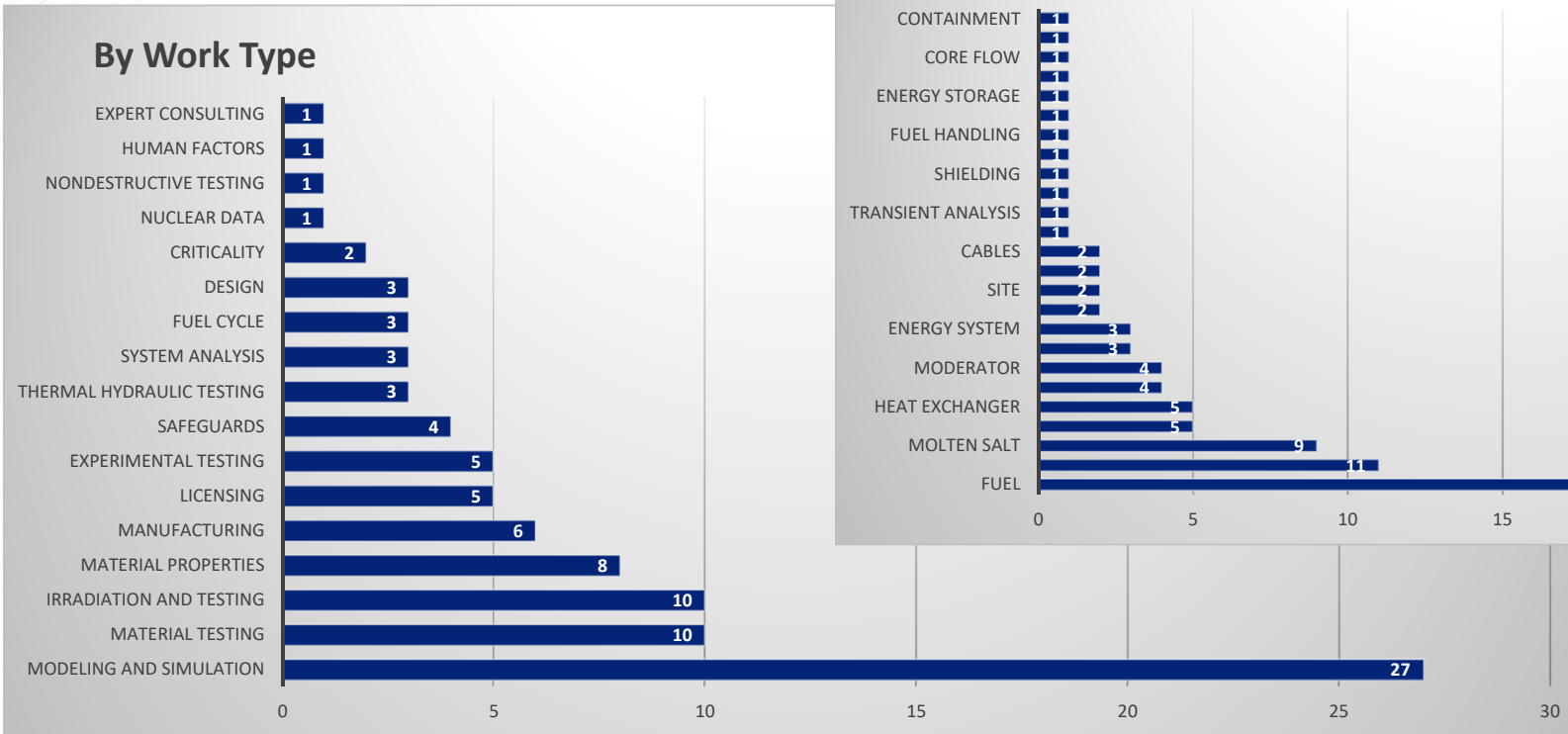


Voucher Award Statistics



*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.

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



SCOT FORGE



Advanced Reactor Cost

Chris Lohse, GAIN Innovation and Technology Manager



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

Technologies

Land-Based Wind

Offshore Wind

Distributed Wind

Utility-Scale PV

Commercial PV

Residential PV

Concentrating Solar Power

Geothermal

Hydropower

Utility-Scale PV-Plus-Battery

Utility-Scale Battery Storage

Commercial Battery Storage

Residential Battery Storage

Pumped Storage Hydropower

Fossil Energy Technologies

Other Technologies (EIA)

Nuclear data >

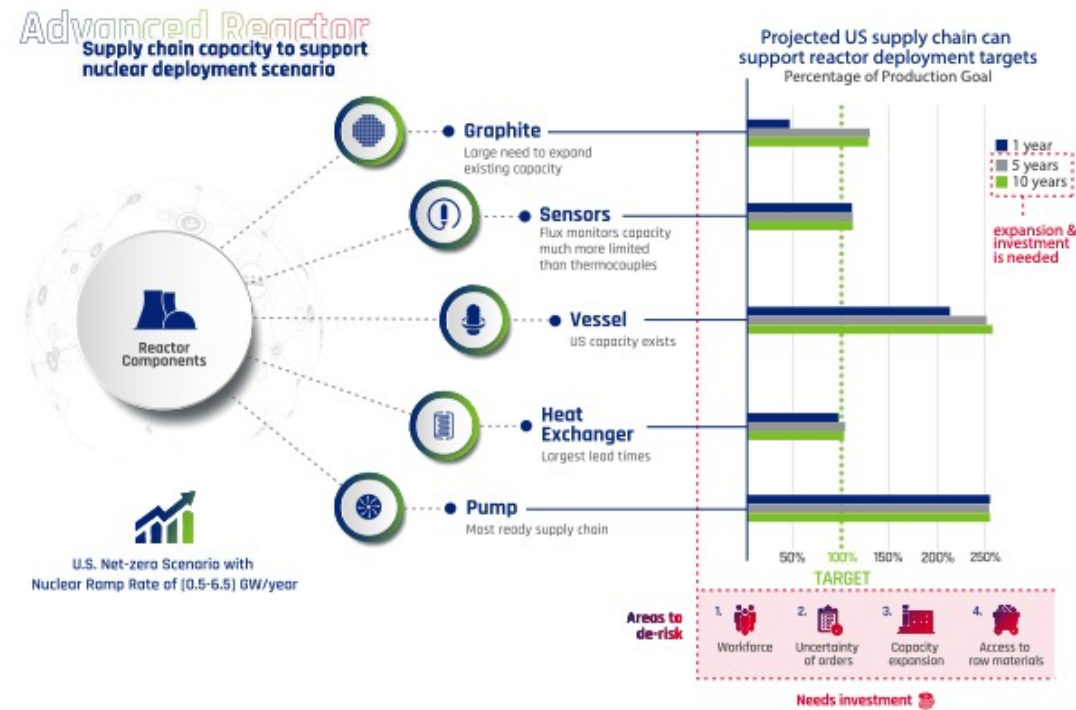
GAIN Supply Chain Assessment

Chris Lohse, GAIN Innovation and Technology Manager



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...

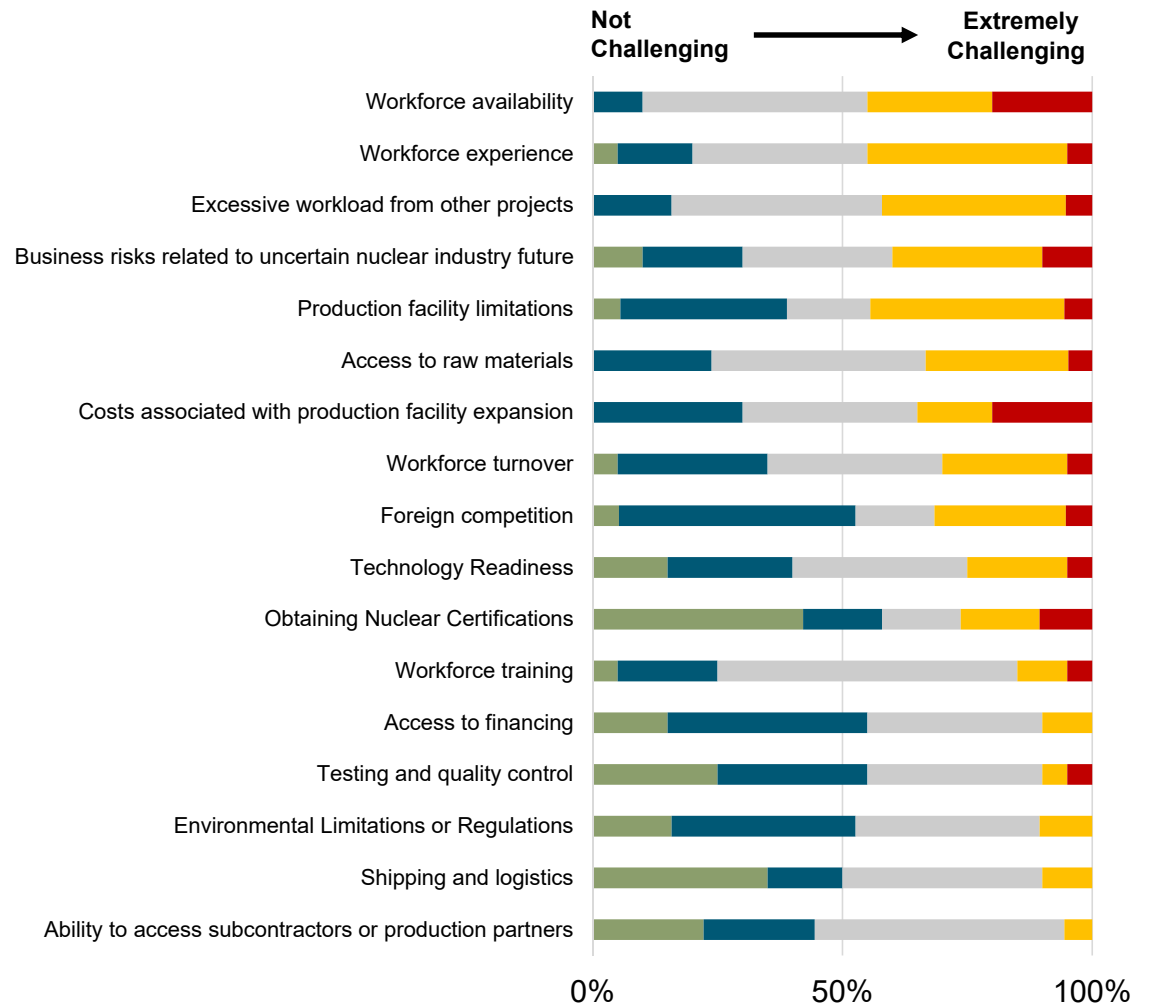


<https://www.osti.gov/biblio/1973747>

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

-  Workforce
-  Uncertainty of orders
-  Capacity expansion
-  Access to raw materials



GAIN State Engagement



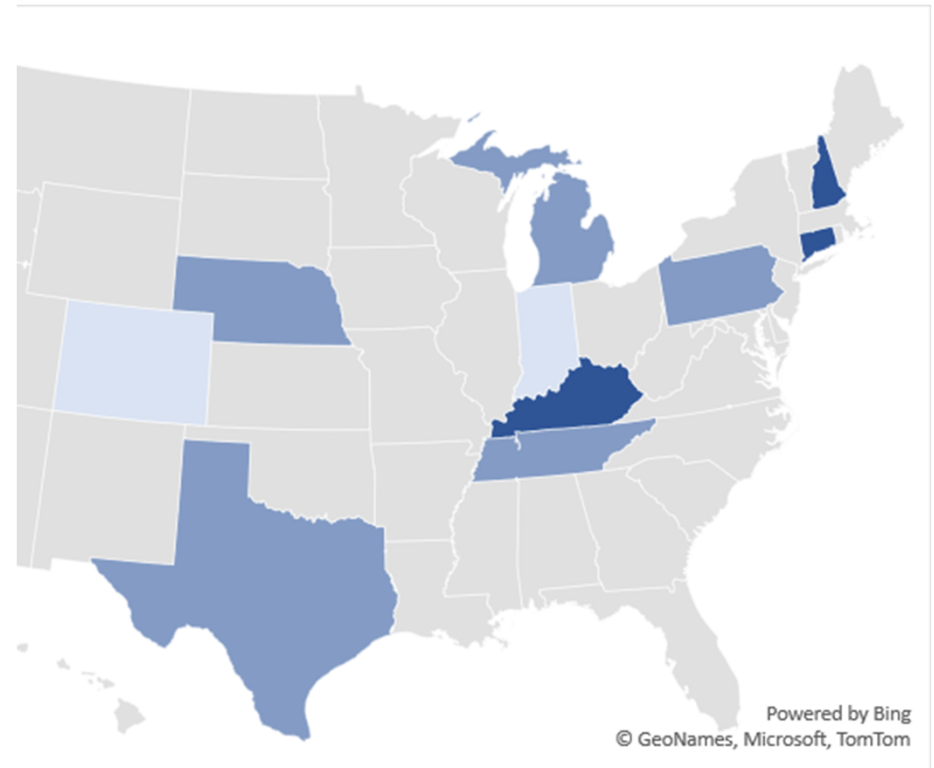
Advanced Nuclear Feasibility Studies

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

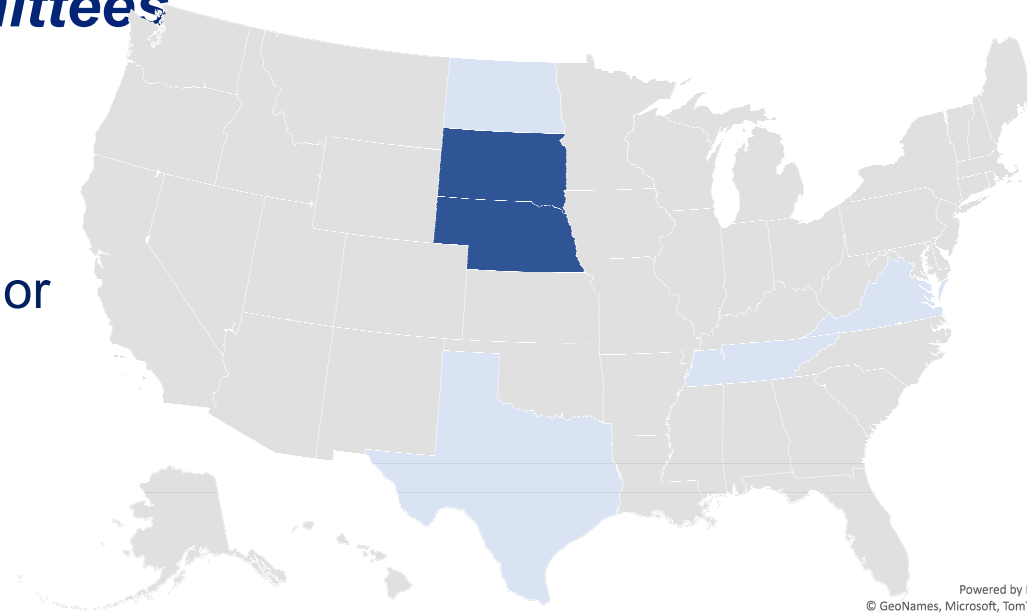
Completed

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

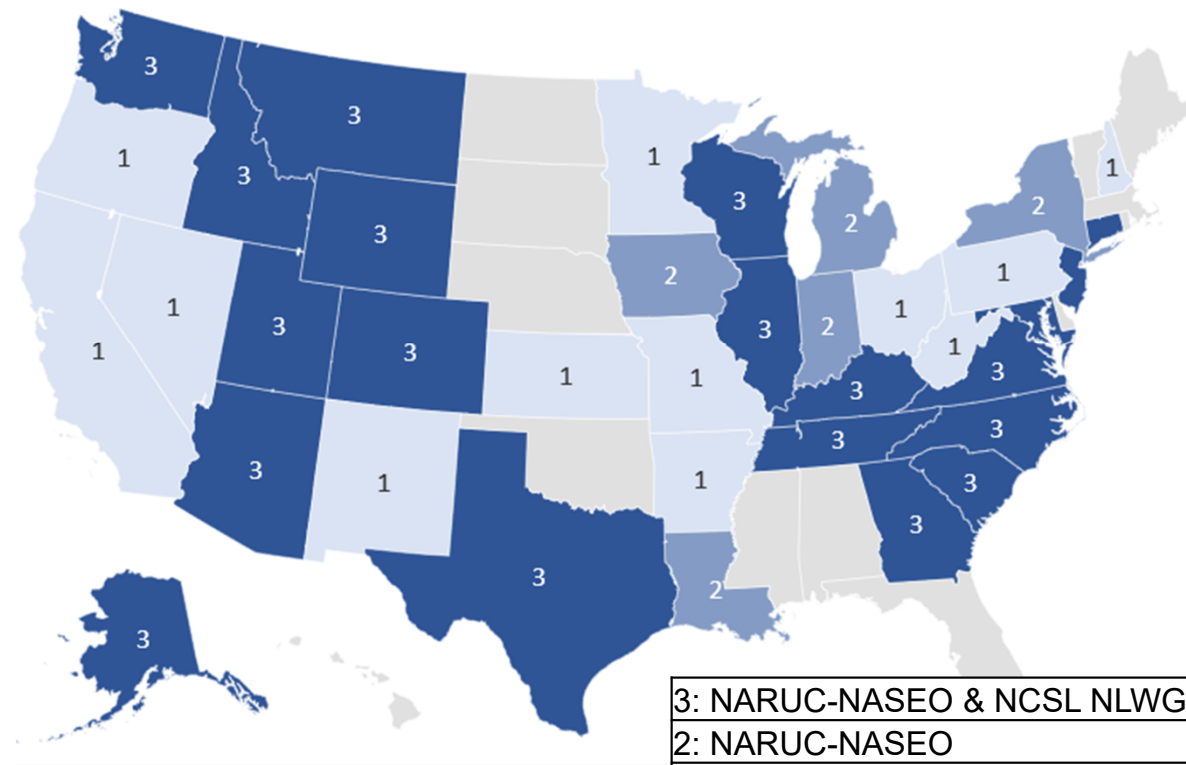
NARUC-NASEO Advanced Nuclear State Collaborative

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

National Level Working Groups



GAIN Coal Transition Research

Emily Nichols, GAIN Project Coordinator

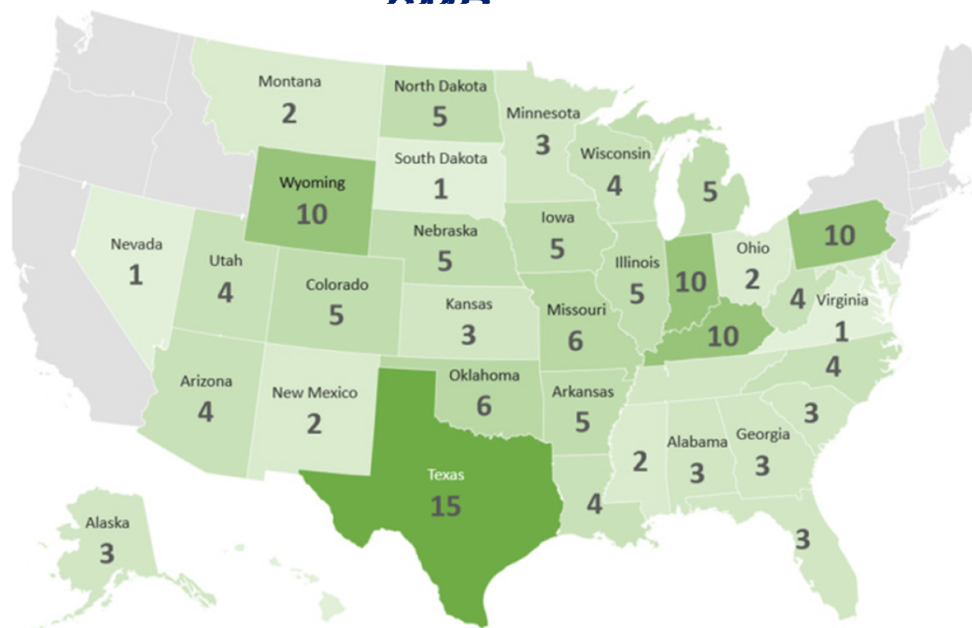


COAL TO NUCLEAR ENERGY COMMUNITY TRANSITIONS



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

80% of Evaluated Coal Sites Suitable for



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

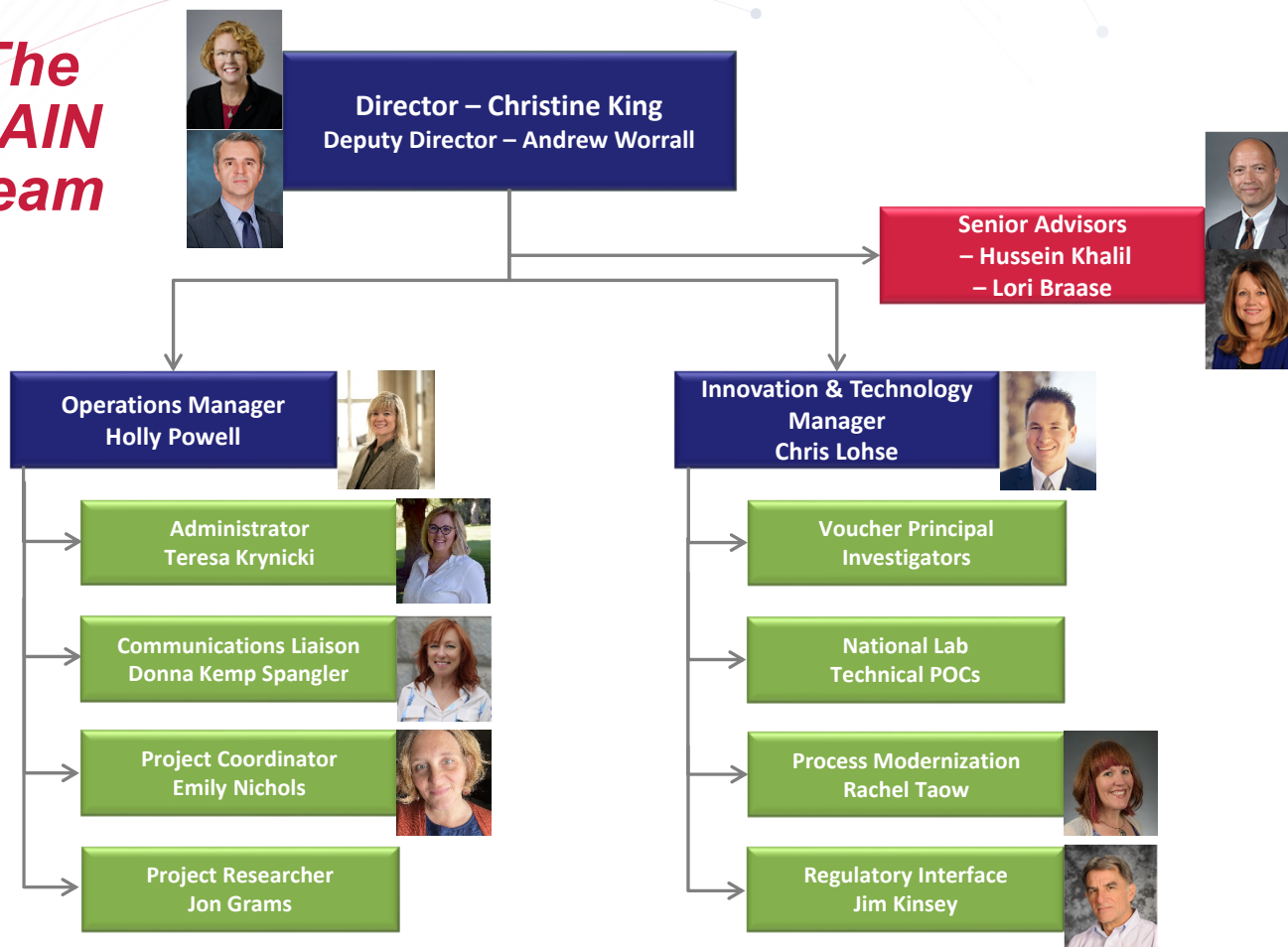
**Primary Objective: Assess the feasibility of transitioning from coal to nuclear;
Learnings can be applied to other coal units within commuting distance from CGS**

- 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

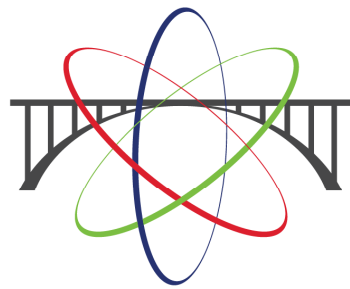


Coronado Generating Station
Owned/Operated by
Salt River Project
Located in
Saint Johns, AZ

The GAIN Team



January 2024



GAIN

Gateway for Accelerated
Innovation in Nuclear

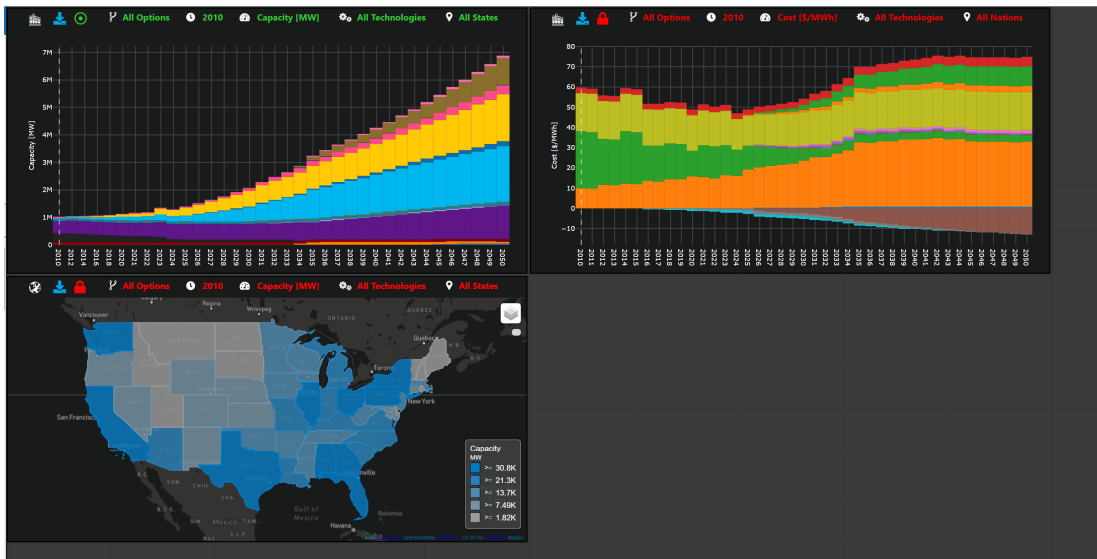


@GAINnuclear

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

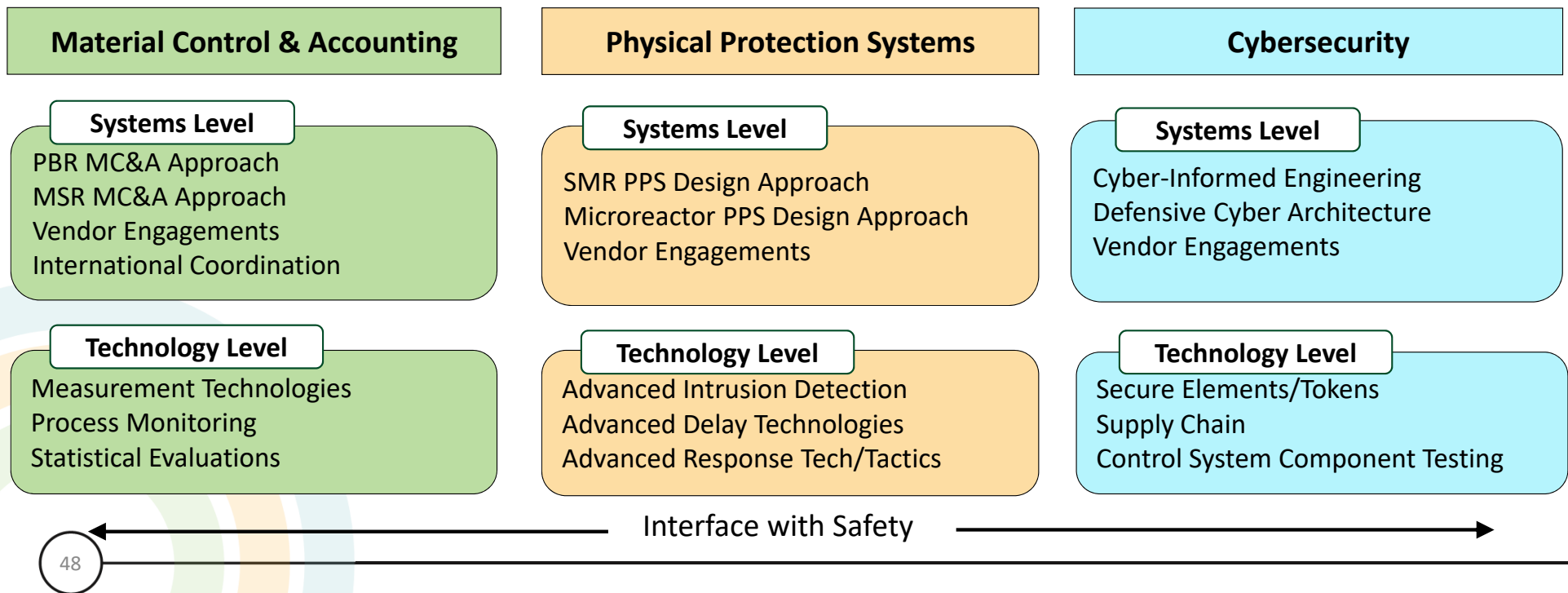
Sandia National Laboratories is a multimission laboratory managed and operated by National Technology and Engineering Solutions of Sandia LLC, a wholly owned subsidiary of Honeywell International Inc. for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-NA0003525.





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.



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.

Ben Cipiti, National Technical Director (SNL) bbcipit@sandia.gov

Katya Le Blanc, Deputy National Technical Director (INL) katya.leblanc@inl.gov

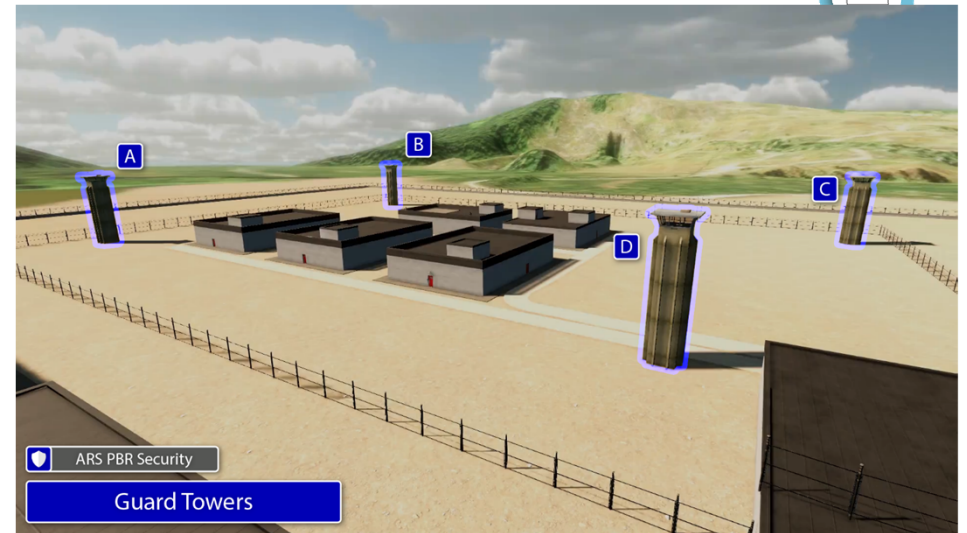
Dan Warner & Savannah Fitzwater, Federal Program Managers (DOE)

daniel.warner@nuclear.energy.gov, savannah.fitzwater@nuclear.energy.gov

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



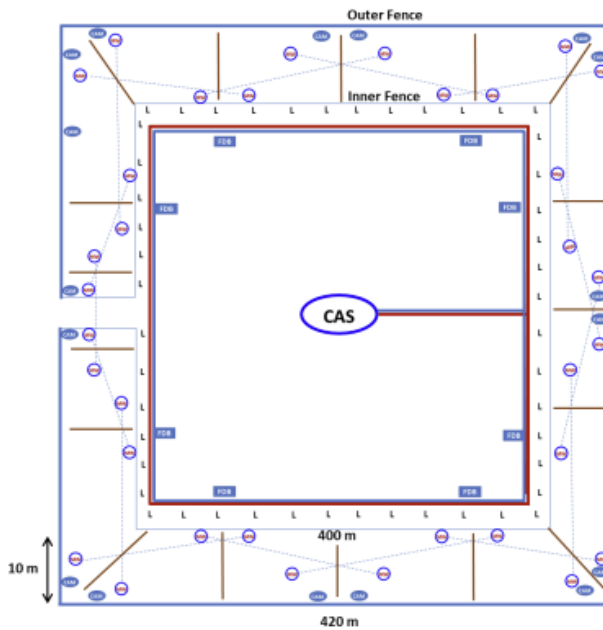
- Initial work examined the use of off-site response but has since moved away from that approach for several reasons:
 - Costs for agreements and training would be the same as on-site responders.
 - Response times lead to the need for significant delay (adding cost)
 - Questions about reliability
- Initial 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 nth of a kind.

Traditional PIDAS Design versus DPIDS (DMA-enabled PIDS Design)



Traditional

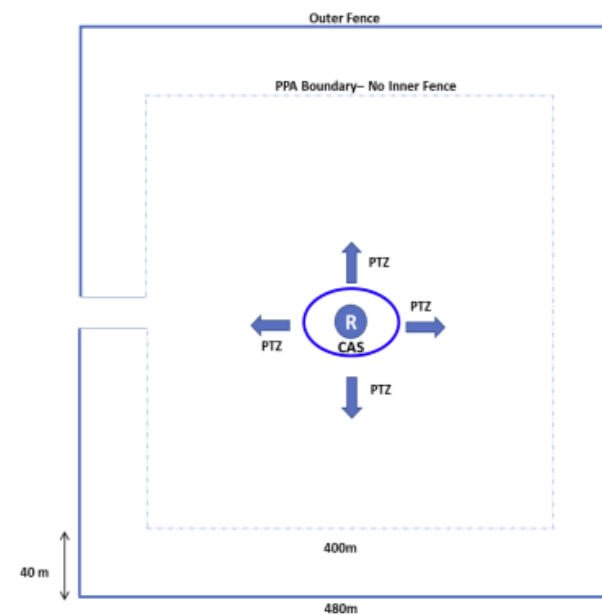
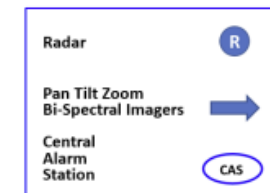
- PPA Boundary 400 m sides
- 17 Sectors
- 34 Microwaves
- 17 Cameras
- 8 FDBs (Field Distribution Boxes)
- 48 Lights/Light Poles
- Trenching for Power or Comms
- 8 Foot Security Fence
- Inner and Outer Fence, 3280m (10800 ft)
- 9 meter clear zone



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

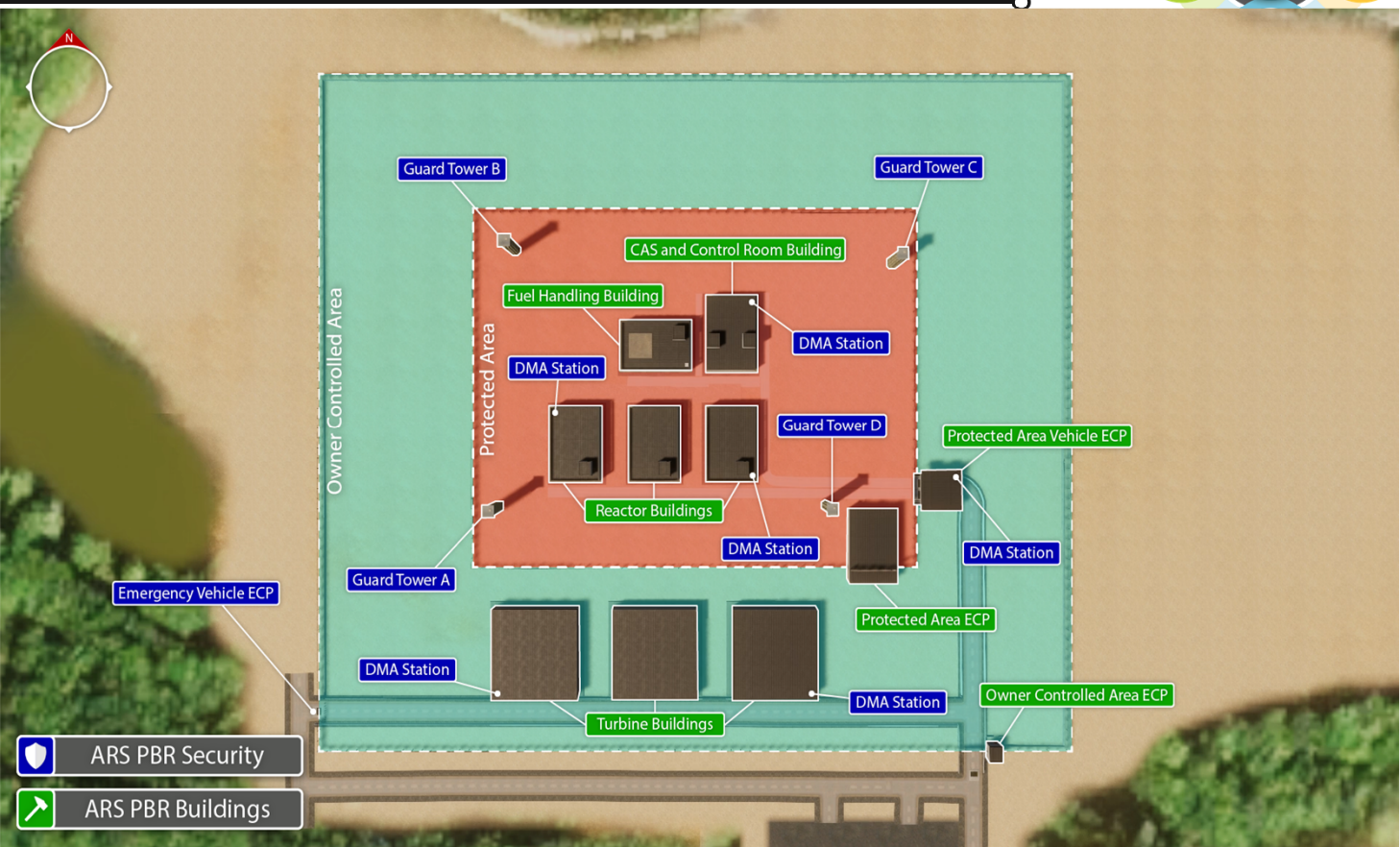
- Caveat Regarding "No Lights"
- No Lights on perimeter needed for intrusion detection
 - Lights on/around the CAS
 - Safety and Response Force may require lights



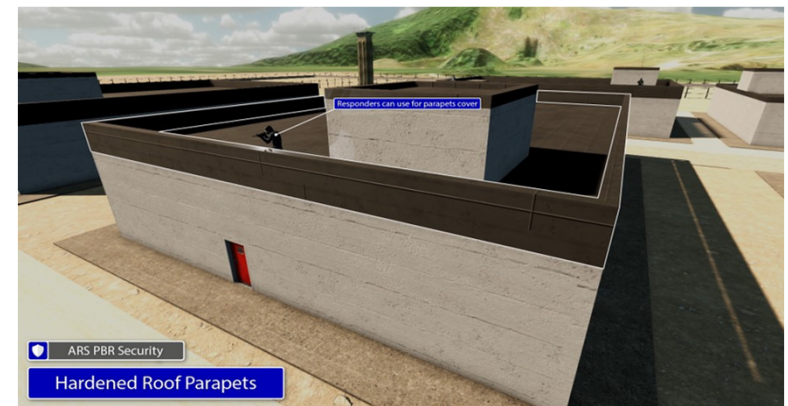
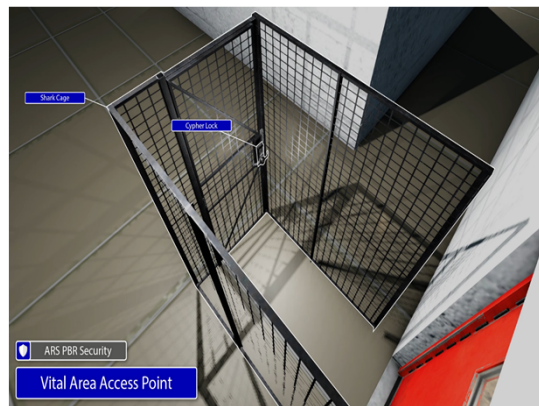
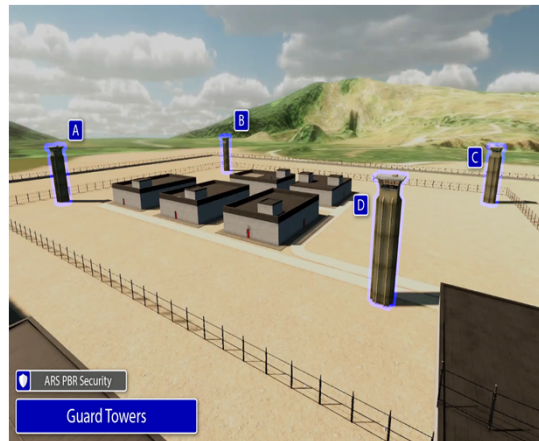
DPIDS Design is an estimated to cost 40% less than Traditional Design

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



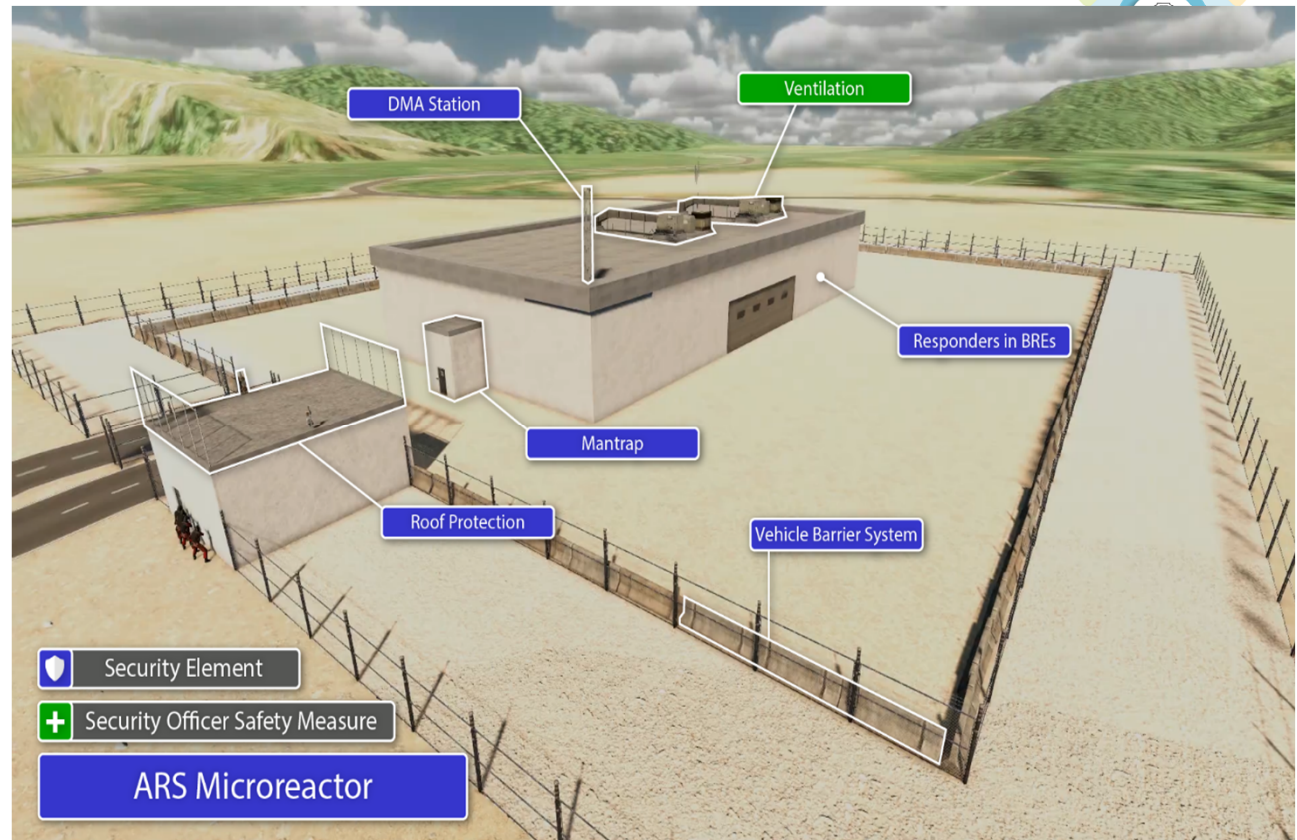
System Effectiveness Positions (Requiring Exemptions)

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

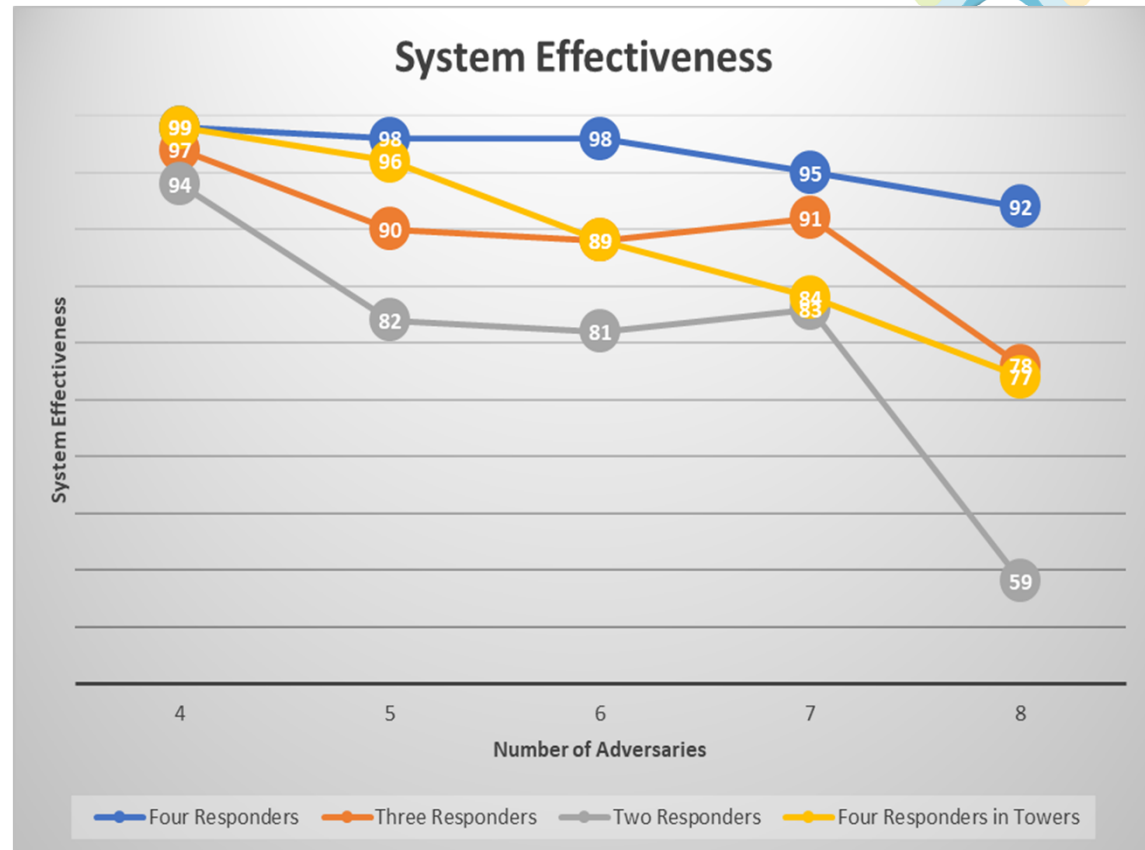
- Deliberate Motion Analytics → External Intrusion Detection
- Owner Controlled Area Boundary
- Protected Area Boundary
- 4 different scenarios analyzed
 - 4 internal responders
 - 3 internal responders
 - 2 internal responders
 - 4 responders in towers
- One Entry Control Point
- Two Vital Areas



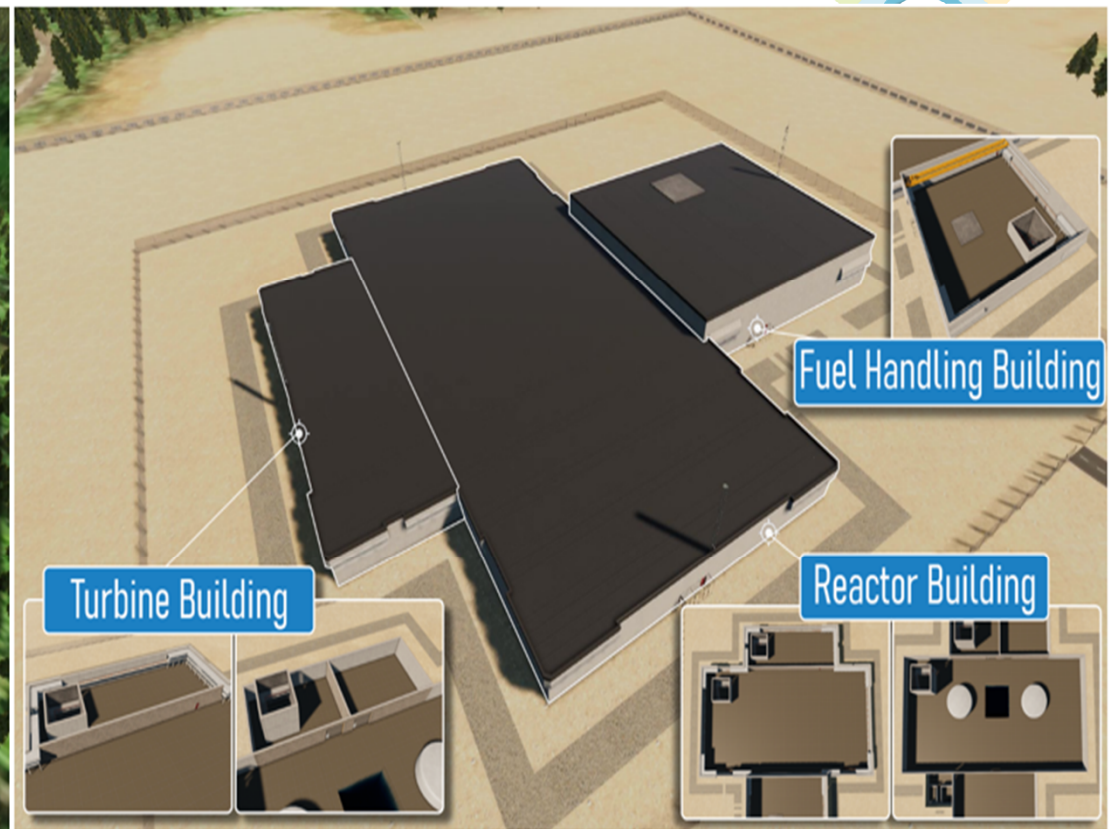
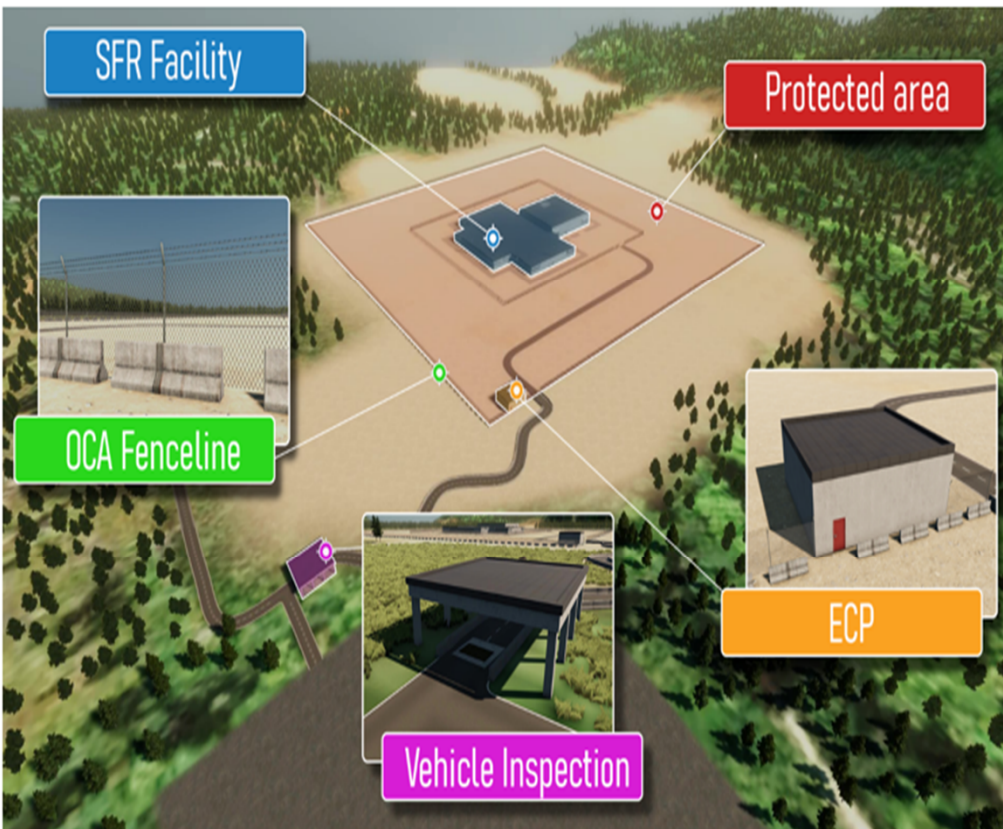
Microreactor System Effectiveness and Staffing Plan



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

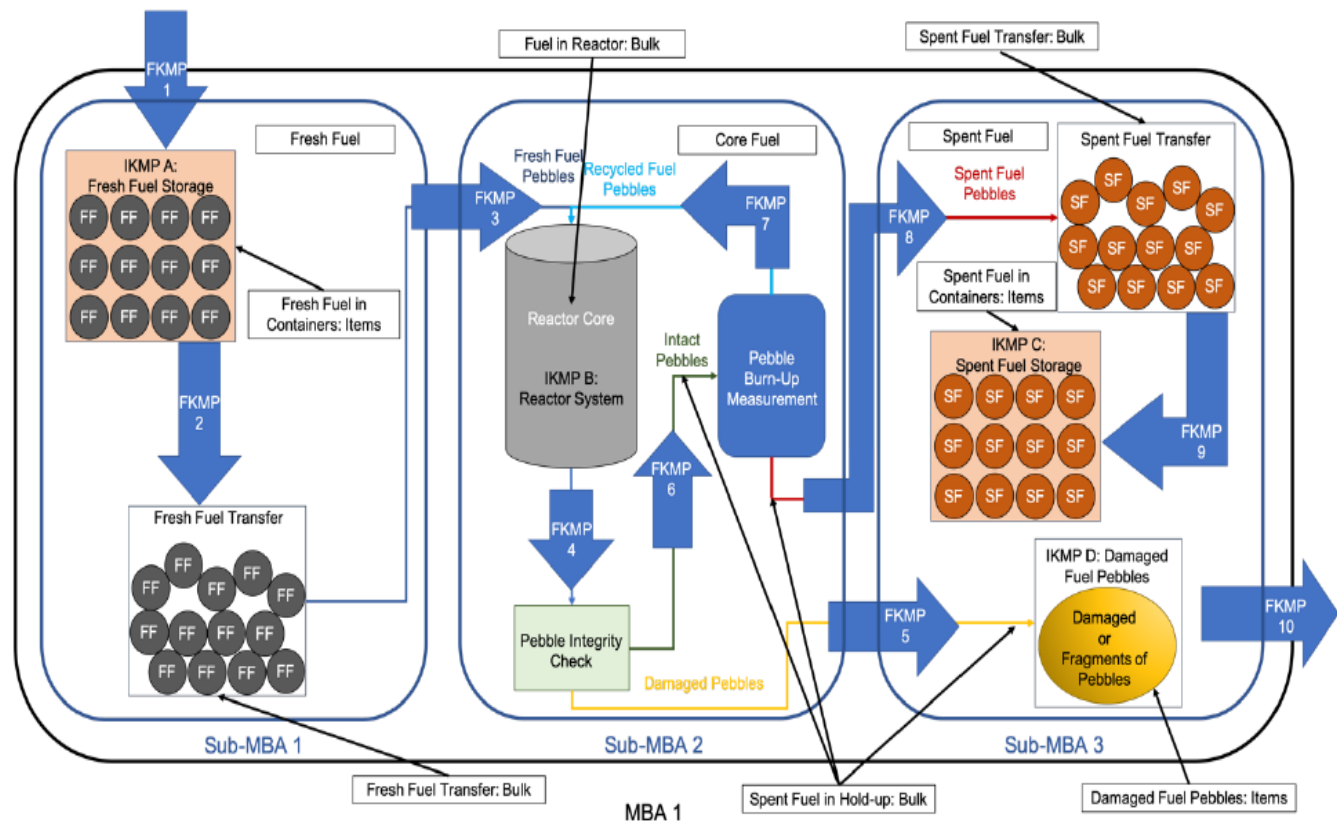
Onsite Response Staffing Plan

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



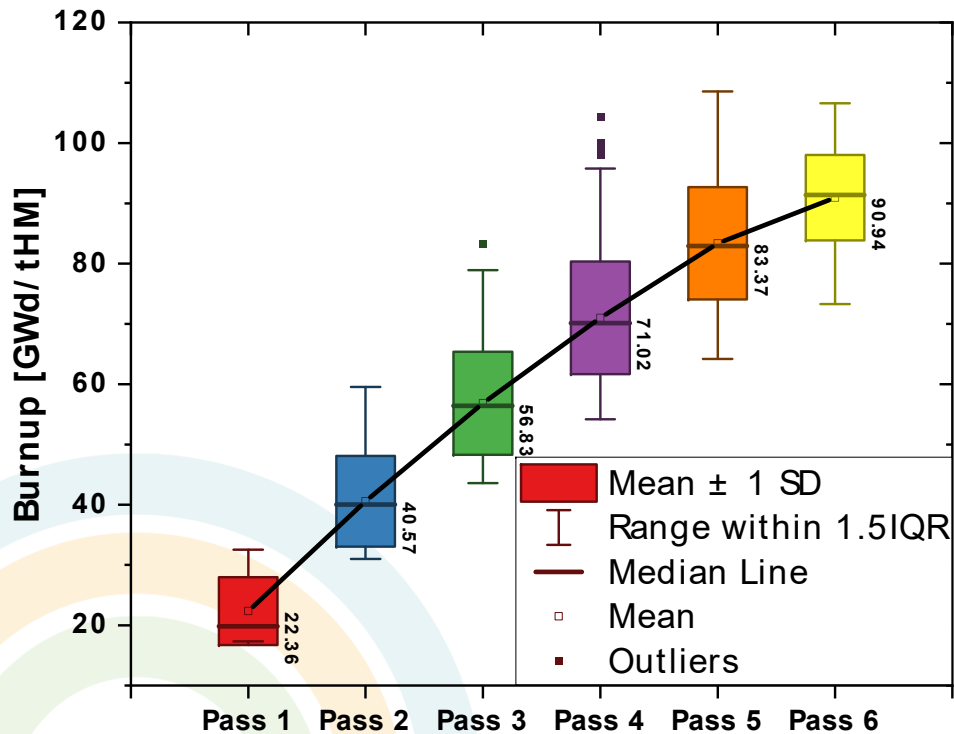
- Completed a milestone report on the MC&A approach for PBRs.
- Item accounting on fresh and spent fuel canisters.
- Fuel handling system consists of pebble counters, pebble integrity check, and burnup measurements.
- The burnup measurements can inform actinide content in spent fuel canisters.



MC&A for Pebble Bed Reactors



Core Exit Characteristics

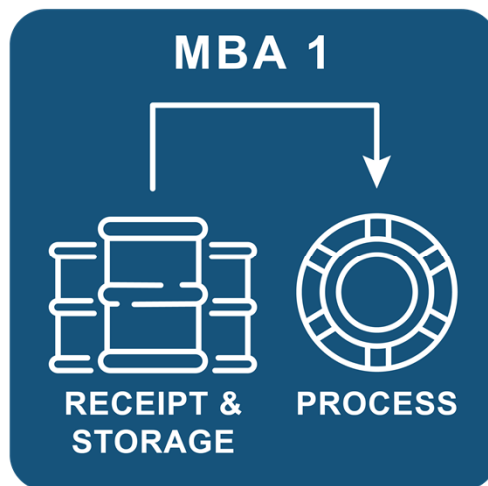


- The analysis on the left shows the range of burnup values achieved based on the pass.
- Based on a PBMR-400 model, the largest additional burnup achievable is 16.8 GWD/MT, so if the burnup limit is 100 GWD/MT, pebbles could need to be ejected once greater than 83.2 GWD/MT.
- ARSS is supporting an NDA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

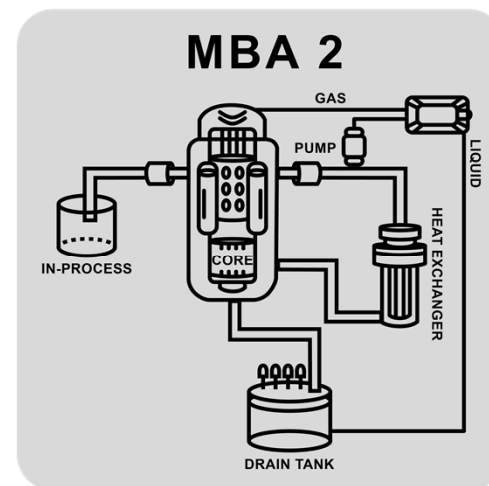
MC&A for Liquid Fueled Molten Salt Reactors



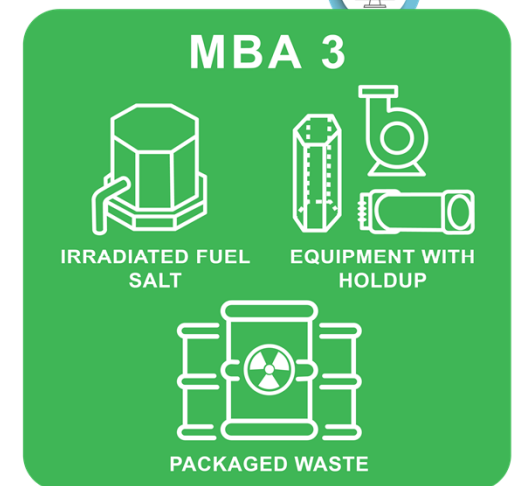
- MSR are bulk facilities and will very likely need to submit an FNMC plan.
- Item accounting at front end and back end, with diversion monitoring for the reactor loop.



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

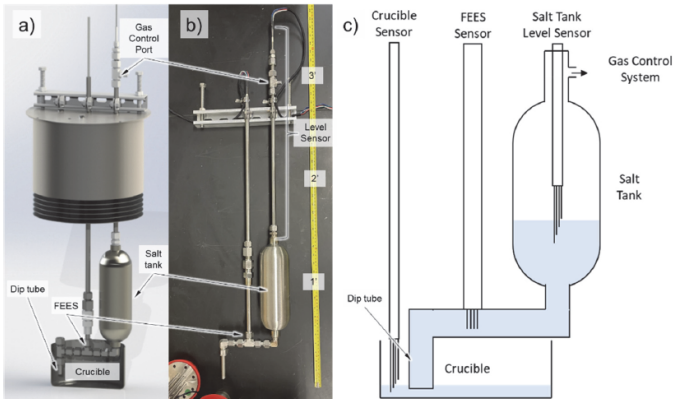


Monitoring performed in specific locations to detect diversion

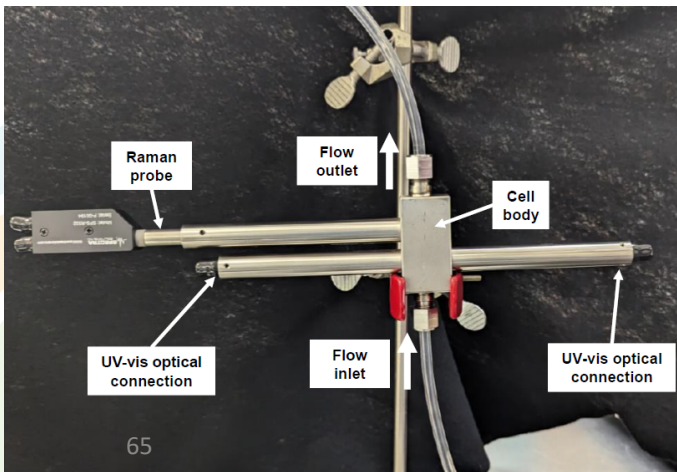


Periodic inventories performed, IDs and SEIDs calculated (follows Part 74 requirements)

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.

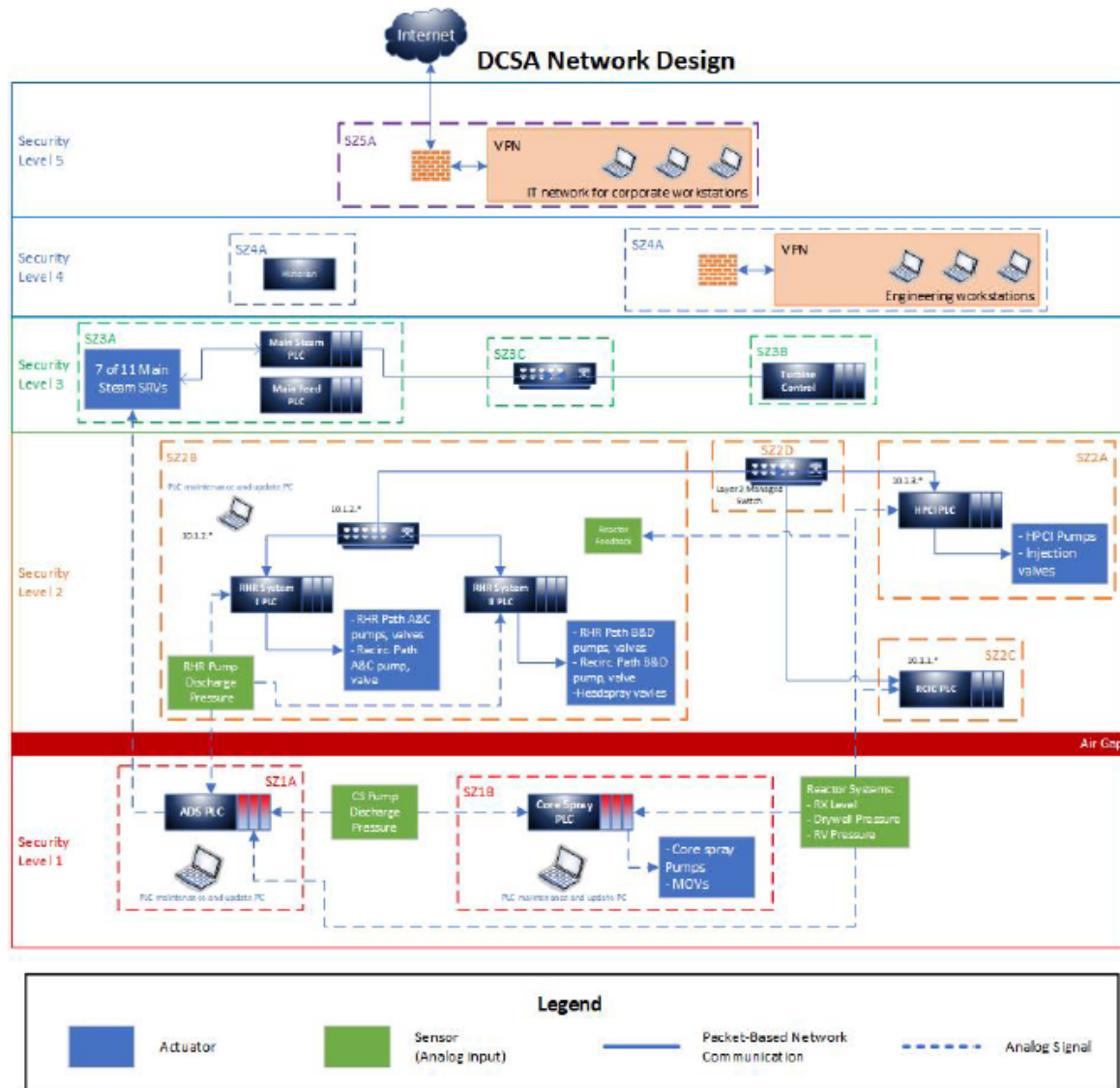
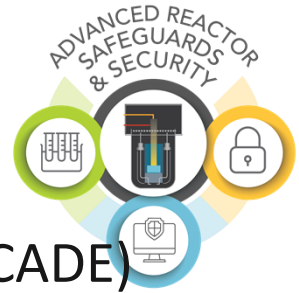


Figure 7. DCSA design of RHR System

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 MSR.
- 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:

Meeting Feedback

Meeting Feedback Form **EXIT**

Meeting Dates and Times

