# An Assessment of Policies and Regional Diversification with Energy, Critical Minerals and Economic Development in Emerging Markets

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**Summary**

The aim of this study is to primarily evaluate: (1) energy policies of the 50 U.S. states associated with carbon and/or nuclear energy, and (2) emerging market or regional diversification potential for Alaska and Wyoming communities in relation to energy, critical minerals mining and related economic development.

A 50-state analysis, primarily of the past couple years, shows recent increases in carbon management policies, namely renewable portfolio standards (RPS), clean energy standards (CES), and targets, reflecting an intensification of net zero priorities. A review of state-wide nuclear policies shows a mix of instruments being introduced, encouraging new nuclear or providing economic support for existing nuclear plants to remain in operation.

Case analyses of Nome, Alaska and Gillette, Wyoming highlight new opportunities with net zero priorities and infrastructure funding, if regional strategies and labor force needs are sufficiently factored.

## TABLE of CONTENTS



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## PART 1: Work Scope

- *Participate in an assessment of the opportunities and barriers for microreactors in emerging markets.*
- *Review recent Microreactor Program reporting and related literature that is relevant to energy system change and industry developments for Wyoming and Alaska (in consultation with project lead).*
- *Review recent carbon and nuclear policies in the 50 states for developments and trends.*
- *Perform expert and stakeholder elicitations, leverage Microreactor Program studies and snowball sampling, and develop a cross-sectoral list of policymakers and key stakeholders in two prospective communities (WY, AK) that is representative of pathway considerations and broader community interests. Conduct elicitations with constituents using semi-structured interviews, public meetings/focus groups, surveys, and/or other techniques.*
- *Evaluate the potential for graphite mining in conjunction with a microreactor versus an alternative form of energy in a community in AK. Complete a similar case for WY. This will include a focus on industry/infrastructure repurposing/adaptation, environmental sustainability, and community/workforce development.*

## PART 2: Overview of Microreactors and Change

### Opportunities and Barriers for Microreactors in Emerging Markets

Participation in discussions about opportunities and barriers in emerging markets occurred with the Kawerak Incorporated Leadership Summit, Nome Workforce Summit, Wyoming Technology Summit and Frontiers Meeting, Alaska Nuclear Working Group, the Alaska Center for Energy and Power, Alaska Power Association, Alaskan stakeholders (including those in economic development, utilities and communities), and Wyoming stakeholders (including with the Wyoming Energy Authority, Wyoming Business Council, Wyoming Geological Survey, Jackson Hole Technology Partnership), Harvard's Growth Lab, U.S. DOE, the Nuclear Reactor Innovation Center, White House Office of Science and Technology Policy, U.S. Nuclear Regulatory Commission, Battelle, the Atlantic Council, Advanced Nuclear and Production Experts, Citizens for Responsible Energy Solutions, Clear Path, Nuclear Energy Institute, and C5 Capital.

### Energy System Change and Microreactor Potential in Emerging Markets

Broadly, there is a strong sense today that energy and related markets need to be managed differently (Araújo, 2023a, 2017). Whether planned or unplanned, public and private agendas increasingly highlight the importance of strategic planning that accounts for resilience and sustainability, safety, security, and affordability, as well as other co-benefits (Ibid, Koerner, 2022). In recent times, geopolitics and extreme weather events have shown how global market dynamics and uncertainties can transform energy outlooks (Araújo 2023a; Araújo and Shropshire, 2021).

In conjunction with the above influences, conventional wisdom increasingly prioritizes mitigation and adaptation to the changing climate (IPCC, 2022). Among energy options, nuclear energy represents a proven, base load form of low carbon energy. Looking more closely, the disruptive potential of microreactors – a subset of small modular reactors on the order of 1-20 MWe – lies in their mobility, transportability, and long refueling intervals in addition to planned design enhancements with passive safety features (Black et al, 2022).

Differences for microreactor technology from traditional GEN III nuclear technology present new markets for adoption, particularly where energy prices are at a premium and/or other energy resources are limited (Ibid). Microreactors may become competitive in locations where large power grids are not present, yet demand exists from communities or industries in which fuel delivery is limited/expensive, or economies of scale are not currently attainable (Ibid). Smaller facility footprints, design simplicity, and more efficient construction represent other distinctions (Ibid).

Focusing on energy transitions as well as other types of technology change, niche markets are seen as opportunities for demonstration (Schot and Geels, 2008; Raven et al, 2010; Araújo, 2023b). In such niches, learning by early adopters allows technology improvements as well as cost reductions, while enabling later adopters to monitor progress (Rogers, 1995; Grubler, 1998; Araújo 2023a). Specific to microreactor technology, **opportunities** for niche markets are seen in remote regions, areas with energy-intensive industries including mining and data centers, distributed microgrids, disaster relief, and marine propulsion, among possibilities. **Barriers** also exist in terms of the uncertainty about the final designs and implications, such as the cost of manufacturing and operations, changes in permitting, and questions about waste management. Current designs regularly factor for adaptations in fuel type, sensors, electronics, materials, and safety systems (Black et al., 2022). These newer designs may be more suited for load-following, black-start capabilities, and more automated functions (Ibid). Regulatory and institutional challenges, in turn, exist in that there is a need for new or revised regulations and related learning where microreactors differ from their larger counterparts.

A number of recent studies by the Emerging Energy Markets Analysis Initiative (EMA), for the DOE Microreactor Program or related studies are outlined.

Shropshire and Araújo (2021) reviewed challenges for electric utilities in characterizing resilience in order to harden power systems. A meta-level framework was put forward that integrates economic, environmental and social attributes with a focus on locally-defined priorities and values. The framework integrates qualitative, quantitative and geospatial assessments. It was then applied to various examples of extreme weather events within the US, including the prospective use of a microreactor following Hurricane Maria in Puerto Rico.

Gerace (2022) completed a multi-study review of Wyoming residents' perceptions of energy, desires and values to highlight opportunities and barriers for the adoption of nuclear technologies in Wyoming. Specific to opportunities, many residents either support nuclear energy or report not being sure, indicating a level of openness for them to learn more and increase their support. In terms of barriers, Wyoming respondents remain opposed to risk (Ibid).

Wise et al completed three studies. The first (2022a) examined western state renewable portfolio standards, finding that a significant portion of the western electricity markets remain available to nuclear generation, yet market restrictions may impact new investments in nuclear generation capacity. A second study (Wise et al, 2022b) assessed conditions under which a microreactor could be considered a qualifying facility under the Public Utility Regulatory Policies Act of 1978. They found “it would need to be operated as a ‘cogeneration facility’ producing not only electricity but also producing heat or ‘useful thermal energy’ for use with other systems and applications (Ibid).” Finally, in an overview of the regulatory framework for nuclear microreactor applications in Wyoming, Wise et al (2022c) found that “Wyoming may be well-suited for the siting of nuclear facilities, including microreactors, due to its open spaces and its largely favorable state and local regulatory environment. Under state law, nuclear projects may require approval from the Industrial Siting Council approval and could be subject to county and city zoning laws.”

Stoelllinger et al examined potential clean energy hubs and stakeholder road mapping for Wyoming (2022). They evaluated three case studies, representing a range of possibilities for the state, then detailed a stakeholder identification process and applied it to a hypothetical example of a microreactor hub for Trona mining and chemical processing.

Black et al (2022) produced a review of the technology, potential markets, economic viability, plus regulatory and institutional challenges of nuclear microreactors. This elaborated technological characteristics for the wide range of microreactor designs, distinguishing them from large nuclear power plants and small modular reactor designs. This analysis also identified areas for regulatory address.

James and Watson (2022) completed an economic study, estimating the medium-term impacts from a broader set of alternative energy capital investments. They found that newer low-carbon generation has much larger (positive) effects than fossil fuel generation on the local economy and affirmed that declining regional electricity prices attract new businesses, especially those that are energy-intensive.

## PART 3: Research Design for Policies and Cases

*Summary: Methods, data and logic are detailed for the in-depth sections of the report.*

The policy review for the 50 states was completed using national sources, primarily the DSIRE database, National Conference of State Legislatures, and Nuclear Energy Institute, that were cross checked with state policy updates.

Background research for case studies was completed on historical and contemporary conditions in Alaska and Wyoming for socio-economic, environmental, energy and industry developments of interest, including the mining history, plus nuclear perspectives and activity. The research included the status of critical minerals in both states, based on the Defense Production Act, Title III Presidential Determination for Critical Materials in Large-Capacity Batteries, plus additional minerals which carry similar national security attributes.

Two community cases were selected for a more systematic study of interests and priorities tied to energy diversification. Nome was chosen for Alaska, based largely on its high energy prices as well as the new mining that is being considered for graphite. Special focus is on not only the prospective Graphite One mine, but also the development of a deepwater port. Gillette was selected for Wyoming, based on a decline in coal mining, plus its history, proximity and resources for uranium mining. Uranium is not currently on the DPA, but a domestic uranium supply is recognized as having national and energy security importance. Special focus, then, is on scaling of renewed uranium mining around Gillette.

The case studies assessed the following meta-level question through elicitation:

**What potential exists for energy diversification and economic development in the next 5-10 years, possibly with a microreactor or other alternative energy, for the communities of focus?**

To do so, the meta-level question was broken down into 4 sub-questions:

1. **What economic developments, including mining of graphite (AK) or uranium (WY), are likely in the communities of focus for the next 5-10 years?**

2. **What considerations were raised for a microreactor vs. another alternative form of energy vs. continued reliance on fossil fuel, if economic development were to scale up due to new mining and/or other development for the respective communities?**

3. **How would greater economic development in the next 5-10 years translate in terms of industry/infrastructure, environmental sustainability, and community/workforce development?**

4. **What are the opportunities and barriers for MRs in these communities?**

A list of prospective interviewees was developed, beginning with a literature review of key actors, then purposive and snowball sampling to reflect stakeholders across the relevant sectors. More than 40 semi-structured interviews were completed in person, by phone and/or via Zoom.

## PART 4: Carbon and Nuclear Policies

*Summary: This section examines recent trends and developments in state policies, with an emphasis on the past several years, for carbon and nuclear support against a backdrop of recent, federal changes.*

### *Federal and State Policy Focus*

Priorities associated with decarbonization and resilience in the context of modernization have been at the foreground of federal and state level energy policies in recent years. With the ongoing conflict in Ukraine and related sanctions on Russia, energy security, extreme price flux, and shortages have further shaped energy agendas.

With the above conditions as the current context, industrial policy has emerged as a driving force. Several major pieces of federal legislation –- namely, the Inflation Reduction Act, the CHIPS and Science Act, and the Infrastructure Investment and Jobs Act -- aim to strategically leverage the resources and capabilities of the federal government to spur production and create industries at the state and regional levels. As the legislative branch of the U.S. remains in a state of contest, executive use of the Defense Production Act has focused on energy-related priorities, specifically critical minerals.

### *Carbon Policies*

The U.S. is pursuing multiple decarbonization goals in alignment with the Paris Agreement and other commitments which target greenhouse gas emissions. The long-term national strategy targets both carbon-pollution free electricity (2035) and net-zero emissions (2050) which need to be rooted in policy and implemented by governmental and non-governmental actors (U.S. Dept of State, 2021). Though the federal government recognizes the need to rapidly decarbonize, non-federal entities, such as states, large corporations, and utilities are leading the way, while the federal government provides financial support for developing technologies and programs through the Inflation Reduction Act, and Infrastructure Investment and Jobs Act. A variety of solutions have been proposed and begun in response to these problems. Individual state responses are categorized and explained in Table 1. In response to international energy market demands, the Executive Branch has used powers to increase the production of gas, critical materials, and to isolate and address supply chain issues. Simultaneously, state-level policy approaches have had to contend with previously established energy goals and critically evaluate clean technologies for renewable outcomes. Policy options employing renewable portfolio standards (RPS) or clean energy standards (CES) remain among the most popular.

There is widespread support for decarbonization at the state level, which can be seen by more than half the states adopting carbon emissions targets, renewable portfolio standards or clean energy standards (see Table 1, later in this section), and the number of states that have released or are developing climate action plans (33 states released, 8 updating, & 1 in development) (Center for Climate and Energy Solutions, n.d.a). The states adopting these plans tend to include three main regions including western coastal states, northeastern states (north of N. Carolina) and states surrounding the Great Lakes. An even more stark pattern of east vs. west coast states appears when looking at states adopting carbon pricing policies and cap and trade policies–which include 11 states in the Regional Greenhouse Gas Initiative as well as California and Washington, on the west coast.

Decarbonization programs at the state level are being promoted across sectors including efficiency standards for buildings and equipment, tax credits for energy efficiency and/or alternative energy sources, rebates for industrial or commercial energy savings programs and carbon offset programs. Some technologies are emerging as cost effectiveness studies and availability in the market are syncing with state incentives, as is the case with heat pumps. Due to large investments from DOE and state policy incentives in California, Connecticut, Massachusetts, Maine, New York, Oregon and Washington – experts are expecting increased uptake in this technology, especially in regions where building codes are requiring electric heating as well (Moore-Bloom, 2022).

Direct Air Capture (DAC) and Carbon Capture, Utilization, and Storage (CCUS) have been endorsed by states like Wyoming and Nebraska, as some states are pursuing a broader approach that encompasses several types of technology. However, despite massive investments in DAC at the federal level, the technology is years away from being a significant counterweight to the yearly global output of $CO_2$. While some states have continued to pursue solar and wind renewables, states with considerable investment in the fossil fuel industries have embraced DAC and CCUS rather than phase out their existing infrastructure (including Indiana, Nebraska, Oklahoma, Utah, Wyoming and West Virginia). The recent increase in coal demand due to natural gas prices and questions about coal plant closures for grid reliability seems to be renewing discussions on the need for this technology development. Given the lack of scalability and current technological inefficiency, it is unclear if DAC and CCUS have the staying power that other more conventional carbon-free energy resources have.

### *Nuclear Policies*

The Inflation Reduction Act (IRA) provides multiple incentives to support the nuclear sector by ensuring energy security and cutting U.S. GHG emissions by 2030 (Office of Nuclear Energy, 2022). This legislation supports the existing nuclear industry by providing production tax credits and incentivizing new advanced nuclear deployment through technology-neutral production credits (Ibid). Further, the IRA provides funding for high-assay low-enriched uranium (HALEU) fuel supply chain development within the U.S., which is urgently required to deploy advanced reactors (Greene, 2022).

Another major piece of legislation supporting nuclear science is the CHIPS and Science Act. This law centers on boosting investment in university science and engineering infrastructure to expand the workforce and drive development of next generation technologies. This includes nuclear research reactors and the involvement of social sciences and law in nuclear investigations (Merrifield et al., 2022). The financing has already been impactful as the University of Illinois is planning for a construction permit in partnership with Ultra Safe Nuclear Corporation to site a microreactor at the Champaign-Urbana campus (McDermott, 2023). Penn State University has also signed a memorandum of understanding (MOU) with Westinghouse to collaborate on microreactor technology with an aim to build collaborations with steel and cement manufacturers regionally and decrease its carbon footprint. Additionally, Abilene Christian University and three partners with Natura Resources are exploring the process to build a molten salt research reactor (Ibid).

Recent national policy also reflects increasing support for nuclear innovation, funding technological developments and improving licensing/regulatory processes for advanced nuclear reactors (Swanek, 2019). Small modular reactors (SMRs) are a powerful focus of the nuclear sector that could allow for factory-fabricated and transported nuclear reactors capable of generating heat and power in previously more carbon-intensive sites. As energy prices increased in early 2022, states began to re-evaluate previous plans to phase out or decommission existing nuclear plants. Some also began to eye potential new construction and installation. For example, West Virginia repealed an article that had previously banned the construction of nuclear power plants. Ten states in 2022 passed legislation regarding the regulation of nuclear power plants, and more policies may be on the way. Even plants scheduled for decommissioning, like California's Diablo Canyon plant may be kept open to mitigate the effects of the energy crunch. This plant's operations have been approved to continue by the Nuclear Regulatory Commission as Pacific Gas & Electric seeks full approval to extend the plant's lifespan (Lopez, 2023).

In addition to carbon policies outlined above, Table 1 also summarizes recent nuclear policy developments from the past several years across the 50 states as well as extension support to keep existing nuclear plants operating. The state-by-state analysis highlights several policy trends which show a spectrum of nuclear support under development. As mentioned above in the carbon policy section, over half of the U.S. states have some sort of clean energy standard, renewable portfolio standard or carbon target, which includes a range of technologies to reduce carbon emissions. Recent policy changes are expanding definitions to incorporate nuclear technologies into zero-emission/carbon-free/clean energy definitions (CA, CT, IL, IN, NJ, VA). Further, policy adjustments to repeal prohibitions on nuclear development or to update siting authority have reduced barriers to deploying advanced reactor technology (AK, CT, KY, MT, WI in addition to WV mentioned above). States like Nebraska and Wyoming have adopted policies that provide tax incentives or exemptions on property, electricity sales, and capital investment tied to nuclear development. These tax exemptions and advanced cost recovery mechanisms can support new reactor development. Several other states are exploring similar legislation. By doing so, the states recognize the need for financial support and for a workforce in regions without current nuclear plants, but have not successfully passed legislation to date.

Through policy direction and appropriations, many states or their leaders have directed task forces, academia, industry, or the public utilities commissions to collaborate and study nuclear potential. Some states are proposing or advancing studies of the potential for siting or permitting of new advanced reactors (MD, MI, NE, NH, PA, SC, VA).

The number and breadth of proposed and adopted policies, especially related to advanced nuclear technologies at the state level demonstrate an increased interest in including nuclear power as a carbon-free solution.

There are changes happening at the sub-state level that are difficult to capture in this type of analysis which focuses primarily on executive order, legislative mandate, RPS or carbon reduction standard. Market forces from customers, shareholders and investors have heavily influenced portfolio diversification for businesses, cities, and utilities in recent years. Due to the sheer number of these kinds of investments, it would be difficult to track, in addition to the privacy of some investments. However, utility industry analysts have demonstrated patterns of self-imposed carbon reduction plans and utility-adoption of other climate-related targets throughout the U.S., regardless of state policy.

**Table 1. Summary of Carbon & Nuclear Policies in 50 States**
(ETS is Emissions Trading System; ✓'s indicate under development or enacted)

| State | RPS/ CES | Nuclear Adoption/ Extension Support | Carbon Targets/ Related Policies | ETS | Other |
|---|---|---|---|---|---|
| Alabama | | | | | |
| Alaska | ✓[1] | ✓[2] | | | ✓[3] |
| Arizona | ✓[4] | | | | ✓[5] |

[1] Alaska set a non-binding goal in 2010 to generate 50% of the state's electricity by 2025 and seeks to adjust this without increasing the overall cost of electricity to consumers. New bills were introduced in the 2022 legislative session. The RPS (SB179) scales required renewable energy shares for Railbelt power producers' net electricity sales: 20% by 2025; 30% by 2030; 55% by 2035; and 80% by 2040. The CES (HB301) requires 25% of net electricity sales to be from clean energy by 2027 on the Railbelt, then 55% 2040. The RPS does not include nuclear energy, and the CES does. *See* also Johnson and Wise, 2023.

[2] A provision was added to 2021 AK S 177 that allows the legislature to approve nuclear and microreactor permits for "unorganized borough(s)" and creates a specific process for microreactor permitting. SB 177 was passed in May 2022, designating Department of Environmental Conservation to permit nuclear reactors, rather than the Legislature.

[3] The Air Force selected Eielson Air Force Base to pilot its first microreactor (Szondy, 2021).

[4] Arizona has a 2006 RPS requirement of 15% renewable energy by 2025.

[5] Arizona has many pending legislative actions and updates, but nothing major for energy policy. Most notable are provisions regarding electric vehicle infrastructure and charging accessibility. (Pending) 2022 AZ S 1150 establishes minimum requirements for residential housing to be equipped with EV-charging accessible outlets. The 2023 AZ H 2241 electric vehicle, charging pilot program has been read in and is in committee.

| State | RPS/ CES | Nuclear Adoption/ Extension Support | Carbon Targets/ Related Policies | ETS | Other |
|---|---|---|---|---|---|
| Arkansas | | | | | |
| California | ✓[6] | *See* Other | ✓[6] | ✓[7] | ✓[8] |

[6] California has GHG emission reduction goals: 40% below 1990 levels by 2030, and 80% below 1990 levels by 2050. It also aims to achieve 100% carbon-free electricity by 2045 and economy-wide carbon neutrality by 2045 (C2ES, n.d.b). 2021 CA S 596 requires the state board to develop a comprehensive net-zero strategy for California's cement sector "within the state as soon as possible, but no later than December 31, 2045." (Pending) 2021 CA A 1322 also states that on or before July 1, 2024, the state board shall develop a plan "to reduce aviation greenhouse gas emissions and help the state reach its goal of net-zero" emissions. Governor Newsom refused to sign this bill into law, recognizing this is already covered in the Low Carbon Fuel Standard.

[7] "California's carbon cap-and-trade system is one of the largest, multi-sectoral emissions trading systems in the world" (C2ES, n.d.a). Revenues from the program supply the state's Greenhouse Gas Reduction Fund and are appropriated to state agencies to implement further GHG reduction initiatives. By law, 35% of the revenues are directed to environmentally disadvantaged and low-income communities. Since its inception, the program has produced $5B of total revenue. This program is connected with the Canadian province of Quebec's cap-and-trade system through the Western Climate Initiative (Ibid).

[8] The future of Diablo Canyon Nuclear power plant is uncertain as its operational license application was rejected by the NRC and PG&E was told to submit a new application if they planned to continue operations past 2025. However, SB 846 authorized the state to provide a $1.4 billion loan guarantee to extend plant operations at Diablo Canyon Nuclear Power Plant through 2030.

| State | RPS/ CES | Nuclear Adoption/ Extension Support | Carbon Targets/ Related Policies | ETS | Other |
|---|---|---|---|---|---|
| Colorado | ✓[9] | | ✓[10] | | ✓[11] |
| Connecticut | ✓[12] | ✓[13] | | ✓[14] | |
| Delaware | ✓[15] | | | ✓[16] | |

[9] Colorado's current RPS goal is 100% renewable energy production by 2050 (Ray et al, 2022). Colorado SB 18-003 (June 2018) required the Colorado Energy Office to work with utilities and stakeholders to promote clean energy sources, such as nuclear energy. 2022 CO S 118 also establishes provisions for the development of geothermal energy under the state's greenhouse gas pollution reduction roadmap, allowing for geothermal energy as a "renewable energy resource that qualifying retail utilities may use to achieve the electric utility sector greenhouse gas pollution reduction goals." This appears to allow geothermal to qualify under the state's RPS standard.

[10] 2022 CO S 51 establishes "maximum acceptable global warming potential" for building materials, effective 2024 (*see* Section 1, 24-92-117), provides a tax credit for heat pumps (Sec 2., 39-22-545) residential energy storage systems (Sec 2., 39-22-546), and eligible decarbonizing building materials (Sec 4., 39-26-731).

[11] In addition to considerable 2021 legislation, Colorado continues to pass policy incentivizing clean energy production, electric vehicle infrastructure, energy storage, and energy justice.

[12] Connecticut's RPS standard has been updated to 45% renewable energy by 2030 and further updated to reflect, "not later than January 1, 2040, to a level of zero per cent from electricity supplied to electric customers in the state" (*see* 2022 CT S 10, Sec. 1, subsection (a), 22a-200a) (Ray et al, 2022).

[13] The HB 5202's (2022) partial repeal of a nuclear moratorium, allows advanced reactor deployment within the footprint of existing nuclear facilities (NEI, 2023).

[14] Connecticut is a member of the Regional Greenhouse Gas Initiative and joined in 2005.

[15] Delaware has recently expanded its RPS to include new minimum levels of solar power production and increased minimum cumulative percentages of eligible energy resources from 2026 onward. Delaware's current standard is 40% renewable production by 2035 (*see* 2021 DE S 33, Section 1, subsection (a)) (Ray et al, 2022).

[16] Delaware is a member of the Regional Greenhouse Gas Initiative and joined in 2005.

| State | RPS/ CES | Nuclear Adoption/ Extension Support | Carbon Targets/ Related Policies | ETS | Other |
|---|---|---|---|---|---|
| Florida | | | | | ✓[17] |
| Georgia | | | ✓[18] | | ✓[19] |
| Hawaii | ✓[20] | | | | |
| Idaho | | ✓[21] | | | |
| Illinois | ✓[22] | ✓[23] | | | ✓[24] |

[17] 2022 FL H 1411 encourages the implementation of floating solar facilities and establishes them as a "permitted use in the appropriate land use categories" of local planning. 2022 FL S 1764 created the Municipal Solid Waste-to-Energy Program that provides incentives for solid waste power production between municipalities and power vendors.

[18] 2021 GA H 355 adds more specific language to the Georgia Carbon Sequestration Registry Act, including definitions of embodied carbon and global warming potential, and directs the Director of the State Forestry Commission to establish the Sustainable Building Material Technical Advisory Committee to "ensure the interoperability, general alignment, and compatibility of credits derived from the carbon sequestration results of building materials and embodied carbon results with global carbon credit and offset markets" (Ray et al, 2022).

[19] As a non-policy, but important development, Georgia Power Co. will begin service for Vogtle Unit 3 & 4 in 2023 -- the first new nuclear reactors to be built in the US in more than three decades (Georgia Power, 2023).

[20] Hawaii's RPS goal of 100% clean energy by 2045 remains unchanged from its 2015 standard.

[21] Executive Order No 2018-07 supports continued promotion, advancement and deployment of advanced reactor technology, including SMRs. HB 591 (2018) supports tax exemptions for research and development associated with SMRs (NEI, 2023).

[22] Illinois 2016 goal of 25% renewable energy by 2025 remains unchanged.

[23] SB 2408, enacted in 2021, updates Illinois's renewable energy goals and establishes measures for zero-emissions credits for nuclear power plants and many other provisions for renewable and clean energy development. The policy itself is robust and requires further research. "Climate and Equitable Jobs Act" commits to keep the nuclear fleet online, even if that means paying during unprofitable times, but also agreed to cap earnings (for a plant owner) if energy prices rise. This paid off for customers in 2022 as there was a major fluctuation in energy prices due to the invasion of Ukraine. SB 18 (2021) established a zero-emission credit program for Byron, Dresden, and Braidwood nuclear facilities within the state, adding to the existing program (SB 2814, 2016) that developed the program for Clinton and Quad Cities facilities (NEI, 2023; Clifford, 2022).

[24] Unrelated to policy, but important to mention is that the University of Illinois Champaign-Urbana is applying for a license to build and operate an UltraSafe microreactor on campus (McDermott, 2023).

| State | RPS/ CES | Nuclear Adoption/ Extension Support | Carbon Targets/ Related Policies | ETS | Other |
|---|---|---|---|---|---|
| Indiana | ✓[25] | ✓[26] | ✓[27] | | |
| Iowa | ✓[28] | | | | |
| Kansas | ✓[29] | | | | |
| Kentucky | | ✓[30] | | | |
| Louisiana | | | | | ✓[31] |

[25] Indiana has a voluntary clean energy standard for utilities to produce 10 percent of the electricity from renewable sources by 2025 (IC 8-1-37) (C2ES, n.d.b).

[26] 2022 IN S 271 added provisions defining small modular nuclear reactors and updated the statute to reflect that qualifying SMRs are "clean energy projects" (*see* Section 1. 1C 8-1.8.5.12.1 and Section 2. IC 801-8.8-2, respectively). SB 271 also directs the state public utility company to develop rules regarding SMR construction at retiring coal and natural gas facilities. 2023 SB 0176 proposes changing the statutory definition of an SMR from 350 MW to 470 MW and provides other updates to the definition (pending) (Ray et al, 2022).

[27] 2022 IN H 1209 provides processes for the underground storage of carbon dioxide, including permitting and easement regulations.

[28] Iowa has the oldest operating renewable portfolio standard, first enacted in 1983, that requires the state's two investor-owned utilities to produce a combined 105 MW of renewable energy (Ray et al, 2022).

[29] Kansas's voluntary RPS goal allows electricity producers to generate up to 20% of utility peak demand from renewable energy resources by 2025 (C2ES, n.d.b)

[30] SB 11 in 2017 removed the moratorium on construction of new nuclear facilities (NEI, 2023).

[31] LA S 110 establishes numerous provisions for the securitization of debt to finance certain energy transition costs, with the express aim of benefiting ratepayers, but the text fails to mention carbon and seems expressly designed with financialization and taxation in mind (*see* Section 2. Par VII-A, Chapter 9, Title 45, S.1271) (Ray et al, 2022).

A critical development, though not directly related to policy is that Dow and X-energy plan to deploy an Xe-100 high-temperature gas reactor at one of Dow's Gulf Coast sites by 2030 through DOE's Advanced Reactor Demonstration Program. The two signed a joint development agreement March 1, 2023. Dow has multiple facilities in Louisiana and Texas (Patel, 2023).

| State | RPS/ CES | Nuclear Adoption/ Extension Support | Carbon Targets/ Related Policies | ETS | Other |
|---|---|---|---|---|---|
| Maine | ✓[32] | | | ✓[33] | ✓[34] |
| Maryland | ✓[35] | ✓[36] | | ✓[37] | ✓[38] |
| Massachusetts | ✓[39] | | | ✓[40] | |

[32] Maine's RPS standard remains at the established (2018) 100% clean energy objective of 2050 and requires 80% electricity sales to come from renewable sources by 2030 (Ray et al, 2022; C2ES, n.d.b).

[33] Maine is a member of the Regional Greenhouse Gas Initiative and joined in 2005 (Ibid).

[34] Maine has been proactive in promoting carbon and clean energy targets and requirements for a variety of sectors. It uses different legislative metrics, such as 2021 ME S 143 expanding the powers available to the Main Clean Energy and Sustainability Accelerator to obtain and guarantee certificates and loans, and expands on what funds can capitalize the Accelerator (Ray et al, 2022).

[35] Maryland's RPS was updated by SB 153, which increased the requirements for municipal utilities to source 20.4% of Tier 1 renewable sources. Maryland's current RPS goal is 50% clean energy by 2030 (Ibid).

[36] SB 528 recognizes the critical role that nuclear power plays in the state's clean energy generation profile and established greenhouse gas emission reduction target (NEI, 2023).

[37] Maryland is a member of the Regional Greenhouse Gas Initiative and joined in 2007 (Ray et al, 2022).

[38] 2022 MD S 348 contains provisions providing for the Maryland Department of Agriculture to help foster development of organizations, contracts, and programs. It does so that facilitate "statewide or regional partnerships" for carbon offset markets and for "minimizing the costs and maximizing the benefits of voluntary enrollment of farmland in carbon offset market programs." (Section 1., 8-702, (C) and (D) (1) and (2)) (Ibid).

Like other states, although not directly policy-related, it should be noted that the Maryland Energy Administration awarded grants to Frostburg State University and X-energy in June 2022 to evaluate the viability and benefits of installing an SMR at a retiring coal site (Tobar, 2022).

[39] Massachusetts's update to its RPS remains unchanged in terms of the share at 35% by 2030. In 2017, Massachusetts adopted a CES requiring 80% of electricity sales to come from clean energy sources by 2050 (Ray et al, 2022; C2ES, n.d.b).

[40] Massachusetts is a member of the Regional Greenhouse Gas Initiative and joined in 2007. Massachusetts also established a separate cap-and-trade program that runs in parallel to RGGI, covering its fossil fuel power plants in an effort to reduce aggregate $CO_2$ emissions in response to a 2016 Supreme Court ruling (C2ES, n.d.b).

| State | RPS/ CES | Nuclear Adoption/ Extension Support | Carbon Targets/ Related Policies | ETS | Other |
|---|---|---|---|---|---|
| Michigan | ✓[41] | ✓[42] | | | |
| Minnesota | ✓[43] | | | | |
| Mississippi | | ✓[44] | | | |
| Missouri | ✓[45] | | | | |
| Montana | ✓[46] | ✓[47] | | | |

[41] Michigan's RPS remains unchanged at the previously established goal of 15% renewable energy by 2021 (Ray et al, 2022).

[42] Public Act 166 (2022) requires the Michigan Public Service Commission (PSC) hire an outside consulting firm to conduct a study on the future of nuclear power generation in Michigan. January 5, 2023, the Michigan PSC issued a call for proposals to evaluate and provide recommendations on: designs, environmental impacts, land/siting criteria, safety criteria, engineering/cost criteria, and many more components related to the social/economic aspects of planning. The report must be delivered to the Governor within 18 months of the enacted bill (Oct 2022) (Michigan PSC, 2023).

[43] Minnesota's RPS (updated in 2018) sets requirements for Xcel Energy (31.5% by 2020), other investor-owned utilities (26.5% by 2025), and other utilities (25% by 2025) (Ray et al, 2022).

[44] HB 863 exempts nuclear generating facilities from county, municipal and district ad valorem taxes, changing the requirement to a payment based on the assessed value of such nuclear generating plant (NEI, 2023).

[45] Missouri's RPS remains unchanged at 15% renewables by 2021 for investor-owned utilities (Ray et al, 2022).

[46] Montana's RPS remains unchanged at the previously established 15% renewables by 2015 (Ibid).

[47] HB 273 (2021) removes a provision requiring the public to approve proposed nuclear facilities. Senate Joint Resolution 3 (2021) requires an evaluation of the economic feasibility or replacing coal facilities with advanced nuclear reactors (NEI, 2023).

| State | RPS/ CES | Nuclear Adoption/ Extension Support | Carbon Targets/ Related Policies | ETS | Other |
|---|---|---|---|---|---|
| Nebraska | ✓[48] | ✓[49] | ✓[48, 50] | | |
| Nevada | ✓[51] | | | | |
| New Hampshire | ✓[52] | ✓[53] | | ✓[54] | |
| New Jersey | ✓[55] | | | ✓[56] | |

[48] Nebraska's utilities (the only state with 100% publicly owned utilities) have all committed to decarbonization goals, most recently with the 2021 decision of Nebraska Public Power District's non-binding 2050 decarbonization goal (Ray et al, 2022).

[49] Nebraska is using pandemic aid to consider nuclear power for grid reliability (American Rescue Plan Act funding) and has begun a study for possible sites for SMRs in low-income communities affected by weather threats to grid resilience (Singer, 2023). L.B. 84 (2021) adds nuclear energy to qualifying renewable energy sources that are eligible for business tax incentives (NEI, 2023).

[50] 2021 NE L 650 empowers the Nebraska Oil and Gas Conservation Commission to establish requirements and penalties under the Nebraska Geologic Storage of Carbon Dioxide Act, incentivizing the geologic storage of carbon dioxide in Nebraska (Ray et al 2022).

[51] In 2019, Nevada moved from a non-binding RPS to a requirement that 50% of electricity sales in the state will come from renewable sources by 2030 (C2ES, n.d.b).

[52] New Hampshire's RPS remains unchanged at the previously established goal of 25.2% renewables by 2025 (Ray et al, 2022).

[53] 2021 NH H 543 (passed in 2022 session) establishes a "commission to investigate the implementation of nuclear reactor technology in New Hampshire." Advanced nuclear reactors, including SMR and breeder reactors, are to be investigated by the commission. Interim reports are to be sent December 2022, July 2023 and December 2023. Proposed: HB 616-FN adds Gen IV or later nuclear energy systems as a new class for the renewable energy portfolio after January 1, 2024 (Ray et al, 2022; NEI, 2023).

[54] New Hampshire is a member of the Regional Greenhouse Gas Initiative and joined in 2005 (Ray et al, 2022; C2ES, n.d.b).

[55] New Jersey's updated (2018) goal of 50% renewables by 2030 remains unchanged (Ibid).

[56] While one of the original seven states to sign the "Regional Greenhouse Gas Initiative Memorandum of Understanding," New Jersey withdrew from the agreement in 2011, rejoining in 2018 by executive order (Ibid).

| State | RPS/ CES | Nuclear Adoption/ Extension Support | Carbon Targets/ Related Policies | ETS | Other |
|---|---|---|---|---|---|
| New Mexico | ✓[57] | | | | |
| New York | ✓[58] | | | ✓[59] | |
| North Carolina | ✓[60] | ✓[61] | | | ✓[62] |
| North Dakota | ✓[63] | | | | |
| Ohio | ✓[64] | | | | |
| Oklahoma | ✓[65] | | ✓[66] | | |

[57] New Mexico updated its RPS in 2019, expanding its goal to 100% carbon-free sources by 2045 (Ibid).

[58] New York's RPS goal of 100% zero emissions electricity by 2040 remains unchanged but did add an additional goal of 70% renewables by 2030 (Ibid).

[59] New York is a member of the Regional Greenhouse Gas Initiative and joined in 2005 (Ibid).

[60] North Carolina's goal of 12.5% by 2021 for investor-owned utilities remains unchanged (Ibid).

[61] Docket No. E-100, Sub 179 (December 2022) requires Duke Energy Carolinas to pursue license extension for the existing nuclear fleet and authorizes the utility to incur project development costs associated with new nuclear generation. The company will provide updates through its integrated resource planning process (NEI, 2023).

[62] NC H 951 authorizes performance-based regulation to effectuate a 70% reduction in emissions by electric public utilities (Ray et al, 2022).

[63] North Dakota's non-binding objective of 10% renewable energy production by 2015 remains unchanged (Ibid).

[64] In 2019, H.B. 6 reduced Ohio's previous RPS target of 12.5% to 8.5% by 2026 (Ibid).

[65] Oklahoma's 2015 goal of 15% renewables production remains unchanged (Ibid).

[66] 2021 OK S 1856 directs the Secretary of Energy and Environment to "create and administer a grant program for entities utilizing sequestration of carbon captured," effective November 1, 2022 (Ibid).

| State | RPS/ CES | Nuclear Adoption/ Extension Support | Carbon Targets/ Related Policies | ETS | Other |
|---|---|---|---|---|---|
| Oregon | ✓[67] | | ✓[68] | | |
| Pennsylvania | ✓[69] | ✓[70] | | ✓[71] | |
| Rhode Island | ✓[72] | | | ✓[73] | |
| South Carolina | ✓[74] | ✓[75] | | | |

[67] Oregon's RPS required that 50% of the electricity used by Oregonians be sourced from renewable resources by 2040 (State of Oregon, n.d.).

[68] In 2021, Oregon's HB 2021 required 100% reduction of carbon emissions by certain electricity providers by 2040 (Ray et al, 2022).

[69] Pennsylvania's RPS of 18% alternative energy resources by 2020-2021 remains unchanged (Ibid).

[70] HR 238 (2022) the Joint State Government Commission was directed to conduct a holistic study on the benefits of nuclear energy and SMRs (NEI, 2023).

[71] Pennsylvania was pending membership to the Regional Greenhouse Gas Initiative and is anticipated for full membership. Most recently, an injunction has been granted in one of several cases preventing Pennsylvania from joining RGGI, halting the membership process while the issue is litigated in the courts (Ray et al, 2022).

[72] Rhode Island's RPS of 38.5% by 2035 was superseded by a new law that was signed June 30, 2022, greatly increasing the timeline for the state's energy production to be 100% offset by renewable energy by 2033 (Walton, 2022). The measure does not require renewable energy be the primary source of power generation, but demonstrates the state's commitment to renewable energy and its climate goals, alongside recent climate-oriented measures like H 5445 (known as the 2021 Act on Climate) and the recent approval of the offshore wind project, South Fork Wind (Ray et al, 2022).

[73] Rhode Island is a member of the Regional Greenhouse Gas Initiative and joined in 2007 (Ibid).

[74] South Carolina's voluntary RPS of 2% of aggregate generation capacity by 2021 remains unchanged (Ibid).

[75] H. 4940 established the Electricity Market Reform Measures Study Committee to examine electricity market reform measures and recognized the benefits of nuclear power. The report was completed in January 2023 but is not available to the public yet (NEI, 2023).

| State | RPS/ CES | Nuclear Adoption/ Extension Support | Carbon Targets/ Related Policies | ETS | Other |
|---|---|---|---|---|---|
| South Dakota | ✓[76] | | | | |
| Tennessee | | | | | |
| Texas | ✓[77] | | | | |
| Utah | ✓[78] | ✓[79] | ✓[80] | | |
| Vermont | ✓[81] | | | ✓[82] | |
| Virginia | ✓[83] | ✓[84] | | ✓[85] | ✓[86] |

[76] South Dakota's non-binding objective of 10% renewable energy production by 2015 remains unchanged (Ray et al, 2022).

[77] Texas's RPS goal of 10,000 MW by 2025 remains unchanged (and already achieved) (Ibid).

[78] Utah's Renewables Portfolio Goal remains unchanged at 20% of retail sales by 2025, but utilities only need pursue cost effective renewables (Ibid).

[79] Senate Concurrent Resolution 6 (2019) demonstrated support for and integration of advanced nuclear reactor technology. SB 24 (2019) amended state energy policy to promote nuclear generation technology (NEI, 2023).

[80] 2022 UT H 244 establishes regulations, guidelines, and requirements for the geologic storage of carbon (Ray et al, 2022).

[81] Vermont's RPS goal of 75% by 2032 remains unchanged (Ibid).

[82] Vermont is a member of the Regional Greenhouse Gas Initiative and joined in 2005 (Ibid).

[83] Virginia's 2020 update to its RPS leaves the share unchanged at 100% by 2045/2050 for Phase I and II utilities, respectively (Ibid).

[84] 2022 VA H 894 directs the Department of Energy to study the development of small modular reactors in the state (Ibid). Senate Joint Resolution 60 (April 2020) encouraged the advancement of nuclear energy R&D and exploration of economic development opportunities tied to nuclear energy. HR 1303/SB 549 (April 2020) directed state agencies to coordinate with the Nuclear Energy Consortium Authority to develop a strategic plan for the role of nuclear energy in VA's progress towards carbon-free energy.

[85] Virginia is a member of the Regional Greenhouse Gas Initiative and joined in 2021 (Ibid).

[86] SB 828 (2020) and SB 817 amend the definition of carbon free and clean energy to include nuclear energy generation (NEI, 2023).

| State | RPS/ CES | Nuclear Adoption/ Extension Support | Carbon Targets/ Related Policies | ETS | Other |
|---|---|---|---|---|---|
| Washington | ✓[87] | | | ✓[88] | |
| West Virginia | | ✓[89] | ✓[90] | | ✓[91] |
| Wisconsin | ✓[92] | | | | ✓[93] |
| Wyoming | | ✓[94] | | | |

[87] Washington's RPS of 100% clean energy by 2045 remains unchanged. The clean electricity standard (SB 5116, 2019) requires eliminating coal generation by 2025 (Ray et al, 2022; C2ES, n.d.b).

[88] Washington passed SB 5126: Climate Commitment Act (2021) and the cap-and-trade program commenced January 1, 2023. The compliance periods have different targets, based on the state's existing GHG limits including 45% below 1990 levels by 2030, 70% below 1990 levels by 2040 and 95% below 1990 levels by 2050. The program focuses on large emitters while also working with businesses to cut greenhouse gasses (WA Dept of Ecology, n.d.).

[89] 2022 WV S 4 repeals the state's previous article banning construction of nuclear power plants (NEI, 2023).

[90] 2022 WV H 4491 establishes a carbon dioxide sequestration program that aims to foster and develop regulations and underground sequestration facilities (Ray et al, 2022; C2ES, n.d.b).

[91] The state is interested in leveraging federal funding to transition its fuel use from coal to nuclear, and is discussing the potential of siting a TerraPower advanced reactor at such sites (NEI, 2023).

[92] Wisconsin's previously established RPS goal of 10% by 2015, with no reduction in renewable percentages at that time, remains unchanged (Ray et al, 2022).

[93] An important non-policy related development for the state is that NuScale and the Dairyland Power Cooperative signed an MOU in February 2022 to evaluate the potential to deploy an SMR in Dairyland's service territory, which covers Wisconsin, Minnesota, Iowa and Illinois (Davis, 2022).

[94] 2022 WY H 131 updates provisions relating to advanced nuclear reactors and instates a tax exemption on qualifying reactors. HB 74 (2020) authorizes permits for SMRs to replace coal or natural gas-generating units as long as the rated capacity is not greater than 300 MW (NEI, 2023).

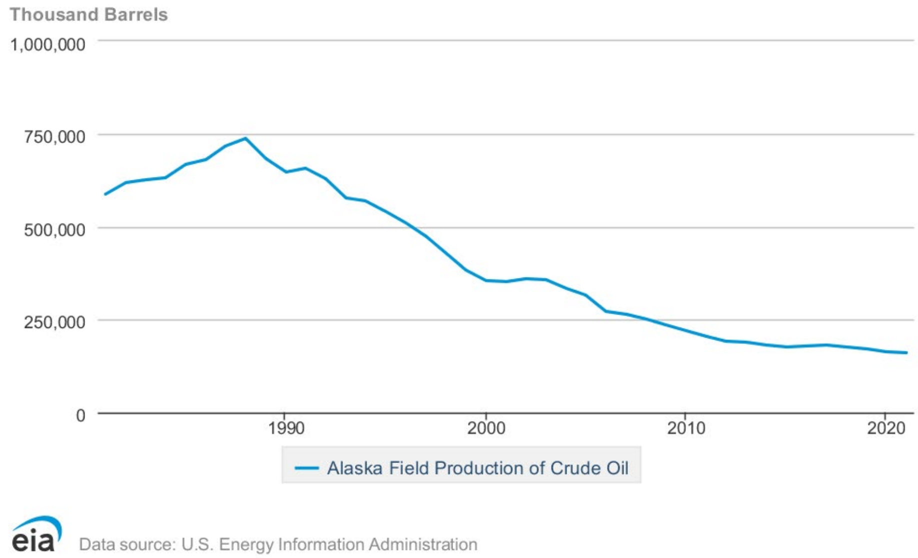
## PART 5: Background on Energy in Alaska and Wyoming

### Energy System Change in Alaska and Wyoming

#### Alaska

Alaska is known as a fossil fuel exporter, particularly for oil and gas. Alaska's Prudhoe Bay field is among the 10 largest oil fields in the nation (EIA, 2022a). However, the state is currently in an extended period of decline for oil production (Ibid). Ranked 4th in the country for proved reserves of oil and oil production in 2020 with roughly 7% of the national share, most of Alaskan oil fields are mature (Ibid). Crude oil production in 2021 was roughly 160 million barrels, down from 187 million barrels in 1981 (Ibid).

**Figure 1: Alaska Field Production of Crude Oil**




Specific to natural gas (marketed production), the recent history is more mixed. Alaska has maintained fairly constant output between 1992 and 2021 onshore, at roughly 314,190 million cubic feet annually (Ibid). For offshore state production, there is a decline by more than a factor of 3 (Ibid). In terms of coal, there is one mine in operation, with Alaska ranked 18th in the country for production in 2021 (Ibid).

In 2020, Alaska generated about 30% of its electricity from renewables (Ibid). Wind resources are strong along the coast, with wind power providing about 7% of the utility scale generation (Ibid). The power market is highly heterogeneous and distributed with many microgrids (Interviews, 2022-2023). Numerous rural communities rely primarily on diesel for energy (Ibid).

Note: Since 1982, every resident in the state is paid a dividend, based on the value of oil royalty revenue, from the Alaska Permanent Fund (Ibid, citing Brooks, 2021).

**Wyoming**

Wyoming has been a major energy producer and exporter of fossil fuels and electricity for years. In fact, it produces 13 times more energy than it consumes (EIA, 2022b). Policy and market changes have affected its status over this time.

At the national level, the passage of the Clean Air Act of 1970 to curb acid rain, created favorable conditions for Wyoming coal, by requiring new coal-fired power plants to limit sulfur dioxide emissions. Amendments in 1990 expanded the scope, requiring all existing coal-fired power plants to reduce their emissions. The coal in the Powder River Basin of Wyoming was low-sulfur, unlike Appalachian and Midwestern coal that had a higher sulfur content (Better Wyoming, 2019). During the period, rail transport costs also improved, enabling Wyoming to become the nation's top coal producer by 1986 (EIA, 2022b). In 2021, Wyoming accounted for 41% of all mined coal in the U.S. (EIA, 2022c). The state continues to hold roughly 40% of the U.S. coal reserves at producing mines (Ibid).

A mix of energy pressures have impacted Wyoming's energy sector in recent years. The global recession of 2008-2010 together with the game change in unconventional oil and gas by way of horizontal drilling and hydraulic fracturing, plus rising cleaner energy interests, place coal in a less favored position. Coal production peaked in 2008 and by 2021, production was roughly half that of 2008 (Pollack, 2023). For the same period, coal mining jobs dropped from 6,827 in the state to 4,567 (Ibid). During the coal production peak, the state earned roughly a billion dollars per year, strictly from coal (Ibid). Today, nearly half the state's annual income is derived from mineral extraction: approximately one-third each from coal, oil and natural gas; together with a smaller share from industries such as soda ash and bentonite (Ibid). *See* also Gerace et al, 2023.

The state shift aligns with a change in U.S. power production based on coal, declining from 48% to 22% for the same period (Ibid). In 2021, 96% of the State's coal was produced in Campbell County, the county where Gillette is based (*see* Case Study). Nine mines in the county still rank among the top 15 in the country, and all of them opened between 1972 and 1985 (Pollack, 2023).

Unlike coal production that was relatively stable before the 2010s and is done principally in the northeastern part of Wyoming, oil and gas are extracted across the state and reflect boom-bust cycles tied to global markets. Wyoming's oil production in 2021 was down by a factor of 1.5 versus a peak in 1981. Its natural gas production peaked in 2009 and is now at par with levels from 1999 (EIA, 2022b, *see* also Figures 2 and 3).

**Figure 2: Wyoming Field Production of Crude Oil**

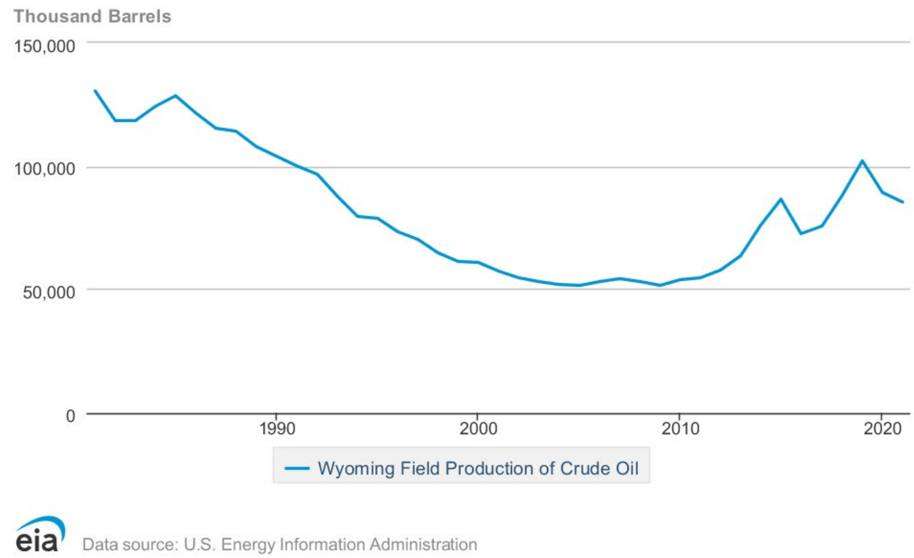
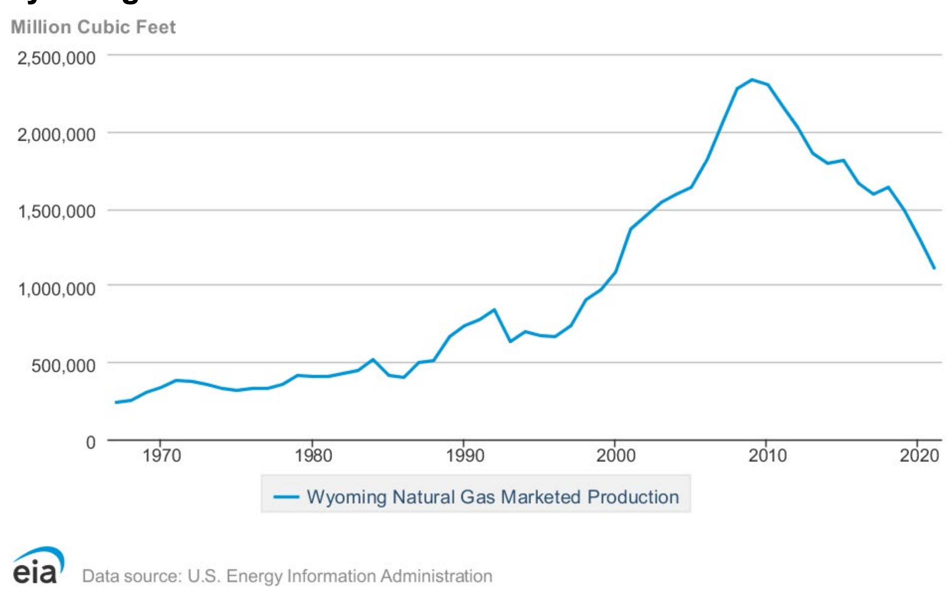



**Figure 3: Wyoming Natural Gas Marketed Production**




In terms of electricity, wind power in the state more than doubled since 2019, providing 19% of the electricity balance in 2021 (EIA, 2022b). Wyoming exported about 60% of its power in the period 2018-2021 (EIA, 2022d).

Note: A considerable portion of state revenue is provided by mineral royalties, severance payments, and related taxes (EIA, 2022b; *see* also Tax section).

**Energy-intensive developments in Alaska and Wyoming associated with Microreactors**

**Alaska - Eielson Air Force Base** was named as a military installation to site and demonstrate the feasibility of a microreactor. This is being done to demonstrate the capability of an MR to supply power in the event that the base's main source of power goes offline (Ellis, 2022). Currently, Eielson AF Base uses a 70-year-old, 15 MW coal-fired heat and power plant, with diesel fuel for back-up (Ibid). The request for proposals reflects a call for construction of a facility to accommodate an MR that would generate up to 5 MW and operate for 10 years, until its fuel is spent. "The plan calls for construction to begin in three years and for the reactor to begin generating power in 2027" (Ibid). The MR will be licensed by the U.S. Nuclear Regulatory Commission, and commercially owned and operated. This initiative reflects actions for the Microreactor Pilot Program that were initiated in response to the Fiscal Year 2019 National Defense Authorization Act requirement to construct and operate an MR by the end of 2027 (Sec. of the Air Force, 2022).

**Alaska - Remote Communities, Studies, and Legislation**
Alaska, especially remote communities, has unique energy needs, with remote communities reflecting electricity costs as much as six times the national average (Herz, 2018). These challenges have spurred communities and energy cooperatives in the region to look for more cost-effective solutions. In the early 2000s, the remote village of Galena studied the potential for installing a small nuclear reactor with Toshiba corporation, but the technology and regulation were not ready (Interviews, 2022-2023; Chaney et al, 2008). Since then, many new SMRs have been developed and are being examined as options across the U.S. and abroad. Copper Valley Electric Association near Glennallen, Alaska is exploring the possible deployment of a MR. The University of Alaska Fairbanks has been watching the development of the technology, especially availability to permit and deploy (Rhode, 2022). Copper Valley Electric has partnered with Ultra Safe Nuclear Corporation to assess the technical feasibility of a 10MW microreactor facility, considering cost, operations, and social acceptance regionally (Ultra Safe Nuclear, 2022). In May 2022, Alaska also passed significant legislation through SB 177 which designated the Department of Environmental Conservation to permit nuclear reactors rather than the Legislature, in the hopes of helping Alaskan communities to reach net-zero carbon goals (Segall, 2022; *see* also Policies Section).

**Wyoming - Kemmerer**
In November 2021, TerraPower announced Kemmerer, Wyoming as the site of the Natrium advanced reactor demonstration plant, supported by the U.S. Department of Energy and in partnership with PacifiCorp, the local utility company (TerraPower, 2021). This followed a review of four candidate communities which included Gillette, Wyoming (Case Study 2). The community of Kemmerer will transition infrastructure from the Naughton Power Plant, a coal facility scheduled to retire in 2025, for utilization with the new reactor. TerraPower planned to submit its construction permit to the NRC in mid-2023, but has announced up to a two-year delay due to a lack of a HALEU supply chain outside of Russia (Stroka, 2022). TerraPower and PacifiCorp also announced a study to

evaluate deploying five additional advanced reactors and integrated energy storage systems in the PacifiCorp territory by 2035, but limited to Wyoming and Utah, which currently house the majority of PacifiCorp's coal-fired plants. This study will focus on existing fossil fuel-fired generation sites, so the utility can continue to leverage infrastructure that is already in place (Clark, 2022).

## PART 6: Case Profile Comparison

The focus on Nome, Alaska and Gillette, Wyoming recognizes certain similarities. First, both are communities in major fossil fuel-producing states that are experiencing industry shifts tied to net zero priorities. Nome and Gillette are communities that were established around the beginning of the 20th century and have potential to diversify with new or renewed forms of mining of minerals that have national security significance. Nome and Gillette also have energy balances that reflect considerable use of fossil fuel. They are remote (Nome, is more so) and in regions with what can be considered extreme winter climates. Based on interviews, their communities appear to be tightly knit and resourceful. Sufficient housing is an articulated challenge for both.

Nome and Gillette also differ in important ways. The population of Gillette is roughly 9 times larger than Nome, while its general fund (a pool including various sources of tax revenues) is about 5 times larger. The early commerce for the communities as well as that today also differ between them. Nome was established with gold mining before Alaska became a U.S. state. Today, Nome is a regional hub for the surrounding area, largely consisting of tribal/rural villages. Its population is diverse with indigenous and Caucasian members. Nome's port, airport and hospital are critical for the area. Gillette was founded as a rail town and is today part of what some refer to as the energy capital of the U.S., with strong ranching ties in the area. Gillette's community profile appears to be more homogenous, with a negligible tribal presence in its part of the state. Fishing and hunting are important for both communities, but may have stronger importance for Nome's subsistence living and cultural ties.

**Table 2: Community Comparison**

**Profiles**

| | Nome, AK | Gillette, WY |
|---|---|---|
| Established | 1901 | 1892 |
| Pop size | ~3,700 (2020) | ~33,000 (2021) |
| Original commerce | Gold mining | Rail town |
| Today's economy | Mining, regional hub, fishing, hunting, tourism | Energy capital for fossil fuel, sports/tourism, rail, ranching |
| Energy today | High burden | Energy production capitol for fossil fuels; also has low-cost wind; |
| Current energy mix | All diesel/gasoline fueled (power, heat, transport), except 8% wind power in electricity mix and dog sleds | Power: Coal and natural gas<br>Transport: diesel and gasoline<br>Heating: primarily fossil |
| Unemployment % | 10-13% (2017-2019)** | 6.9% (2020, Campbell Co) |
| General fund – gov tax | $10,251,600 (2020) | $49,803,458 (2020) |

*Source: Authors' compilation, citing Alaska Department of Labor and Workforce Development, 2021; Kawerak, 2019; Campbell County Wyoming, 2021.*

## Case 1: Nome, Alaska

Nome, Alaska is a rural community on the western coast of the state. Located 2 degrees below the Arctic Circle, Nome is on the Norton Sound of the Bering Sea. The City of Nome is recognized as a regional hub for the area villages, as it has regular boat and air traffic plus a major hospital. It is an isolated community without road access to the Alaskan Highway system. Nome's terrain and built environment, including pipelines, the grid, storage, etc. must account for regular permafrost changes.

As an unorganized borough, Nome has local governance in the form of a city mayor and city council. It does not have a municipal government, but does offer public services with its school district and law enforcement.[95]

[95] Kotzebue, which is of comparable size and is an organized borough, collects taxes on area mines which support the local public services (NJUS Interview, 2022).

**Figure 4. Map of Nome, Alaska**

*Department of Community and Regional Affairs, 2023.*

## History

### Community History

Malemiut, Kauweramiut, and Unalikmiut Eskimos have inhabited the Seward Peninsula since its early history, hunting caribou and fishing to support their diet in the harsh northern environment (Kawerak, 2019). The city of Nome, established at the beginning of the 1900s, was once one of the most populated areas in Alaska (Interviews, 2022-2023). Founded following the discovery of gold in the area, Nome's location on the Bering Sea has led to it being exposed to natural disasters. For instance, five hundred buildings were washed out to sea when a storm devastated the city in 1913, causing $1.5 million in damages (NYT, 1913). Most of Nome was later burnt down in 1934, with only the Government Wireless Station left standing (Time, 1934). In 1974, a 13-foot wave destroyed the city, causing over $30 million in damages (Johanson, 2011; Steever and Campbell, 2016).

In military history, Nome's geostrategic location allowed it to become a transfer point for lend-lease aircrafts from the U.S. to Russia in WWII. Between 1942 and 1945, nearly 8,000 planes came through Nome on the way to Russia for use in the war (Pitcher, n.d.).

Nome's population is a mixture of Inupiat and non-natives (Kawerak, 2019). Subsistence activities remain central to many community members, which leaves employment opportunities in retail services, transportation, government, and medical services open (Ibid).

### Industrial History

Gold deposits are said to have attracted the first people to what is modern Nome (Pitcher, n.d.). There have been many attempts to mine the offshore gold, with early attempts being largely unsuccessful due to machinery needs and other conditions. The area has other commodities such as silver and lead, and has great fishing waters, hosting one of the three fish processing plants in the Bering Sea (Interviews, 2022-2023).

Between 1898-1993, more than 4,800,000 ounces of gold were mined (Hawley and Hulson, 2000). The area has also produced more than 550,000 ounces of silver and small amounts of stibnite and scheelite. A significant amount of offshore gold remains at Nome. The total gold resource in the area is estimated to be approximately 1,000,000 ounces (Ibid).

The growing trend of offshore gold mining in Nome has been enabled by the pre-existing fishing industry that provided vessels to be retrofitted into gold dredges (Interviews, 2022-2023). Mining has been key to the local economy by allowing for a longer economic season than fishing (Ibid).

The Northern Bering Sea has experienced warming and thawing, and increased industrialization. Ship visits in Nome have increased from 34 in 1990, to 635 in 2015 (Rosen, 2021). The Dredge-mining fleet increased from 5 vessels in 2008, to more than 100 in 2016 (Ibid). “Bering Sea Gold”, a Discovery Channel reality show set in Nome beginning in 2012, has helped industry growth. The Alaska Department of Natural Resources reports there were 5 active offshore gold-mining leases before 2011, and by 2020 the number had increased to 86 leases (Ibid). For the near-term, considerable change in the number of vessels to the Nome port is not anticipated with the enlargement of the port (U.S. Army Corp, 2020). Yet, the size of the vessels is expected to increase, incorporating added capacity and efficiency of delivery and supply (Interviews, 2022-2023).

Updated regulations have impacted industry in the area. In 2018, the International Maritime Organization approved a joint US-Russia plan, establishing “designated two-way traffic lanes and protective buffer zones for ships sailing the strait and the northern Bering Sea” (Ibid). The U.S. Coast Guard also has created new safety regulations. For example, since 2015, gold dredges are classified as commercial vessels, not recreational vessels. The largest dredges are subject to mandatory inspections and must have “credentialed masters and chief engineers on board”, with some of the safety regulations not applying to smaller dredges (Ibid).

Climate change has also impacted offshore mining in Nome. Conditions have expanded the open-water period and, therefore, the possibility of increased profits (Ibid). However, global warming has weakened ice floats during the winter months, creating dangerous conditions for winter miners (Ibid). From an environmental view, the impact of offshore mining on the seafloor habitat is inconclusive (Ibid). Seabed mining is controversial in other parts of the country, with it being banned in Oregon state waters (Ibid). There can also be conflicts of interest between miners and local/Indigenous fishing and subsistence food harvests. There was pushback on a gold dredge project proposed along the coast near Nome in Safety Sound (Ibid). The Safety Sound wetlands area is vital for local wildlife, especially as there are endangered species there. The area is also an important source of wild food for Indigenous people (Ibid).

## Current Economic Development

The average income recently in Nome was $30,087, slightly higher than the national average of $28,555, however, the median household income of a resident is $75,952 (Bestplaces.net, n.d.a).

In 2022, Alaska had a Gross State or Domestic Product of $49.6 billion (IBIS World, n.d.a).[96] The Gross State Product (GSP) growth rate on an annualized basis for the past five years to 2022 declined at a rate of 1.3%, ranking Alaska 50th of the 50 states (Ibid). As of 2022, Alaska had 114,911 businesses, with the average annual business growth of -0.7% for the years 2017-22. The following table depicts Alaska's top five Gross State Product sectors.

**Table 3: Alaska Gross State Product by Sector**

| Sector | **GDP** ($ thousands) | Growth 2022 (%) | Annualized Growth 2017-2022 (%) |
|---|---|---|---|
| Mining, quarrying and oil and gas extraction | 9,291,741 | -8.8 | -7.2 |
| Transportation and warehousing | 5,580,445 | 0.7 | -1.0 |
| Real estate and rental and leasing | 4,572,095 | -0.3 | -0.3 |
| Health care and social assistance | 4,074,464 | 2.0 | 1.5 |
| Retail trade | 2,168,442 | -1.1 | -0.1 |

*Source: IBIS World, n.d.a.*

### Rare Earth and Critical Minerals

Alaska's Department of Natural Resources and partners have been assessing and documenting Rare Earth Elements (REE) and Critical Minerals (CM) in preliminary studies as well as discussing waste stream reuse strategies to help Alaska's REE-CM become economically competitive relative to imports (Alaska Department of Natural Resources, 2022). In August 2022, Alaska was awarded $6.75 million from the Bipartisan Infrastructure Law to conduct geologic mapping, airborne geophysical surveying and geochemical sampling in several high interest areas of Alaska to assess the mineral potential in these regions. The surveys will include arsenic, antimony, bismuth, cobalt, graphite, indium, platinum group metals, rare earth elements, tantalum, tellurium, tin and tungsten (USGS, 2022). The CORE-CM (carbon ore, rare earth and critical minerals) project will focus on existing mines for both coal and graphite, as researchers believe an REE mine would not be economical on its own in Alaska. The following section focuses on the potential of the Graphite Creek project, located near Nome.

### Graphite One

The Graphite Creek flake graphite deposit, designated as the largest known graphite

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[96] Gross state product (GSP) and gross domestic product (GDP) are used interchangeably, with recognition that GSP is more relevant for state reporting.

deposit in the United States (Junior Mining Network, 2022), is situated about 40 miles north of Nome in the Kigluaik Mountains on the Seward Peninsula.

Graphite is used in many technical applications due to its high thermal and electrical conductivity, high lubricity and light weight. The most beneficial uses are in anodes for batteries, fuel cells and capacitors–which are expected to ramp up as production of electric vehicle battery demand increases. The United States has not produced any graphite since 1990. Although many discussions surrounding electric vehicles are focused on the need for lithium, EVs use over 110 pounds of graphite per vehicle and graphite production will be critical to meeting demand globally (Graphite One, 2022a).

Vancouver-based company, Graphite One Resource, completed its prefeasibility study (PFS) for a prospective mine outside of Nome in 2022 and is moving forward with permitting and environmental assessments. The PFS estimated a pre-tax net present value (NPV) of $1.9B and post-tax NPV of $1.36B, before accounting for tax credits enacted by the U.S. Inflation Reduction Act of 2022, effective December 31, 2022 (Graphite One, 2022b). Graphite One aims to leverage a vertically-integrated approach from mine to material manufacturing. In doing so, it seeks to “produce high-grade anode material for the lithium-ion Electric Vehicle battery market and Energy Storage Systems, with significant additional production for a range of value-added graphite applications” (Graphite One, n.d).

The study assumes an operational life of 26 years with average production of 75,026 tons of advanced graphite products per year (Graphite One, 2022b). “Graphite Creek would be the country’s only operating graphite mine and give the U.S. a stake in the graphite market that has been dominated by Chinese mines for decades” (Brehmer, 2017).

Graphite One (2022b) expects to operate its mine for 23 years, supplying 100% of the natural graphite ore to a graphite manufacturing plant in Washington state. Its rationale for the export of raw material is based on prohibitively high energy costs in Alaska and low-cost electricity in Washington. The proposed mine would produce as much as 11,000 tons of ore per day (Mining.com, 2022; Lasley, 2022). The prefeasibility study estimated initial capital expenditures for the mine near $500 million with an additional $571 million for the manufacturing plant; however, the integrated project would be able to repay the debt in 5.1 years and would generate an estimated post-tax NPV of $1.4 billion (Mining.com, 2022).

Table 4 below shows the company’s estimated resources, which are anticipated to increase with further exploration when mining is underway. *See* also Energy Aspects of Select Economic Activity.

**Table 4. Graphite One: Graphite Creek's drill tests and exploration potential**

| Type | Tons | Grade | Cut-off | In-Situ Cg (graphitic carbon) |
|---|---|---|---|---|
| **Measured** | 1.69MM | 8% | 5% | 135,171t |
| **Indicated** | 9.26MM | 7.7% | 5% | 715,363t |
| **Total Measured & Indicated** | 10.95MM | 7.8% | 5% | 850,534t |
| **Inferred** | 91.89MM | 8% | 5% | 7,342,883t |

*Sources: Alaska Department of Natural Resources, 2022; and Graphite One, 2022a.*

**Deep Water Port**

Development of the deepwater port of Nome is underway and in the first of three planned stages (Interviews, 2022-2023). In line with the National Defense Authorization WRDA 2022, project cost sharing for this project will be 90% Federal and 10% State/Local until construction is complete (no cost share after construction, Interviews, 2022-2023). It is characterized as the only deepwater port in the U.S. Arctic and serves as a critical link for 60+ regional communities to the rest of Alaska. The development is being done as existing port facilities in the region are seen as overcrowded, with insufficient draft to accommodate larger, deep-draft vessel traffic (Ibid). Energy for port operations is anticipated to be provided by the NJUS utility along with increased fuel for additional ships (Ibid). Nome will be positioned better for global traffic (e.g., Northwest Passage melt, trade with Asia). The project is expected to improve the efficiency of buying/shipping costs; enable access for more industries in the Arctic; increase workforce needs for the Port and ancillary services; and will have upstream and downstream implications for banking, hotels, restaurants, tourism, etc. (U.S. Army Corps, 2020).

**Nome Energy Overview**

**Nome Joint Utility System** (NJUS) is the local, municipality-owned electric utility. In collaboration with area utilities, NJUS contracts for diesel oil shipments (Interviews, 2022-2023). With requests for proposals, they select a supplier on a 3-year contract basis with a minimum amount to be delivered at set rates (Ibid).

**Energy breakdown**

- Power: diesel and wind.
- Transport: diesel, wind/water propulsion, animal power (dog sleds).
- Heat: Diesel, process heat, wood/biomass, other.

As reported mid-2022, 92% of Nome's power is provided by diesel oil and 8% by wind power (NJUS, 2022). Newer data for the full year of 2022, indicates that wind represented 12% of the load (NJUS, 2023; Parsons, 2023). Its recent energy costs are broken down in Table 5.

**Table 5: Nome Energy Costs**

| Energy source | Spring 2022 | Fall 2022 | RANGE Past 10 Years |
|---|---|---|---|
| **Single phase electricity** ($/kWh) (base rate + fuel surcharge before PCE) | $0.3574 | $0.4456 | $0.3089-$0.4025 |
| **Home Heating oil** ($/gallon) | $5.42 | $7.135 | $4.41-6.28 |

*Source: NJUS, 2022; Interviews, 2022-2023; PCE refers to the Power Cost Equalization Program.*[97]

The city of Nome's electricity grid is powered by an islanded wind-diesel microgrid with no current option to connect to a larger power grid (ACEP, n.d.a; Vandeer Meer and Mueller-Stoffels, 2014). Its current production is 32,500 MWh/year to meet community power needs (NJUS, 2022). This is fueled by approximately 1.8 million gallons of #2 diesel oil per year (Ibid). In 2021, the reported power load was approximately 2.7 MW to 5 MW (Ibid). Nome's baseload is experiencing average annual growth of 2% (Ibid). Nome's grid has diesel generators as follows: two 5.2 MW Wartsila which alternate to supply power; a 3.6 MW Caterpillar for back-up; a 1.9 MW Caterpillar for back-up. It also has two 900 kW EWT wind turbines (Ibid). Total generation capacity is 16 MW, with a normal operating capacity of 10.4 MW (Ibid). Nome also has a reported 0.4 MW generator for black starts and peaking (Pike and Green, 2017). The Nome diesel generators are among the most efficient in Alaska, based on PCE data (Ibid). Since 2008, wind has contributed to Nome's energy mix, currently at 8%, and during peak periods, wind supplies 40% of electricity (Ibid).

The Nome electric utility system underwent considerable capital improvements in the late 2000s, including the addition of two new 5.2 MWe Wartsila generating units, upgraded fuel storage as well as substation equipment (NETL, 2008). Heat recovered from generation is used to heat utility buildings and the community's potable water system (Ibid).

**Space heating**

Specific to heating, fuel oil is used to heat buildings and water at considerable cost. Heating costs per square foot for single family homes in Nome are 3+ times greater than costs in Anchorage and more than 2 times that of Fairbanks (NJUS, 2022, citing McKinley Research Group, 2022). Fuel suppliers deliver roughly 1,100 gallons of heating oil on average per building annually (NJUS, 2022). This translates to $8,300 per

[97] The Power Cost Equalization Program "provides economic assistance to communities and residents of rural electric utilities where the cost of electricity can be three to five times higher than for customers in more urban areas of the state." The Alaska Energy Authority and Regulatory Commission of Alaska administer "the program that serves 82,000 Alaskans in 193 communities that are largely reliant on diesel fuel for power generation" (Alaska Energy Authority, n.d.).

Nome household based on estimated costs of $7.50/gallon delivered in summer 2022 (Ibid). If Nome taps less expensive energy, more people may switch to electric heating, which other parts of Alaska do with cheaper electricity use (Ibid).

**Diesel** use for power and heating in Nome is estimated at 25% (electricity) and 75% (heating) (Alaska Energy Authority and NJUS interviews, 2022-2023). Fuel deliveries to Nome are lightered (transported by a smaller boat), given that the current port lacks the depth necessary for direct tanker docking (*see* Port section). Nome's diesel tank farm storage is 3.3 million gallons (Interviews, 2022-2023). It is located north of the port on permafrost that is degrading (NJUS, 2022). Currently, NJUS is completing design planning to relocate the tank farm to more stable ground (Ibid).

Potential Energy Pathways

**Wind + Storage**
Recent studies indicate that more wind could be added to the system at shares of 20+% and 40%. These are broken down in Table 6.

**Table 6: Potential Wind Power Expansion**

| Location | Banner Ridge | Cape Nome |
|---|---|---|
| Projected specifications | 2 x 1 MW EWT turbines would have an installed cost estimated at $14 million.<br><br>If done with a Battery Energy Storage System (BESS) potentially paid for by the Alaska Energy Authority, this could increase Nome's power from renewables to over 20%. However, a study completed following the grant application found there was only room for one additional turbine within the leased portion at Banner Ridge. | 4 x 1 MW wind turbines with a BESS would cost an estimated $44 million.<br><br>This requires a line extension with considerable potential for expansion to other sites.<br><br>It would increase Nome's wind power penetration to 40%. |

*Source: NJUS, 2022.*

Penetration at 40% would necessitate controls for storage and/or curtailment. Use of an electric boiler or other option to convert excess wind to heat would be an economic option for Nome (Pike and Green, 2017; *see* also Araújo, 2014 and 2017).

**Pilgrim Hot Springs** 60 miles north of Nome with transmission expansion. A 2008 study of a 5 MWe installation indicated that Pilgrim Hot Springs could provide 41,600 MWh/year, which could cover nearly the entire power load (NETL, 2008). The estimated cost, including exploratory drilling, construction and transmission to connect to Nome, was determined to be $12,800/kW for a system lifetime of 30 years (Ibid). There may be an increase of two-line worker requirements with potential to realign current generation staff from the diesel system (Ibid). Operation costs are assumed to be primarily for staffing and supplies (Ibid). Adaptation is expected for water heating. Permitting is assumed for land only. Use of a binary power system without a steam phase would mean that CO2 and other gases would be reinjected. Costs for Nome power users were estimated to decline considerably with this option. However, questions existed over the capacity of the geothermal resources to cover expected needs (Ibid).

**Microreactor – At the proposed mine with a microgrid or as part of NJUS with a transmission line addition**

With planning underway for a microreactor (MR) at Eielson Air Force base, Nome has an opportunity to also gauge the applicability of an MR. In 2006, Toshiba evaluated permitting and the potential for a nuclear power plant in Galena. Around that time, Nome communicated with the Nuclear Regulatory Commission its interest and support for the Galena project (NJUS, 2022).

**Other energy options:**
Recent energy assessments of natural gas and geothermal prospects for Nome indicate these options reflect unproven sources (NJUS, 2022). For hydropower, the resource is insufficient, and for solar, the resource could add incrementally to the Nome grid (Ibid).

**<u>Additional Energy Aspects of Select Economic Development in Nome</u>**

**Graphite One**
In production, year-round graphite mining, processing and haul activities would entail 200 employees and estimated monthly energy needs of 4-12 MW (NJUS, 2022). These numbers reflect more energy than NJUS can currently supply. Moreover, the anticipated load could be accommodated with a power line, but if power is to come from Nome, NJUS would not have the right equipment to provide that (Loewi, 2022). Mine studies for Graphite One are also currently focused on the use of a microgrid, rather than extending transmission from Nome (Interviews, 2022-2023).

**Port Development** (NJUS, 2022)
Preliminary analysis by NJUS considered primary use for electrical loading. This excludes Nome's power baseload and secondary development, such as the needs brought about by the buildings that might be built if the port expansion causes increased development in Nome. This assumed shore power provided to an Arleigh-Burke class destroyer, a cruise ship, power pedestals, lighting, water-sewer systems, etc. Estimated needs for December to April would be < .5 MW. For May-September would be <.5 to approximately 5.5 MW. October to November would require an estimated <.5 to approximately 3.5 MW. Incremental growth thereafter is anticipated.

In looking ahead to development opportunities, Nome's community power load and some estimated diversification paths are outlined next. Table 7 shows what is currently available and what would need to be expanded.

**Table 7: Current and Projected Power Load for Nome w/ Various Economic-Energy System Changes**

| Load Range (MW) | Current Community Baseload (MW) | Community Baseload + Arctic Deep Draft Port (ADDP)(MW) | Community Baseload + ADDP + Graphite One (MW) | Community Baseload + ADDP + Graphite One + Space Heating (MW) |
|---|---|---|---|---|
| **Minimum** | **2.6** | **2.7** | **6.7** | **8.5** |
| **Average** | **3.7** | **5.2** | **13.2** | **20.1** |
| **Peak** | **5.0** | **9.4** | **21.5** | **34.4** |
| | **Normal Operational Capacity** | | **Exceeds Current Normal Operational Capacity** | |

The perceived feasibilities of the following three energy paths were discussed in the elicitations: expanded fossil fuel (diesel), renewable energy (wind) + storage with some diesel, and nuclear (MR) to accommodate the above. *See* Part 7: Findings.

## Case 2: Gillette, Wyoming

Gillette, Wyoming is located within the northeastern corner of Wyoming in Campbell County, between the Black Hills of South Dakota in the east and the Bighorn Mountains in the west. Campbell County was a hunting ground for the Sioux and Crow Tribes. In the 1880s, ranchers used the land for grazing longhorn cattle and sheep, that were then followed by homesteaders (Campbell County, n.d.). Today, ranching is the predominant form of land use in the county (Ibid). Campbell County has been described as one of the top 100 places to live in rural America (Ibid).

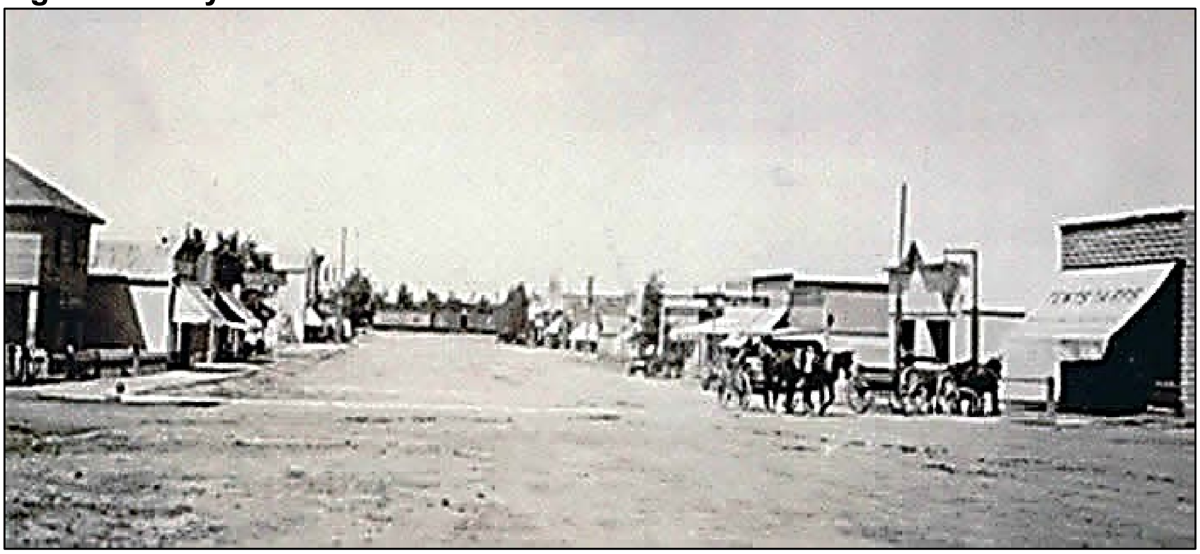
Gillette is the 3rd most populous city in the state out of 192 cities, with a population density of 2,396 people per square mile and a demographic breakdown reflecting 85% White and 10% Hispanic for the two largest groups (Wyoming Demographics, 2023; City Data, n.d). The City's land area is 13.4 square miles at an elevation of 4,550 feet (City Data, n.d). Gillette is a trade center for a region that produces grain, livestock, oil, uranium and coal (Brittanica, 2022). A large open-pit coal mine is nearby along with a state university agricultural experimental station (Ibid). In 2019, its population was 99% urban and 1% rural (City Data, n.d).

## History

### Community History

In 1891, Gillette became a terminus point for the Burlington and Missouri River Railroad, allowing ranchers to ship cattle (Wyohistory, n.d.). The following year, Gillette was incorporated and developed to serve cowboys, ranchers and homesteaders (Gillette History, n.d.).

**Figure 5. Early Settlement Photo of Gillette**



*Source: Rockpile Museum, Gillette, WY, n.d.*

### Industrial History

Early industries in Gillette included hotels, cafes, bars, stables and blacksmiths providing services for travelers. Coal mining started as early as 1909 (Wyohistory, n.d.) The Wyodak Mine, which opened in 1923, runs today as the oldest operating coal mine in the U.S., despite workforce reductions by 40% in 2012 (Ibid; Interviews 2022-2023).

The first commercial discovery of oil in Campbell County occurred in 1948, followed by additional oil discoveries (Hein, 2014). Such energy development, together with that of coal, was a factor in the County's population doubling in the 1960s, followed by another near doubling the next decade (Ibid; Interviews, 2022-2023). Within Campbell County, Gillette's population alone grew by 69% from 7,194 in 1970 to 12,134 in 1980 (Ibid). These boom and (later) bust cycles have been dubbed the 'Gillette Syndrome', referring to a range of pressures including demands for water and sewer systems, rising property prices and competition for labor in the local community (Hein, 2014).

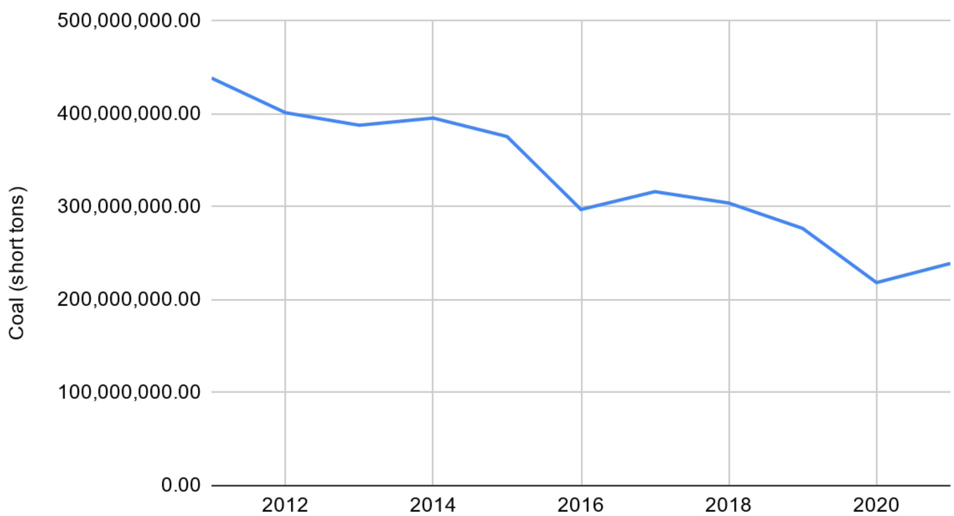
The 1973 OPEC oil embargo catalyzed interest in producing greater domestic energy supplies (Araújo, 2017). During this time, the Powder River Basin which surrounds Gillette increased coal output and, by the 1980s, had seven of the ten largest coal mines in the U.S. (Gaudet, 2019). By 2010, Black Thunder Mine in Campbell County was the top U.S. coal producer, supplying 116.2 million tons of coal (Hein, 2014). In

2013, nine coal mining companies were located in the county, along with eighteen oil and gas producers in the region (Ibid).

Largely due to coal production, Campbell County in 2012 was the richest county in Wyoming with an assessed valuation of $5.8 billion (Ibid). Campbell County has traditionally brought in more revenue than any other county in the state, with revenue from taxes on the energy industry being used for the city, schools and other services (Mills and Hershman, 2017).

More broadly, the Powder River Basin now produces ~40% of America’s coal (Wyoming Mining Association, 2023). However, as shown in Figure 6, the industry is experiencing longer term decline. In 2016, roughly 500 miners were laid off in one day, drawing widespread attention to the disruption (Propp, 2017; Interviews, 2022-2023). Patrick Hladky, who (with his brother) manages Cyclone Drilling, an oil rig company started by their father, indicated “Natural gas is in competition for power generation … [t]he downturn in coal was less to do with regulation by the federal government and more to do with the price of natural gas” (Mills and Hershman, 2017).

**Figure 6: Wyoming Coal Production**




*Source: Wyoming State Geological Survey, 2022.*

Alongside the above challenges for coal, railroad capacity constraints in the Powder River Basin have also been highlighted as currently constraining Wyoming coal output (Interviews, 2022-2023). Travis Deti, Executive Director of the Wyoming Mining Association stated that with increases in demand and pricing, but an absence of sufficient rail transport Wyoming lost an estimated $60 million dollars in state revenue, or 12.5% of annual coal production in 2022 (Bleizeffer, 2021).

In line with the above conditions, it is widely accepted in the community of Gillette that the economy needs to adapt (Interviews, 2022-2023). As part of the new economy, PacifiCorp recently opened a 520 MW wind farm an hour and half south of Gillette (Sutter, 2021). Atlas Carbon is also making activated coal for use in water filters such as with Brita or Piore, as well as huge chemical filters for water and air that remove pollutants such as mercury from coal in power plants (Mills and Hershman, 2017). The local Dry Fork Station, one of the newest coal-fired power plants in the country, runs on local coal and uses activated carbon to clean up its emissions (Ibid).

For over half a century, uranium mining also has been an important industry in Wyoming. The federal government established the Atomic Energy Commission (AEC) in 1946, which provided incentives for uranium mining (Larsen, 2019). In the 1950s, the Lucky Mc company began mining uranium in the Shirley basin area of Wyoming, alongside a number of other mining companies. By 1960, the AEC recognized that stockpiles were growing too large, so presented the mining companies with two options: continue with the current contract until 1967 and no guarantee of price afterwards, or produce 50% more by 1970, but at a reduced price (Ibid). The situation triggered bankruptcies and scale-backs (Ibid). Following this period, four major uranium producers remained in Wyoming: Western Nuclear, Lucky Mc, Federal American Partners, and Globe/Union Carbide (Ibid). The fuel crisis of the 1970s spurred uranium price increases and demand growth for use in nuclear power (Ibid). As most of the country struggled with the energy crisis, Wyoming thrived due in part to its uranium production (Ibid; Interviews, 2022-2023). The Three Mile Island nuclear accident brought a swift end to the uranium boom in 1979, as companies cancelled plans for nuclear power plants and regulations increased surrounding nuclear power (Ibid).

## Current Economic Development

In 2016, the average income for Campbell County was $54,654, 2% below Wyoming's per capita income ($56,081) and 14% above the US per capita earnings (Campbell County Board of County Commissioners, 2017). Notably, the population of Campbell County is relatively young, compared to other locations (Ibid).

In 2022, Wyoming reported a Gross State Product of $36 billion, with a declining annualized growth rate of -0.7% for the years 2017-2022 (IBIS World, n.d.b). This GSP/GDP growth rate ranked Wyoming at 48th among all 50 states. As of 2022, there are 86,201 businesses in Wyoming, with an annualized business growth rate of 2.1% for the years 2017-2022 and a state growth rank of 36th for the same period (IBIS World, n.d.b). The following table outlines Wyoming's top five GSP or GDP sectors.

**Table 8: Wyoming Gross State Product by Sector**

| Sector | GDP ($Thousands) | Growth 2022 (%) | Annualized Growth 2017-22 (%) |
|---|---|---|---|
| Mining | 7,093,873 | -5.4 | -4.6 |
| Real estate and rental and leasing | 3,601,583 | -1.0 | -1.6 |
| Manufacturing | 3,549,062 | 4.4 | 7.7 |
| Transportation and warehousing | 2,336,080 | -5.7 | -3.8 |
| Retail trade | 1,922,390 | -1.0 | -0.5 |

*Source: IBIS World, n.d.b.*

The average unemployment rate in Wyoming is 3%, with Campbell County having one of the highest rates in the state at 3.3% (DOE, 2022). The total number of people working in Wyoming decreased by -5.1% between 2019 and 2021, from 354,815 to 336,824 (Wyoming Department of Workforce Services, 2022). **50% of Wyoming's general revenues for public goods come from the "three-legged stool" of coal, oil, and natural gas** (Ibid). Therefore, public services have been hit by the reduction in output. The state's school systems have also been impacted, as coal revenue is by far the most prominent source of education funding. Policymakers in the past used this model of coal-heavy funding for education due to the non-cyclical nature of coal production, compared to oil and natural gas which experience greater price fluctuation, but are now facing challenges as coal reliance is waning (Godby, 2021). When all the coal revenue streams are added together, the amount roughly equaled $567,227,776 in 2020, which is a significant decrease from 2012's total coal revenue of $1,263,851,007 (Godby et al, 2015; Wyoming Mining Association, 2021). The lay-offs are expected to continue as more coal stations are set to close in the near future (Interviews, 2022-2023). Therefore, there may be an available workforce primed for a new industry.

**Energy Redevelopment**

While the region around Gillette has been producing fossil fuels for years, decarbonization goals and competitive rates of other fuels have been driving decline in recent years. Projects such as those on carbon capture feasibility, activated coal, and non-thermal uses of coal are being conducted to align with net zero carbon emission targets and refocus the region as a carbon management hub (Interviews, 2022-2023; *see* also Part 7).

**Tourism and Recreation**

The city of Gillette has been diversifying its economy in non-energy sectors. This is accomplished by building venues, such as the Energy Capital Sports Complex and Cam-Plex aimed to increase tourism and recreational opportunities in the area (Bleizeffer, 2021; *see* also Part 7).

**Innovation**

The U.S. Department of Commerce has invested $3.4 million to "Support Business Development and Job Growth in Campbell County, Wyoming" (U.S. Dept of Commerce, 2022). Of this total, roughly $2.8 million is allocated toward infrastructure improvements at the Pronghorn Industry Park, a site set to explore the future of carbon technology in the U.S. (Ibid). The Wyoming Innovation Center was opened in Gillette in 2015. The center's first tenant is planned to be the National Engineering Technology Laboratory (NETL) and the University of Wyoming is expected to be a partner, offering opportunities for students and graduate students to engage on tests of novel technologies (Cook, 2022).

**Uranium Mining Potential**

Wyoming contains the largest known uranium ore reserve in the U.S. and, in the past, was ranked number one in uranium production (WY State Geological Survey, 2022b). Since the 1950s, more than 200 mines have been sited in Wyoming and experts estimate more than 200 million pounds of uranium ore remains economically recoverable (Ibid).

Uranium is highly valued, but mining, especially in Wyoming, only occurs when market prices make mining viable or when strategic investments make sense to maintain a federal uranium reserve. Production of yellowcake was dramatically lower over the past decades due to international market conditions, but forecasters are expecting conditions to improve (Interviews, 2022-2023).

As the primary feedstock for nuclear power plants and nuclear-powered submarines, uranium is now more fully seen as a mineral of national/energy security importance (Powers & Rubin, 2022). At its peak global production in the 1980s, the U.S. produced over 40 million pounds per year (Cook, 2022). Travis Deti, the Wyoming Mining Association's Executive Director, does not see why the U.S. couldn't reboot, with western state mines producing 10-20 million pounds per year (Ibid). Uranium production had a steep decline after 2016 and, though prices rose in spring 2022 to $60/pound, Wyoming Consensus Revenue Estimating Group (CREG) estimates prices will need to be sustained between $60-80/pound in order for operations to restart (CREG, 2022). Current uranium concentrate pricing is at $40-50/pound.[98] CREG forecasts uranium production will increase in coming years as the U.S. focuses on the establishment of a domestically produced uranium stockpile (Ibid).

The U.S. has not been producing uranium domestically because it is less expensive to import from other countries, and options remain such as with Canada and Australia which have large reserves (EERE, 2022). Furthermore, all commercial conversion of uranium currently occurs outside the U.S., although the ConverDyn/Honeywell plant is expected to come back online in 2023 (WNN, 2021). State-owned Russian and Chinese conversion operations have dominated the global market with over 40 percent of capacity in the supply chain (Ibid). Experts indicate it is difficult for independent companies to compete with state-owned enterprises, but it will be necessary for the U.S. to strengthen each section of its supply chain to continue competing in nuclear technology globally. This is an argument for industrial policy, if not a strategic uranium reserve.

The COVID-19 pandemic disrupted supply chains, transportation and global operations which constricted uranium supply. U.S. uranium production is the lowest it has been since the 1940's which has left the nuclear industry reliant on foreign imports (Barrasso, 2021). To be more self-sufficient and improve energy security, the government is looking to invest in the nuclear supply chain in the U.S. In 2021, Congress provided $75 million to the DOE in the $1.9 T pandemic relief bill to acquire domestically mined and converted uranium (Ibid; Powers & Rubin, 2022). Russia, Kazakhstan, and Uzbekistan provide nearly half of U.S. supplies for nuclear fuel–causing concern over whether a national uranium reserve should be created and if uranium should be listed as a critical

[98] Wyoming has removed severance tax on the production of uranium when spot prices are lower than $30/pound, but the severance tax will increase incrementally to 4% when spot prices exceed $60/pound (CREG, 2022).

mineral under existing circumstances (Powers & Rubin, 2022). Concerns remain over the environmental risks from expanded uranium production in the U.S. As global supply chains continue to be disrupted, uranium suppliers and political supporters have encouraged Congress to act in the development of a domestic uranium supply chain, including both mining and enrichment operations.

Currently Russia is the only commercial producer of HALEU uranium which is required for advanced nuclear reactors. The U.S. is focused on a growing number of advanced reactor projects to move energy portfolios toward carbon neutral futures. Therefore, the DOE is looking to include HALEU and standard low-enriched uranium in its uranium strategy (WNN, 2022a). Energy security is at the forefront of policy makers' minds, as well as the possible economic and job impacts such a facility could bring (Ahn et. al., 2022). DOE released a request for information in December 2021 seeking public input on its plans to create a new HALEU program in the U.S. to demonstrate the potential for commercial deployment of advanced reactors, leveraging funding from the Infrastructure Investment and Jobs Act (Office of Nuclear Energy, 2021). Comments submitted to the RFI assert establishment of a supply chain domestically is necessary for commercial investment into the advanced reactor technology to ensure a steady demand of HALEU production (WNN, 2022b).

Specific to Wyoming, the uranium industry and related exploration have been a part of the mining playing field as far back as the mid-20th century (Cook, 2022). Since then, the industry has undergone boom-and-bust cycles, with cheaper uranium produced in countries, as noted above. According to Scott Melbye, Executive Vice President of Uranium Energy Corp., and President of the Uranium Producers of America, he has “never been more optimistic about the prospects for nuclear energy and also what that means for uranium mining and the supply and demand of uranium (Ibid).” Today, all of Wyoming's uranium mines are in-situ operations (in contrast to open-pit mining), resembling oil and gas wells (Ibid). Operations that are on standby or fully licensed and ready to move are where the focus can be expected. Wyoming’s congressional delegation is prioritizing fuel cycle needs for advanced reactors that can be met domestically (Ibid).

Importantly, with the announced plan for Wyoming to adopt its first nuclear plant using small modular reactor technology to replace a retiring coal plant in Kemmerer, public discussions have expanded around nuclear technology and uranium. According to interviews, a questioner in one public discussion about the Kemmerer project asked whether the plant would use Wyoming-sourced uranium (Interviews, 2022-2023). The answer currently is no. As noted earlier, the plant opening has been pushed back roughly 2 years by TerraPower to 2030 (Tan, 2022), given that HALEU is currently only sourced from Russia, a country under major sanctions. Brian Muir, the city administrator of Kemmerer indicated, “I think this might actually give our Wyoming uranium industry a little more time to put things together to provide that uranium (Ibid).” In December 2022, Senator Barrasso of Wyoming and other senators urged the Senate Committee on Appropriations to include funding in Energy & Water Development for the U.S. nuclear fuel security consistent with section 8103 of S.A. 5499, the FY 2023 National Defense Authorization Act (U.S. Senate, 2022).

**Wyoming Taxes**

Wyoming applies a gross products tax in lieu of a tax on the land, unlike other states which often tax mineral properties based on reserves in the ground. Wyoming only taxes a mineral once–when it is produced (WY Leg, 2015). The fair market value of the mineral being produced is assessed and taxed after mining or production, with the assessed, gross product tax to be given to counties and the severance tax imposed for state projects and taxation purposes (Ibid). Though Wyoming's mineral severance tax is a central source of revenue for the state, the percentage taxed does not differ much from other mineral rich states such as North Dakota and Texas (5-7%), but has been criticized for not following a more state-focused model like Alaska which takes 35% of net production value (NCSL, 2018; Western, 2008).

Wyoming has been providing minimal reductions to severance tax for coal in hopes of increasing overall production (severance from 7 to 6.5%). Recent Wyoming nuclear legislation also provides tax exemptions for the production of electricity from advanced nuclear reactors that use at least 80 percent uranium mined in the US (WY HB0131, 2022).

Beyond the above taxes, Wyoming currently has a $1/MWh tax for wind and increases to this tax have been discussed for over a decade (Thompson, 2010). As Wyoming contemplates the transition away from fossil fuels, the state continues to look for ways to fund state programs and budgets. These discussions have required tax advocates to balance the desire to increase the production tax on wind projects without undermining the potential for project development as an economic diversification strategy, especially when compared to wind potential and economics of projects in surrounding states (Cook & Godby, 2019). Under current tax policy conditions and economics, Wyoming is fourth in western states for its low tax rate–but the cost differences between Montana (#2) and Colorado (#3) estimates are less than 3% when a 20 to 30-year project life is assumed (Ibid). This highlights the competitiveness of these projects across states, which could likely be impacted by any changes to tax incentives.

## Gillette/Campbell County Energy Overview

Coal makes up 98.44% of the fuel used for electricity in Campbell County, offset by only 1.42% natural gas, and less than 1% of each distillate fuel oil and waste oil (Reese, 2022).

The City of Gillette is represented in electricity by a municipal utility that serves residential, commercial and industrial electric customers. The city provides electricity from two generation facilities, including partial ownership of the 100 MW WyGen III coal plant and full ownership of a 40 MW simple-cycle gas-fired combustion turbine as well as bilateral purchases from regional utilities (City of Gillette, 2021). The utility has also secured future resources to meet increasing energy needs through a long-term contract

(2054) for 3-4 MW of hydroelectricity from Western Area Power Administration, a power purchase agreement with Black Hills Wyoming to purchase 5 MW additional power from Wygen I (beginning in 2023), and a regional peaking contract (Ibid).

The municipal utility serves 15,576 customers, including 13,081 residential, and 2,495 commercial customers as of December 31, 2020 (Ibid). The City of Gillette is a summer peaking system, which experienced an all-time peak demand of 77.8 MW during summer 2017, but demand and energy consumption has leveled off over the past several years (Ibid). Gillette's average residential electricity rate is 11.48 cents per kilowatt hour, which is 3.51% higher than Wyoming's average rate of 11.09 cents (Reese, 2022). Campbell County is the fourth highest electricity generating county in Wyoming, but due to the large energy-producing sector and small population the state has one of the highest per capita energy consumption rates in the US (EIA, 2022c).

Energy adaptations for uranium mining and other economic development are conceptual at this point and will be reviewed in terms of perceived outlooks in Part 7. The options that are examined include ramping fossil fuel, a microreactor, and use of wind plus storage.

## PART 7: Findings

This section distills the findings from the elicitation, case analysis and literature reviews.

1. **What economic developments, including mining of graphite (Alaska) or uranium (Wyoming), are likely in the communities of focus for the next 5-10 years?**

### Nome, Alaska

Nome's traditional economic activity in gold mining and fishing/hunting has several areas of prospective growth.

**Graphite One mine**

Development of the Graphite One mine outside of Nome is an option that is quite likely to occur, barring any surprises in the later stages of feasibility assessment and permitting.

Graphite One has been engaging with communities near the proposed mine, including Teller, Brevig Mission, Mary's Igloo and Nome to discuss the project and provide updates (Interviews, 2022-2023). The proposed mine is located in a remote location and would require a crew of up to 200 people to live onsite year-round. Initial processing of graphite is expected to take place at the site before transporting by truck to Nome and sending it by barge to the final processing destination in Washington (Gannon, 2022; Interviews, 2022-2023).

The strong mining history and culture of the region provide a certain level of familiarity for community acceptance. (However, a recent failure with Nova Gold's Rock Creek

Mine in the area is acknowledged in community discussions, so there is a mix of expectations.)

Current activity at the proposed Graphite One mine site is being fueled by diesel that is brought in by helicopter. Modeling by Graphite One is based on assumptions that indicate diesel will be the fuel source. However, they are open to considering nuclear. Some reservations were voiced that combining new mining in the location with nuclear power generation, such as that from an MR, presents a twin challenge for stakeholders who may be concerned. Ancillary services can be expected (trucks, port, repairs, components, etc) with this economic development.

**Deep water port**

Development of the deep-water port is already underway with the Army Corps of Engineers and the City of Nome. Agreed funding (90:10, federal-local) is outlined up through the construction. Three stages were broken out to allow for more staging around funding. The Award for Phase 1 competitive bids is expected in 2023, with Phase 2 – 2025 and Phase 3 – 2027.

Energy and economic implications are expected to be notable, with planning underway for workforce development, discussions about housing, and electric utility planning.

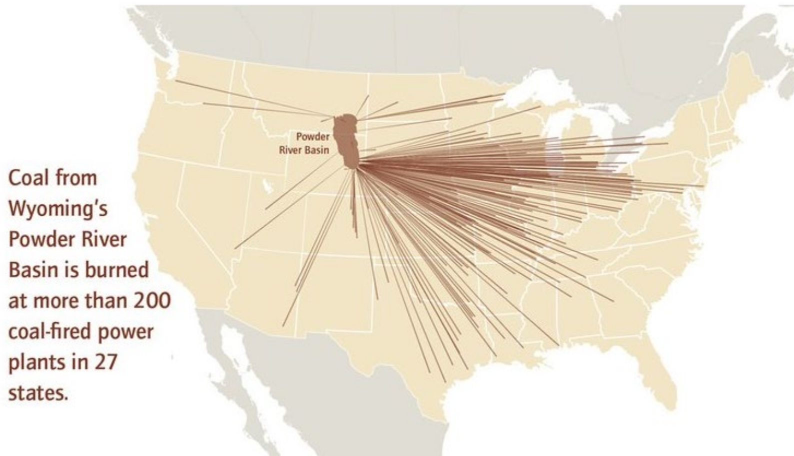
**Additional economic development potential**

Other areas of development that were raised include the possibility of a Coast Guard base installation and increased tourism. With the addition of a Coast Guard facility, the currently limited housing market will need to be expanded. There is also some concern that prices will be skewed from a military installation, with the federal government covering whatever is needed for service families, displacing the local residents. Considered from a different vantage point, the build-out of a Coast Guard facility or additional development between Nome and the mine could be well-suited for synergies between energy and economic development. With respect to tourism, an increase was evident prior to the pandemic, which seems in line with interest in greater adventure-based destinations.

## Gillette, Wyoming

Gillette self-identifies as the energy capital of the U.S. and is positioned to continue building on these strengths.

**Figure 7: Gillette, WY as the Energy Capital of the US**




*Source: High Country News, Luna Anna Archey and Jonathan Thompson. Reprinted with permission.*

### Uranium mining

Wyoming has a considerable history in uranium mining. While more than 200+ mines have operated in the State since the 1950s, with more than 200 million pounds of uranium ore still deemed to be economically recoverable (WY State Geological Survey, 2022b), closures in previous decades were noticeable, as the global uranium markets shifted toward a less costly supply that was available from countries like Russia, Kazakhstan, and Canada. The U.S. is now reconsidering its domestic supply strategy to fuel its nuclear fleet as geopolitics placed Russian imports out of bounds. While the global market is constricted, the U.S. is no longer buying from Russia, and prices increased, low-cost sources remain (Canada, Kazakhstan, etc). This raises credible questions for U.S. policymakers on whether the U.S. will move past pure global, market conditions and spur a domestic supply chain for security reasons.

According to those in the uranium industry, global prices need to be at $60/pound or higher and remain there, for the domestic industry to want to restart and scale. Wyoming is well positioned to restart uranium mining operations in Cambell County as well as Casper, Sweetwater and Freemont Counties (more southwestern in Wyoming). In Campbell County, one mine is on standby, and others are permitted to restart and ready to go if uranium pricing hits and stays above $60/pound or if policies shift toward strengthening a domestic supply.

Compared to coal mining and other fossil fuel extraction, the skill, expertise and infrastructure requirements are not as considerable and do not directly correlate in a 1:1 job substitution opportunity. Campbell County's uranium mining is based on in situ recovery which functions more like oil and gas wells, as opposed to open pit or underground mining that pertains to coal. However, interest was stated during industry interviews in Gillette and/or the Powder River Basin becoming part of an emerging supply chain for the nuclear industry and, where possible, to mine and process uranium for Wyoming plants, as well as those operating elsewhere in the U.S.

Notably, Gillette currently has many other highly paid jobs available in the fossil fuel industry, so uranium mining is less visible. Nonetheless, Campbell County has the capabilities and readiness to (re)start uranium mining and processing.

**Energy-based entrepreneurial eco-system centered on low carbon adaptations of with fossil fuel and rare earths**

The community and industries of Gillette are deeply rooted in the production of coal, oil, and natural gas, with many public services and venues supported through taxes and other aspects of these industries. They also recognize that decarbonization is underway globally, and there is a long-term downward trend with coal, with short-term uptick from global market flux.

Looking ahead, Gillette appears to be focusing on innovation/entrepreneurship and education to advance with the changing playing field, such as with non-thermal use of coal (e.g. bricks), direct air capture, and alternative carbon value streams.

- **Wyoming Innovation Center:** WIC is incubator space to commercialize carbon products using coal and coal by-products. It also focuses on rare earth element processes. Its first tenant is the National Energy Technology Lab with R&D for commercialization of rare earths.

- **Integrated Test Center**: ITC is a test site for carbon capture, utilization and sequestration (CCUS); with demonstration at the Dry Fork Power Plant.
To date, it has been involved with the UW Carbon X Prize, a competition for best CO2 utilization; and Carbon Safe, currently in Phase III with Site Characterization and CO2 Capture Assessment.

- **Gillette Technical Center/Gillette College**: Gillette College is currently completing the accreditation process as it spun off independently from Sheridan College. This modern campus has state-of-the-art equipment, including augmented reality/virtual simulation that is suited for training a new workforce on safety needs, and other industry requirements. Gillette College is also well positioned for industry adaptation with numerous industry-specific advisory boards.

- **Wyoming Innovation Entrepreneurs**: This group is designed to mentor, advise and innovate with business opportunities that focus on Wyoming advances, by leveraging local resources and business insights.

The energy and workforce needs will depend on what emerges for new industry.

**Additional economic diversification**
Gillette is actively retooling itself to be an events and tourism destination. A signature

development to watch is its Cam-plex venue that is designed for conferences/ conventions, theater, dance, trade shows, livestock shows and rodeos, horse racing, RV events, and Scout as well as religious gatherings.

2. **What considerations were raised for a microreactor vs. another alternative form of energy vs. continued reliance on fossil fuel, if economic development were to scale up due to new mining and/or other development for the respective communities?**

**Nome, Alaska**

Specific to mining of graphite by Graphite One, the company staff does not see MR technology readiness as mature enough to align commercially with a planned operational start for the mine around 2028. They also see the social license for mining + an MR as a dual challenge.

In technical feasibility terms, an MR could serve as the basis for a microgrid that produces power and heat at the mine. An MR could also be installed with Nome electric utility NJUS, displacing some diesel, and requiring a transmission line to be added. Renewables in the form of wind plus storage could be added to a mine-based microgrid or NJUS. This option is not being considered at the mine, but is under consideration for integration by NJUS in its system.

In terms of other economic development beyond graphite mining, with the port plus other activities, the addition of an MR to displace some/most diesel, or the scale-up wind (plus storage) to 40% of the power mix appears to be a plausible option for further study.

**Gillette, Wyoming**

In terms of uranium mining, there is natural synergy and interest expressed by the community in using an MR. Many (not only in uranium mining) see Wyoming as very well suited to stand up a nuclear hub for the fuel cycle, nuclear technology supply and ancillary services. In fact, a number of people in industry expressed strong ambition to contribute to the global nuclear build-out with Wyoming as a hub.

Gillette's economic activity around fossil fuels does not appear to have an immediate point of opportunity for an MR. However, if rare earth extraction ramps up, or more advanced carbon management occurs with CCUS or hydrogen production, an MR appears to be a candidate technology for nuclear energy.

Gillette's tourism and events activity do not naturally lend themselves to choices for or against an MR. Yet, Wyomingites value nature and tourism, and could conceivably replace some fossil-based generation with an MR and use tourism as a way to educate visitors about the state's carbon management hub (aim).

Across many discussions, renewables, such as wind power, were dismissed either because the resource is stronger in another part of the State or it was not seriously pictured, despite Wyoming doubling its share of wind power since 2019 to 19% in 2021 (EIA, 2022b).

The cultural focus seems to be more centered on new nuclear, if Gillette is to move past fossil fuels.

3. **How would greater economic development in the next 5-10 years translate in terms of industry/infrastructure, environmental sustainability, and community/workforce development?**

**Nome, Alaska**

Graphite mining with an MR or renewables on a microgrid is not currently being considered by Graphite One. If instead, an MR were included in electric utility NJUS's supply, a transmission line would need to be built to the mine, along with an already anticipated road build-out. If an MR were sited in the area, additional consideration will be needed to account for regular permafrost shifts in the terrain. For this reason, an MR may need to be sited above ground or in areas of thaw-stable permafrost (previously mined areas that are primarily gravel).

Access roads and infrastructure will be needed for the mine, as the deposit site is about 20 miles from spur-road access to that region's Taylor Highway.

Transmission line expansions will have land use implications. Ancillary activity/services can also be expected (trucks, port, repairs, components, etc) with such economic development.

In environmental sustainability terms, some asked what would happen with an MR in terms of the nuclear waste. Others noted that increased economic activity (in any form) will likely displace wildlife, which matters, especially for subsistence hunters. Specific to the community and workforce development, a number of people noted that local expertise would be needed for an MR, especially given the remote nature of Nome.

Looking next at the same question with wind and storage, the transmission build-out is seen to have the same implications for land use and wildlife. There was not notable concern about environmental sustainability aspects of renewables scaling or community and workforce concern. Historic issues with older, misaligned wind turbines were occasionally mentioned, yet there is also recognition that the larger modern EWTs function noticeably better.

**Gillette, Wyoming**

Wyoming is quite focused on diversifying its economy. Gillette especially is leveraging state and federal funding to build out projects to commercialize carbon products to maintain economic development from its wealth of mineral resources. The coal economy has been central to Wyoming's general fund and continues to support most of Gillette's central and ancillary services. Thus, considering economic development outside of fossil fuels that could provide high-paying jobs consistently over time may be difficult.

Business developers and local leadership estimated that the most important first steps for Gillette would be to obtain properties ready for industrial and commercial development to attract new companies to the area. The region currently has plenty of fossil-fuel powered electricity, but is constrained in the infrastructure for natural gas. Residents recognize carbon policy could quickly limit the economic and technical viability of coal mining and their operating coal plants, and a shift to nuclear, especially advanced nuclear could be a next step. Gillette was one of four sites being considered for the Natrium reactor, sited in Kemmerer, and its existing coal infrastructure could be leveraged for a nuclear reactor if another one was sited locally.

Gillette is currently a hub for coal/natural gas/methane drilling and mining technicians and machinists, internationally. Some members of the industry see themselves as flexible and available to adapt the nuclear workforce to support with manufacturing, assembling, transporting, or working on aspects of the fuel supply chain. Companies and individuals stated interest in exploring participation in the fuel supply chain in greater depth.

Residents do not appear to have any major concerns with the environmental sustainability of proposed development projects. Currently, oil and gas traffic and open pit coal mining have significant air, water and vegetation abatement plans. The level of proposed uranium mining, especially in-situ would require much less of a footprint or traffic than other types of mining. There have been discussions regionally about wind development and wildlife habitat including sage grouse and large game animals, but Wyomingites seem confident that adequate measures are being taken to protect the environment, balanced with development.

The Gillette Community College and Tech Center are points of interface with different industries and are able to provide community development through educational opportunities. Their structure is much more nimble than traditional educational institutions and able to provide training and certificate programs in a range of technical careers, necessary to the energy ecological system. Employers and community members indicate that the community college, in partnership with industry, will play a key role in workforce development, but it will need to find fast pathways to credentials or micro-credentials in the right fields. If Gillette is going to build a nuclear workforce and strengthen the existing pool of skilled workers, it needs to improve linkages to engineering schools/internships which bring talented workers who will stay in Gillette. Residents see opportunities to learn from the experience of Kemmerer and possibly bridge the workforce digitally, as PacifiCorp has expressed its intent to site as many as five reactors across its territory.

**4. What are the opportunities and barriers for MRs in these communities?**

**Nome, Alaska**

If cost estimates are seen as credibly firmed up and show improved competitiveness with existing diesel, there is general interest in exploring new options for Nome. There is also widespread interest in following what occurs with Eielson Air Force Base and in terms of learning more. There is recognition that MRs are still under development and adoption may be 10 or so years out. Those who are interested in thinking through MR adoption also see that planning needs to begin soon to be in the 'pipeline'.

If an MR were installed, for instance in the electric utility NJUS's market, the utility would need to consider whether to buy and train its staff or lease the technology in such a manner that expert maintenance would be handled by the owner.

More broadly for Alaska, some see a regional industrial hub opportunity for the state with multiple MRs along the rail belt and as an MR hub.

In relation to security, Nome's proximity to Russia was noted. With current hostilities, there is some acknowledgement of a security risk in having a nuclear plant installed. Here, one simply can look to the Russian firing upon the *Zaporizhzhia Nuclear Power Station* in southwestern Ukraine. However, generally speaking, this was not a widely raised concern.

Those who are less interested in MRs mentioned national waste management issues and alternative opportunities with renewables. Others don't see the current, costly diesel dependence as a problem. Permafrost is an environmental condition that would affect siting as it currently affects diesel tank storage.

**Gillette, Wyoming**

Unlike Alaska, the driver to find and adopt a cheaper source of electricity is not an express goal in Wyoming at this time, especially in Gillette where so much of the economy depends on coal. Gillette residents recognize their community as the energy capital for U.S. fossil fuel production and a technological hub for future energy development. Due to this identity, businesses and individuals would like to participate in the buildout of the advanced nuclear economy, identifying general community acceptance of industry and resource utilization as readiness to build competencies in this area. The community seems to be looking at the disruptive potential of the nuclear industry as a whole rather than siting just one nuclear reactor in the community—and would like to understand the viability of the technology.

Like Alaska and the Eielson Air Force Base MR, Gillette is watching closely as the Natrium Reactor is sited on the other side of the state to understand the social, technical and economic barriers such a process might take. However, at the same time, some companies are more broadly considering how they might participate in different components of the MR economy. Transportation strategists are considering how rail and trucking routes could be utilized to move MR components across the US.

There are currently six operating coal plants in Gillette. These are likely both opportunities and barriers to nuclear in Wyoming. Since the Gillette economy is largely based on coal mining and coal-fired power generation, community members and industry will continue to run these plants as long as economically feasible. Some community members noted the current economics of coal are likely preventing longer term investments in other economic opportunities and, more importantly, hiding the oncoming bust. This is particularly impactful because there seems to be funding for communities in crisis, but little for those transitioning on the precipice of crisis. The opportunity in repurposing the large amount of infrastructure following coal-plant closures is credible. As in Kemmerer, and discussed in other locations, existing infrastructure could be leveraged for the nuclear build.

Given that uranium mining has taken place in Wyoming and specifically near Gillette for decades, community members seem comfortable with nuclear technology and waste—though, as in Alaska, they believe having a permanent nuclear storage solution would help the nuclear case.

## Part 8: Limits

As with all research, it is important to acknowledge limits.

The policies portion of the study drew from national and state-level resources that reflect diverse timelines for policy changes and published updates. This report represents a distilled snapshot of available information that we were able to access for the period of this study.

Specific to the interviews, we continue to see more people who would be valuable to engage on the subjects that we examined. We also found there were perspectives that were not able to be included, either because of availability or interest. For Nome, it would be beneficial to engage more voices from the indigenous communities. Similarly for Gillette, it would be beneficial to engage more voices from the power sector. Across both communities, it would be insightful to engage with school superintendents and hospital administrators as they represent key community voices and are also point people for prime energy users. In the case of Gillette, schools are also seen as beneficiaries of energy/mineral tax money. Further, to improve our understanding of the workforce potential, demographics, and general ideas about transient worker populations in each location, we could engage with more people in technical training/education on how they are planning for boom/bust expansion/contraction.

## Part 9: Discussion and Future Research

Interviews and case analysis revealed that both states produce considerable natural resources that are exported out of state for higher value refining or processing. If low carbon energy could be scaled more fully in both states at competitive costs for **advanced manufacturing, the state economies have considerable potential for added depth and breadth of existing and new industries.**

This study also showed that Nome and Gillette are forward-looking communities that anticipate palpable economic change in the next 5-10 years. They are strategically asking how they can adapt to leverage inherent strengths which align with community interests.

**Workforce development** priorities are at the foreground of discussions in both locations. As substantial economic choices are still dependent on studies, demonstrations or shifting market developments (e.g., Graphite One mine; uranium mining restarts; carbon management build-outs), workforce educators need more clarity in order to anticipate the need gaps and timing. The remote and less dense nature of the community populations presents opportunity for innovative adaptations in virtual, augmented reality and other forms of training that the State and federal government could support. Moreover, there is interesting potential for learning across the two communities.

In terms of **prospective regional energy choices, increased information sharing** was commonly voiced as important for both communities. This suggests that public officials and industry should work more with educators through public meetings and other planning activities to inform on needs, prospective options and tradeoffs as well as **engaged decision-making**.

Specific to nuclear energy, consistent questions were raised among interviewees about how spent nuclear fuel (SNF)/nuclear waste would be handled. Given that some microreactor designs envision ‘plug and play’ technology, planning will need to factor for microreactor SNF/waste being shipped back to a manufacturer or another designated site with fuel intact for refueling or replacement. In such cases, **regulations that are under development need to account for transport of a microreactor + SNF/waste via a plane or ship** (Law of the Sea) in addition to more conventional transport (Shropshire et al, 2021; Black et al, 2022). For microreactor technology that can refuel on site, the States may wish to consider **State-Federal agreements on nuclear waste management or new consent-based siting calls**.

Thinking about microreactor challenges across groups, the limited data on expected costs for adopters and the pre-commercialization status of the technology were voiced as areas that need to be more mature for prospective adopters to think more seriously about the technology. If microreactor vendors are anticipating their technology to be used like the larger reactors in terms of project lives of at least 40 years, it would be helpful to indicate this. A 40-year project life matters significantly for the project calculus of communities thinking through microreactor technology. Likewise, recognition of specialized workforce needs presents an opportunity for deeper discussion in community planning.

More broadly, shifting policies and perceptions around decarbonization are impacting energy diversification conditions. Pathways and timelines to decarbonization at state and federal levels will heavily influence Nome and Gillette communities, as both locations depend on fossil fuels in varying ways and energy economics will trickle down into community projects and workforce needs.

This report identified high-level tax policies and the significance of mineral taxes to the economies of both states. A more in-depth analysis of the **tax and mineral schemes with a review of relevant peer models** could provide decision-makers with a comparative baseline for adaptation to leverage new opportunities. Additional analysis of a range of **critical minerals and rare earths or materials of national security significance** could also be completed to shed light on expanded market potential in each state.

**Specific to land ownership, access and rights of way,** these may well present barriers to energy and economic development. In states like Wyoming and Alaska, which have considerable state and federal lands, projects can face obstacles due to the complexity of jurisdictional boundaries and necessary assessments. Further, transmission and roads may need to cross private lands and require additional permissions and permitting. Contextualizing and evaluating these possibilities would be important considerations regarding siting energy in these locations.

Alongside decarbonization, tax-minerals policies and land rights, the policy playing field has clearly been evolving in recent years across multiple jurisdictions, as the federal government, Tribes, and states have seen increased needs to develop flexible regulations and procedures for regional diversification and infrastructure, as well as jobs. A more in-depth assessment of **interjurisdictional oversight in each case location would be beneficial to understand the intersecting authorities tied to land use, permitting, mineral rights and mining, port oversight, energy and the environment**. This would be especially relevant in Alaska, considering the numerous Tribal organizations.

Finally, Nome, Alaska and Gillette, Wyoming have provided important natural resources to their regions and the US economy. Amidst shifting priorities tied to decarbonization and national security, their communities now face important choices for energy and economic strategies. Both communities have histories of navigating booms and busts with natural resource markets. They are preparing for transitions that present unique opportunities to develop new industries from existing resources. Both are well-suited for establishing innovation hubs that leverage natural strengths. We recommend that the stakeholders work through community-informed planning measures to discuss concerns and opportunities, while developing locally-relevant approaches to address the coming changes.

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# APPENDIX

## Interviewee Affiliations

**Alaska:**

- Alaska Dept of Environmental Conservation
- Alaska Department of Transportation
- Alaska Energy Authority (multiple)
- Alaska Mining Association
- Bering Straits Native Corporation
- Denali Commission
- Consultant - Mining
- Consultant - State energy
- Geological Survey
- Graphite One (multiple)
- Kawerak, Incorporated
- Kotzebue Electric Association
- Marine Exchange, Alaska
- Nome City (multiple)
- Nome City Council
- Nome Joint Utility Services (multiple)
- Port of Nome (multiple)
- Sierra Club
- Sitnasuak Native Corporation
- University of Alaska (multiple)

**Wyoming:**

- Campbell County (multiple)
- Cyclone Drilling
- Earthwork
- Energy Capital Economic Development Entrepreneur (multiple)
- Gillette Community College
- Journalist
- L&H Industrial
- Powder River Basin Resource Council
- Resident
- University of Wyoming (multiple)
- Uranium Energy Corporation
- Wyoming Business Council
- Wyoming Department of Workforce Services
- Wyoming Economic Development Association
- Wyoming Energy Authority (multiple)
- Wyoming Innovation Partnerships
- Wyoming Mining Association
- Wyoming Workforce Development Council

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