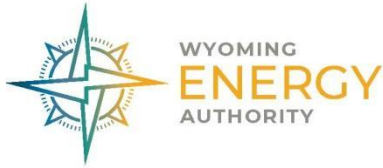




# **Nuclear Energy - Industrial Development**

Strategic Framework and Roadmap - Ver 1.6 - 06/05/2023



## **Wyoming's Energy Strategy**

[Wyoming's energy strategy \(WES\)](#) focuses on delivering the total value of our energy resources, from the extraction of commodities to transportation and transformation of raw products to the commercialization of energy services and goods.

The WES is an all-of-the-above plan of action that elaborates on how the Wyoming Energy Authority (WEA) will continue developing our existing industries while expanding investment in renewables, hydrogen, nuclear, geothermal, and rare earth elements.

This nuclear energy strategic framework is a component of the broader strategy. It details a strategic structure, a preliminary roadmap, and initial actions.

## **Wyoming Energy Authority (WEA) Intent**

- Provide a strategic framework that enables key stakeholders to accelerate their efforts to develop the nuclear energy industry in the State of Wyoming.
- Leverage the combined strengths of key stakeholders to implement an impartial, credible, and rational strategy that develops the nuclear energy industry from Q2 2023 to Q4 2026.
- Foster a regional-to-national alignment of efforts and resources to deliver precise and tangible outputs and achieve desired outcomes locally, nationally and globally.

## **Other potential uses**

- Provide uniform and consistent reference points for briefing or engaging internal and external stakeholders, potential partners, and the general public.
- Contribute to internal and external briefing and communication materials.
- Promote the formation of coalitions and collaboration with regional and national stakeholders by sharing purpose (why), objectives (how), and goals (what).

## **Intended Audience**

- This document is for broad distribution. This version and subsequent iterations will be shared on the Wyoming Energy Authority website.

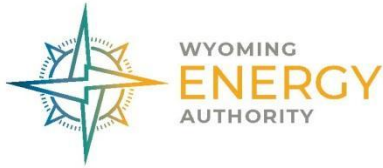


The strategic framework, preliminary roadmap, and initial actions described in this document were created from inputs collected in listening sessions, meetings, and industry-related events, and from the information gathered on the WEA's nuclear industry situation size-up and initial assessment, a vast array of publications, and engagements with state agencies and institutions.

This document describes a vision and ways to implement it, focusing on the structure necessary to deal with uncertainties and the complexity of these developing efforts. Depending on changing conditions and upcoming inputs, this document could be updated to continue to support establishing the Nuclear Energy industry and related industries in Wyoming.

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## Vision

As the Energy State, Wyoming will be the leader in the advanced nuclear energy economy: developing activities related to the production and trade of goods and services related to nuclear energy while integrating this technology with an all-of-above net zero energy strategy.

### **Lead and secure a sustainable position on nuclear energy technologies and related know-how for the world to become net zero.**

- Markets signal increased demand for net zero energy and products. It is also probable that other energy sources alone cannot satisfy end-user needs, and nuclear energy will complement other technologies with reliable, low-emissions energy.
- Advanced nuclear technologies will be critical in reducing uncertainties and securing energy and high-quality heat for specific applications (starting with military, remote locations, and niche applications).
- In this paradigm, developing Wyoming-based nuclear energy technologies and associated know-how is essential in securing Wyoming's prosperity for future generations while playing a key leadership role in securing America's economic security.

### **Lead and secure a sustainable position on technologies and know-how related to the use of nuclear energy for industrial and other specific applications.**

- Energy-intensive industries, extractive industries (e.g., critical minerals mining), remote locations, and the military are pressured to secure reliable, resilient, sustainable energy sources to sustain or grow their operations and expand to new markets or regions.
- Regions that offer reliable solutions to energy-intensive industries and other specific applications are likely to be disruptive and attract investments and industries due to their comparative advantage in low emissions and net-zero economy.
- In this paradigm, the first movers that secure these energy sources with commitments to develop the technologies and the associated know-how will likely secure sustainable positions in producing raw materials, parts, equipment, and related services to net zero energy.



## Strategic Framework

### **Nuclear Energy Value chain - Industrial applications of heat and power**

**Grow existing industries and activate new industries** - Leverage nuclear energy (heat and power) as a driver for low-emission, high-value industry development.

- Connect key players (end users, reactor vendors, operators, and local entrepreneurs) to develop the end-user cases to secure Wyoming's leadership in advanced nuclear reactor demonstrations.
- Create the supporting ecosystem that leads to these demonstrations and the development of heat and power applications for industrial purposes and specific needs.
- Leverage the know-how gained from these activities to expand into other regions, maximizing this approach's reach.

### **Nuclear Energy Supply Chain - From raw materials to finished products**

**Grow capabilities in the nuclear industry** - Target opportunities in the nuclear supply chain, including fuel cycle, materials, construction, fabrication, manufacturing, and services.

- Develop firm capabilities and the necessary public services/goods to secure gradual and sustainable participation in demonstration projects by early connecting developers, key partners, and stakeholders.
- Leverage this know-how by accelerating projects with similar needs and applications in other regions. This applies to places starting demonstrations and developing technologies related to advanced nuclear energy.
- Activate new markets for Wyoming-based technologies, know-how, materials, parts, and services.

### **Nuclear Energy Generation - Grid Scale Generation and Cogeneration**

**Support advanced nuclear generation** - complement the generation of dispatchable power with a high capacity factor using advanced nuclear technologies.

- Sustain Wyoming's leadership position as a first mover in grid-scale advanced nuclear energy, growing into a regional provider of nuclear-generated electricity.
- Continue to support utilities that want to add nuclear reactors to their generation capabilities and secure Wyoming leadership in the sector.
- Reduce financial and operational risks by collaborating and developing partnerships with nuclear reactor operator firms that could facilitate the adoption of nuclear energy generation by smaller utilities and cooperatives in the state.

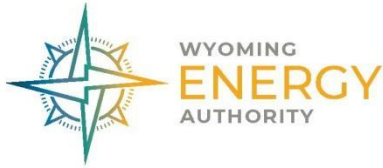


## Strategic Framework (visual representation)



## Strategic Priorities

1. Support the development of end-user cases and facilitate advanced reactor demonstrations. Aiming to connect opportunities with existing capabilities and develop relevant, productive know-how in Wyoming. Eventually, create the conditions and activate new capabilities for Wyoming-based firms to develop commercial projects in our state and other regions.
2. Continue identifying opportunities and developing markets for Wyoming’s natural resources (uranium). Also, identify opportunities and promote existing and newly acquired capabilities (productive know-how) in nuclear and adjacent industries such as construction, fabrication, and manufacturing.
3. Create the basic structure for a thriving industrial ecosystem that further develops the nuclear energy economy in Wyoming with a local-to-regional-to-global strategic approach.
4. Continuously identify growth barriers and develop specific solutions to address these constraints in collaboration with other stakeholders.
5. Invest in developing core and adjacent infrastructure that serves the needs of generation projects, supply chains, and industrial applications for nuclear energy.
6. Identify gaps and develop the solutions to support each strategic pillar (generation, supply chain, and value chain), including policy and regulatory recommendations, financing mechanisms, revenue structure, outreach, education, workforce training, and others.

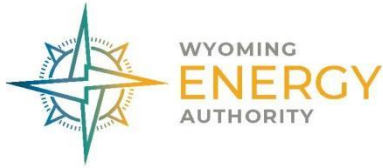


## Execution Guidelines

The execution of this strategic framework requires a minimal structure that defines the first steps that initiate action and empower the Wyoming Energy Authority (WEA) to facilitate the identification of forward pathways.

It is equally important to determine the initial guardrails that will support WEA's coordination role and other stakeholders' actions to implement this framework successfully. So the effort to implement this framework will be informed by the following guidelines:

1. Benefit Wyoming-based firms, entrepreneurs, communities, and the state regardless of demonstration/project long-term life cycle.
2. Leverage existing capabilities of business leaders and their firms to seize targeted opportunities across the entire nuclear energy supply and value chains.
3. Reduce information gaps related to demonstration and project needs in infrastructure, supply chain, public services, and goods.
4. Connect developers to existing local supply and services where possible.
5. Enable future possibilities by building capabilities linked to multiple opportunities in emerging energy technologies.
6. Leverage strategic partnerships (local, national, and international) projecting Wyoming leadership and capabilities into new and emerging global markets.
7. Provide clarity on the availability of financial resources and incentives.
8. Develop procedures and systems to support and attract new investments.
9. Address specific workforce needs in projects and adjacent opportunities by industry-led coordinated education and training.
10. When appropriate, agencies and stakeholders working on implementing this framework will coordinate efforts with the Wyoming Energy Authority, the School of Energy Resources, the Governor's Office, and the Joint Minerals, Business & Economic Development Committee.



## Critical Success Factors

As the WEA executes Wyoming's all-of-above energy strategy (which includes nuclear), the essential circumstances that help clarify opportunities and allow us to focus collective efforts to deliver tangible benefits are an iterative approach and an agile structure.

To enable this agility, the WEA will create and facilitate high-bandwidth teams that work independently of the existing structures necessary for current governmental functions. Due to the situation's complexity, this is essential to make a sustainable impact that produces a return on public investments that benefits firms, communities, and the state.

### Agile structure

Each strategic pillar (generation, supply chain, value chain) will have the necessary workstreams and workgroups with adequate structure, systems, and routines that enable agility. This is the conceptual model of this structure:

Strategic pillar(s) - Supply Chain

Workstream(s) - Materials, parts, and services

Workgroup(s) - Quality control and assurance programs

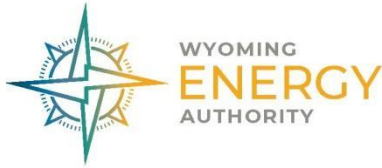
- Basic structure - project charter, initial action plan, routines, methodology, milestones, timeline, and communication plan
- Objectives and Outcomes - What problems are we trying to solve? What are we trying to achieve? What is the business case guiding our actions?
- Approach - What are the contributing factors to this problem? How will that achievement be realized?
- Measurement - What are the deliverables we are working towards? And how will progress be measured and reported to different stakeholders?

## Identifiable challenges

The successful execution of this framework will also require the State of Wyoming to overcome the following challenges:

1. A permitting and regulatory system mostly controlled by the federal government. This federal regulatory environment has been rigid but is evolving, which may or may not become more efficient and effective without compromising safety and reliability.
2. The uncertainties and risks inherent to technology development add to this regulatory uncertainty. Creating a situation where our ability to estimate development costs far exceeds our capabilities to identify specific outcomes and evaluate benefits.
3. The demand signal for advanced nuclear and its fuel is infrequent, creating uncertainty and dimming some development efforts and investments in the sector.





4. Currently, there are limited investments from the industry (end-users) ordering multiple reactors. And it is unclear where public investments are necessary to reduce uncertainties and cascade other investments.
5. Barriers to entry (e.g., high fixed costs, qualifications, etc.) could prevent many firms from entering the nuclear supply chain. In addition, a highly consolidated industry could present harder-than-expected obstacles to profitability.

## Success Enablers

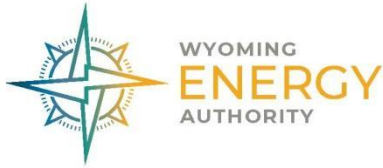
To overcome the challenges identified above, groups implementing this framework will maintain their agility, focusing on providing clarity and supporting ongoing private sector initiatives and projects. It is crucial to evaluate and monitor the progress of these success enablers to determine the most effective ways to support the industry and companies in their efforts to demonstrate and commercialize their products.

**Technologies readiness levels** - Technology readiness and pathways to demonstrations include developing end-user cases and identifying market positioning. Categorizing technologies into groups could clarify specific challenges that developers are facing and inform further action to support their demonstration efforts. Further analysis of these subgroups' technology readiness and development pathways is necessary.

- Microreactors, small modular reactors, medium and large reactors
- Grid-scale, scalable, land-based, mobile, and marine

**Commercialization Pathways** - As technologies advance and demonstrations are secured, several development pathways will continue to evolve and influence technologies' time to market. Categorizing pathways by these themes will help to inform the execution of this framework.

- Policy, regulatory and legal pathways
- Technology readiness beyond demonstration (market fit and scale-up)
- Social license and public engagement
- Supply chain development
  - Fuel cycle
  - Reactor parts and services
  - Engineering, project management, and construction
- Operations innovation
- Talent Pipeline
- Infrastructure needs
- Economics, Finance, and business models

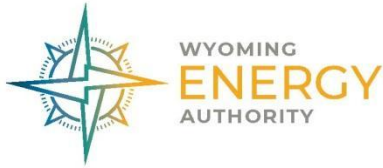


**Applications and Markets** - firms that successfully attend to end-users' needs and develop specific applications are most likely to find their pathways to commercialization. Initial efforts to understand what partners and stakeholders are involved in accelerating pathways to demonstration and commercialization will also be helpful.

**Key partners and stakeholders** - collaborative engagement and avoiding duplication of efforts at national and regional levels will help Wyoming continue to be a first mover in advanced nuclear energy domestically and globally.

- First Movers - military, remote, scheduled demonstrations and niche applications
- Early adopters - extractive industries, utilities, and critical applications
- Communities and public - communities and early adopters regions
- Universities - research and development
- State and Federal policymakers - licensing, siting and permitting
- Education and training institutions - workforce development

If necessary, these success enablers should become the primary focus of the workgroups responsible for implementing this framework.



## Initial Steps

This strategic framework is a multidimensional strategy that supports firms and addresses industry-wide development barriers. The initial steps proposed on the following pages organize and align efforts to maximize the direct and indirect participation of the private sector.

### GENERATION

This pillar focuses on supporting utilities and those interested in pursuing advanced nuclear energy to generate electricity.

#### **Desirable Outcomes:**

- The success of Natrium - Enabling this project to be on time, on budget, and on scope will continue to signal to the nuclear energy industry that Wyoming is a great place to host energy projects.
- The success of other reactor deployments - Enabling other utilities to reduce investment risk and add nuclear reactors to their generation capabilities will secure Wyoming's leadership position.
- Reduced financial and operational risks - Developing novel value propositions and partnerships with nuclear reactor operator firms could facilitate the adoption of nuclear energy generation by utilities around the state.

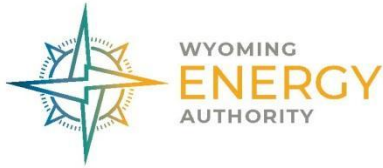
#### **Initial Focus:**

- Continue to support the efforts of the Nuclear State Agency Working Group.
- Formalize a workstream to support utilities and those interested in developing nuclear assets to generate electricity.
- Capability building of different state agencies and institutions to support existing and upcoming projects.
- Develop an industry permitting guide similar to solar and wind permitting guides.

#### **Initial Structures and Investments**

Utilities Workstream – Formalize the necessary workgroup(s) to support utilities developing nuclear assets and others considering adopting nuclear power generation.

- Initial workgroup (capability building) - Wyoming Energy Authority, Wyoming Public Service Commission, Wyoming Department of Environmental Quality, Idaho National Labs and Advanced Nuclear State Collaborative - National Association of State Energy Officials (NASEO), and National Association of Regulatory Utility Commissioners (NARUC).
- Supporting and Collaborating Institutions - School of Energy Resources, Wyoming Rural Electric Association, Nuclear power plant operators, Wyoming County Commissioners Association, and Wyoming Association of Municipalities. Others to be considered as necessary.



**Other efforts being considered:**

- Support TerraPower and Rocky Mountain Power in identifying other Natrium project sites in Wyoming.
- Engage with other utility leadership to understand their nuclear energy aspirations.
- Engage in strategic discussions with co-ops and municipal-owned utilities.
- Facilitate discussions with utilities and reactor owner-operators to discuss potential, timing, investment, and policy needs to develop new generation capabilities.
- Support utilities in community outreach and identification of potential sites.
- Further develop systems supporting utilities with their permitting process.
- Develop long-term solutions that mitigate investment and operational risks for utilities.
- Identify constraints to grow nuclear generation capabilities and identify legislative and policy needs and priorities.
- Engage with the Governor's Office and Legislature to identify policy gaps.
- Engage in national and regional energy discussions to leverage Wyoming's position in advanced nuclear energy generation.



## **SUPPLY CHAIN**

This pillar focuses on identifying nuclear energy supply chain segments where Wyoming firms can differentiate and compete, alone or in partnership with firms in other regions. This includes nuclear materials and parts, uranium mining and processing, fuel development and management, nuclear and non-nuclear grade construction, fabrication and manufacturing, and technical and operations services.

When targeted opportunities in the nuclear supply chain are identified, the workstreams in this strategic pillar will identify barriers and constraints for the industry and a path to grow.

### **Desired Outcomes:**

- Expansion of Wyoming's uranium industry.
- Established position in uranium conversion, enrichment, and HALEU production.
- Increased capabilities and certification of manufacturing and construction firms.
- Expanded production of existing manufacturing and construction firms.
- System to track opportunities related to the nuclear energy industry.
- Process to identify capabilities gaps in firms pursuing supply chain opportunities.

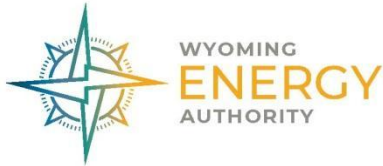
**Initial Focus:** Formalize the following two workstreams

#### **Fuel workstream:**

- Analyze the current status of the domestic nuclear fuel cycle.
- Identify gaps or barriers and determine the role that firms and institutions in Wyoming could have in addressing these existing constraints.
- Engage with the Wyoming Mining Association uranium committee to complement their development efforts.

#### **Materials, parts, and services workstream:**

- Organize town halls for Wyoming-based firms interested in diversifying their portfolio.
- Assess the advanced manufacturing supply chain, identify gaps in the nuclear fuel cycle, and the role of firms and institutions in Wyoming could have in addressing these existing constraints.
- Assist manufacturers in developing their manufacturing capabilities (equipment, labor, and processes) to serve nuclear and non-nuclear (energy and balance island) sectors.
- Develop quality assurance certification in manufacturing and construction in nuclear standards (NQA-1) and industry-wide standards (ISO).
- Assist manufacturers in identifying partnerships and opportunities for demonstration, development, and construction (domestic and international projects).
- Assess the feasibility of developing a microreactor center of excellence that addresses manufacturing needs, systems development, and fuel fabrication.



## Initial Structures and Investments

### Fuel workstream:

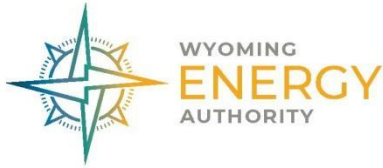
- Initial workgroup - Wyoming Energy Authority, Wyoming Department of Environmental Quality, Wyoming State Geological Survey, Idaho National Labs, and Wyoming firms.
- Initial structure - authority, project charter, initial action plan, routines, communication plan, and methodology.
- Work with Wyoming Mining Association to create a development strategy for the initial stages of the fuel-cycle front end.
- Supporting institutions: Nuclear power plant operators, firms in the sector, School of Energy Resources, Wyoming Business Council, Wyoming Business Resource Network, Wyoming Innovation Partnerships, Wyoming Mining Association, and WyGISC (NREX). Others to be considered as necessary.

### Material, Parts, and Services workstream

- Initial workgroup - Wyoming Energy Authority, Manufacturing Works, Wyoming Business Council (WBC), Department of Environmental Quality (DEQ), Idaho National Laboratory, and Wyoming firms.
- Integration of systems that enable connection of energy project needs with local suppliers and firms.
- Continue to enable Wyoming businesses and entrepreneurs with technical perspectives to develop the manufacturing, fabrication, and construction brain trust.
- Supporting and collaborating institutions: Nuclear reactor vendors and developers, firms in the sector, School of Energy Resources, Wyoming Business Resource Network, Wyoming Innovation Partnerships, CONNEX Marketplace, and WyGISC (NREX). Others to be considered as necessary.

### **Other efforts being considered:**

- Assess the need for a health physicist at UW.
- Develop partnerships with advanced reactor developers and vendors.
- Educate Wyoming firms on the nuclear energy market, industry trends, current opportunities, and quality standards.
- Enable Wyoming firms to access federal programs (GAIN) and nuclear energy-related procurements.
- Develop a compelling reason and process for recruiting firms in the nuclear energy industry.



## **VALUE CHAIN**

This pillar focuses on developing next-generation industrial and manufacturing activity driven by nuclear energy heat and power. This will be done by leveraging the high energy density and zero emissions thermal output of nuclear reactors to sustain and increase the competitive advantage of selected industries (e.g., trona, hydrogen, and critical minerals). And leveraging nuclear energy (heat and electricity) as a driver to support the development of other high-value industries (e.g., critical materials) by creating a sustainable comparative advantage for Wyoming.

### **Key Outcomes:**

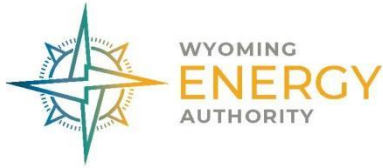
- Wyoming industries established a sustainable position in their pathways to net-zero and long-term production with the support of advanced nuclear technologies.
- Matured coalitions of technology developers, reactor vendors, industrial end users, and communities are effectively supported by a practical innovation ecosystem.
- Major industrial players were recruited to Wyoming and benefited from the above outcomes. Targeted industries may include pig iron, modular steel, specialized glass, critical minerals and materials, chemical manufacturers, digital technology centers, and direct air capture.
- Establish partnerships with other regions to reach new opportunities and markets.

### **Initial Focus - Formalize the industrial application workgroup**

- Continue to facilitate the formation of strategic partnerships between technology developers, reactor vendors, industrial end users, and communities.
- Continue to develop the Frontiers partnership at Wyoming Energy Authority, leveraging the existing statute and capabilities, such as bonding for infrastructure improvements.

### **Initial Structures and Investments**

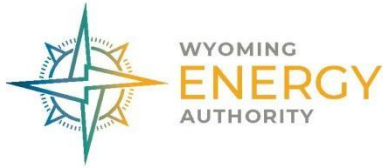
- Initial workgroup - Wyoming Energy Authority, Wyoming Business Council, Idaho National Laboratory, energy-intensive industry, nuclear industry firm, and Wyoming firms.
- Creation of the “Frontiers Industrial Innovation Center” at Wyoming Energy Authority. This structure will support existing and new industrial users in their pathways to net zero.
- This structure also aggregates efforts and financial services (bonding, cost match, or other services), aiming to complement these with existing federal and commercial financing.
- Supporting and collaborating institutions: Nuclear reactor vendors and developers, other firms in the sector, School of Energy Resources, Wyoming Business Resource Network, and Wyoming Innovation Partnerships. Others to be considered as necessary.



**Other efforts being considered:**

- Develop a sharp focus on energy-driven industrial production leveraging advanced nuclear technologies like microreactors to grow existing industries or develop low-emissions industrial sites.
- Develop infrastructure for these energy hubs that can grow incrementally, allowing it to be deployed at different geographic locations and increase the productivity of low-emission, high-value manufacturing firms in different state regions.
- Support this incremental and distributive approach with existing energy technologies (e.g., Natural Gas and CCUS), signaling that Wyoming is developing low-emission industry zones that utilize Wyoming's all-of-the-above strategy and secure affordable and reliable energy.
- Support industrial end-users' identification of potential technological solutions to attain their energy needs and development of connections with vendors/developers.
- Identify technology and policy needs to advance this vision, engaging regulatory, academic, and legislative bodies to close those gaps.
- Identify focus for academic research and technology development. For example, develop a simulator and test facilities providing a test bed for advanced nuclear technologies and net-zero industrial heat (process heat) systems with supercomputing, cyber security, and electrical engineering capabilities.





## **EXTRA CONSIDERATIONS**

As the implementation of this framework accelerates, these considerations will become more relevant and support efforts in all pillars:

### **Forward-looking considerations**

- How to create global partnerships and collaborations to build markets and strengthen Wyoming's position?
- How to support the development of new business models that are innovative and build on Wyoming's strengths?
- How to engage in national policy (industrial, energy and trade) to include regulatory frameworks and become a more influential player in this sphere?

### **Education & Outreach**

- How to create a technical nuclear energy council to advise and answer questions and concerns from the executive and legislative branches of the Wyoming government?
- How to further develop a nuclear energy introductory track for stakeholders in Wyoming?
- How to develop professional development support for state employees? Consider initially leveraging existing external resources than developing new courses or programs.
- How do we evolve the advanced nuclear webinar series to provide education and continuously share information with the general public?
- What courses should be offered at UW and Community Colleges in nuclear-specific education? What type of certificates could help upskilling workers in the energy and adjacent industries?
- Could UW also develop a nuclear policy class that could be offered as part of this certificate program and as an elective within our energy resource management minor?

### **R&D**

- How to support the development of innovative technologies and practices by leveraging existing federal efforts like Gateway for Accelerated Innovation in Nuclear (GAIN) and HALEU Availability programs?
- What is the opportunity for innovation in the fuel cycle and the solution for the increasing demand for advanced fuels? This will include policy development options.
- How to leverage opportunities for the benefit of Wyoming citizens while preserving environmental stewardship and maintaining social license?
- How best to engage with Federal agencies as they develop new regulations for the advanced nuclear reactor and microreactor industries?