MICROREACTORS IN ALASKA

Use Case Analysis: Railbelt Energy Producers

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Introduction

Alaska's energy landscape can be roughly divided into two buckets - remote microgrids and the 'Railbelt'. The state is home to over 100 very small micro-grids which provide power to individual communities, mostly with fewer than 500 residents and isolated from the road system with only air and, sometimes, barge access. However, the majority of Alaskans live on the road system that connects Southcentral Alaska and parts of the state's Interior. This is a region of Alaska serviced by a system of five interconnected but separate utilities stretching from Homer in the south to Fairbanks in the north, encompassing what is colloquially called the 'Railbelt'.

Population and Demographics

The Railbelt region had an estimated population of 550,000 individuals in 2019,[1] 63 percent of which is of working age—between the age of 20 to 64.[2] Figure 1 maps population size by community across Alaska. More than half of the state's 280,000 jobs are located on the Railbelt.[3] In the utility sector, 1,348[4] are employed across the Railbelt at electric, gas, water, and other utilities.[5] As a region, the Railbelt has access to a deeper labor pool than isolated rural communities, both within and outside of the utility sector.

Trained personnel are an important component of the success of any energy system. Nuclear Regulatory Commission's (NRC) current regulations include requirements for nuclear system operators. These requirements are designed for traditional nuclear reactor systems, and it is still unclear what requirements will be placed on advanced reactors; therefore, a flexible workforce will be an important component of commercial deployment of the technology at the local level.

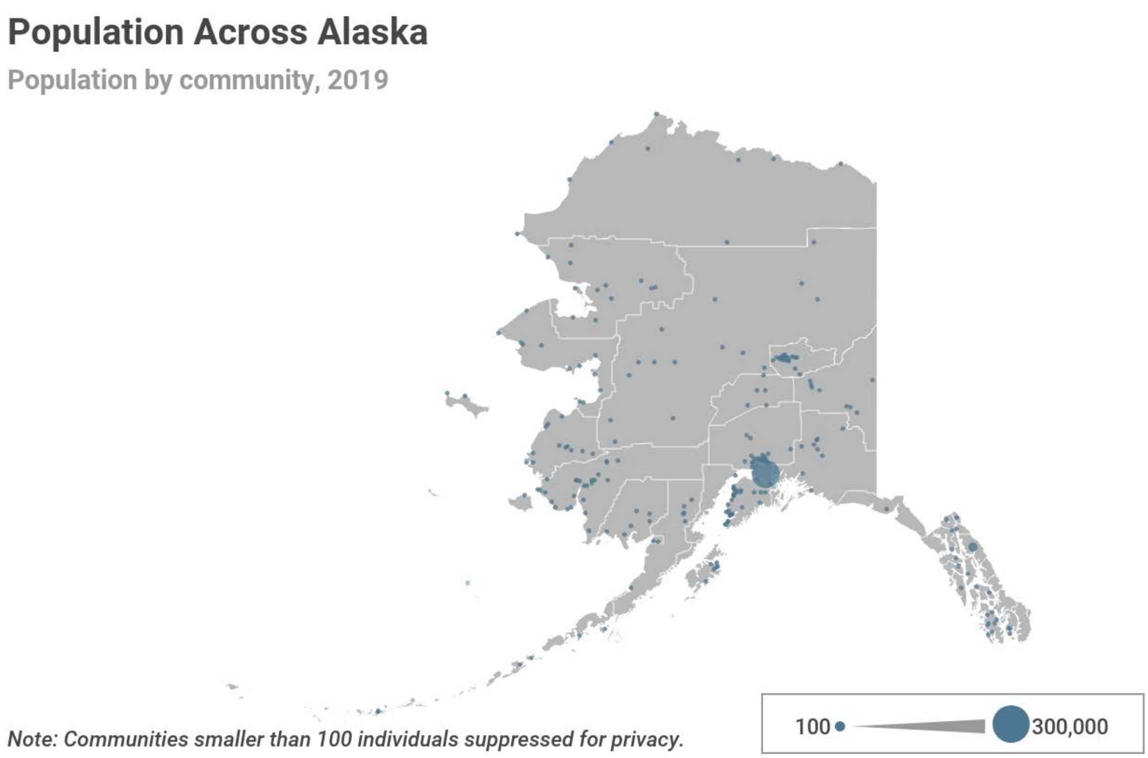

Figure 1: Alaska Population by Community.
Source: Alaska Department of Labor and Workforce Development (AKDOLWD), 2019.

Current Energy System

The five electric utilities that serve the Railbelt region operate an integrated system which enables all of the utilities to buy and sell power from each other. Several independent power producers (IPPs) produces and sell power to local utilities. The Alaska State Legislature passed a bill in April 2020 to enable the creation of an electric reliability organization (ERO) tasked with the planning of all new generation and transmission projects.[6] The ERO's other potential duties include development of reliability standards for interconnected utility systems, developing integrated resource plans, and overseeing planning and integration of new transmission, generation, and interconnection infrastructure. In addition, through the ERO, the Regulatory Commission of Alaska (RCA) will also be enabled to play a role in approving future generation projects.[7]

The Railbelt utilities are powered through a mix of natural gas, coal, diesel, and renewable resources.[8] Figure 2 maps the installed power capacity across the Railbelt. Each of the utilities purchases power from an established hydro-electric asset, Bradley Lake. An extension of Bradley Lake, the Battle Creek Diversion Project, is currently under construction.[9] An addition 20 MWe of wind capacity and 27.5 MWe of coal generation capacity is used to sell power to adjacently-located utilities.[10]

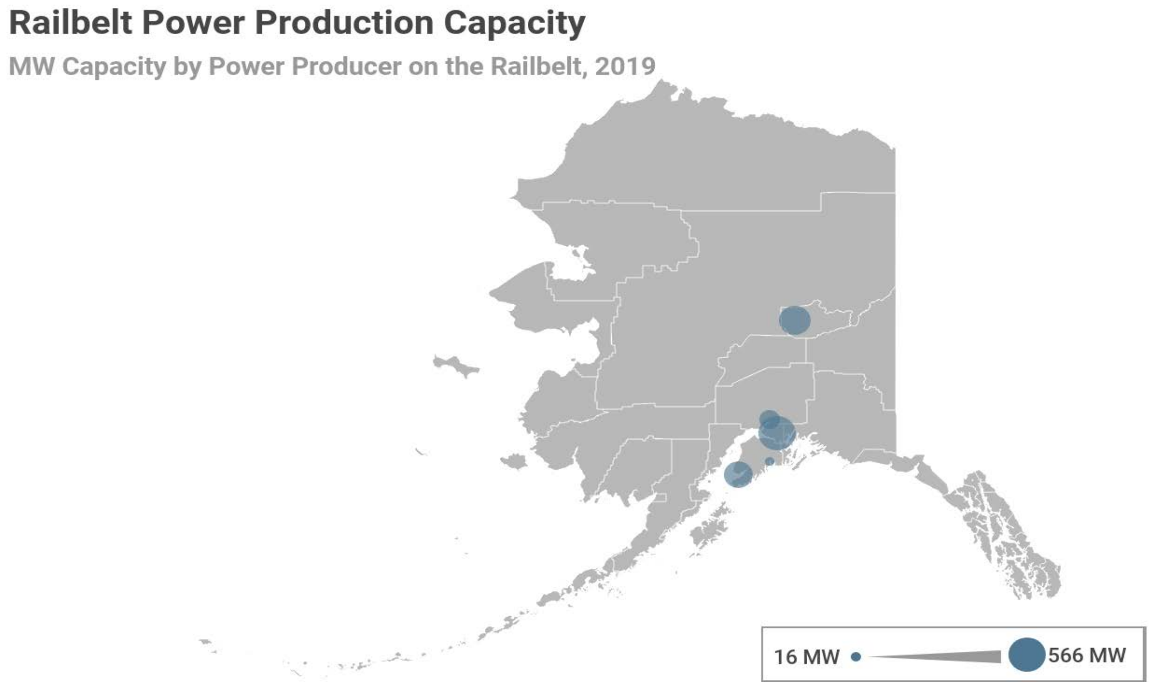

Figure 2: Railbelt Utility Generation Capacity.
Source: EIA, 2019.

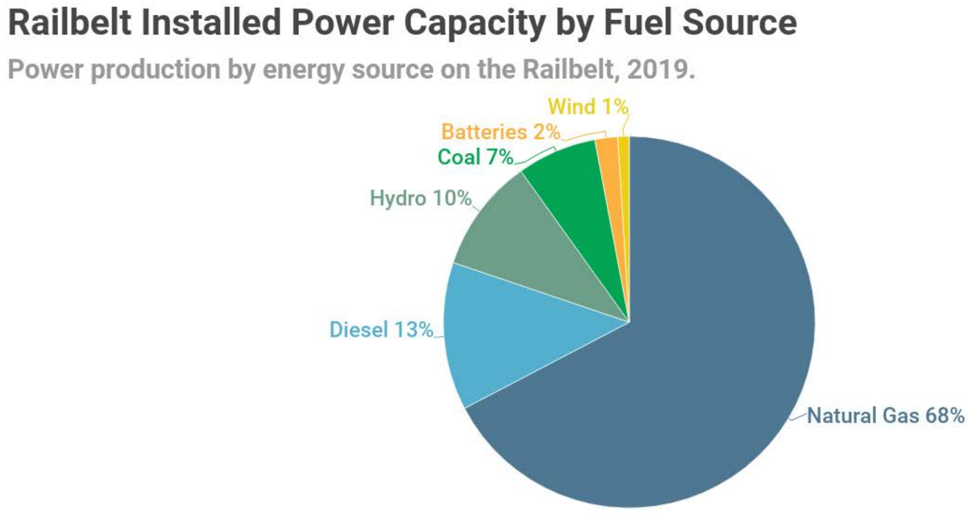

Figure 3: Railbelt Utility Installed Capacity by Energy Source.
Source: EIA, 2019.

Four of the utilities are able to purchase Cook Inlet natural gas. A locally available and relatively cheap resource, natural gas enables most of the Railbelt to keep the realized cost of power to customers down. Approximately 45 percent of Alaska's electricity is produced through natural gas, and nearly 70 percent of Railbelt power comes from this source.[11] Figure 3 shows the portion power production by energy source. Each of the utilities operate newly built generation assets.[12] Tables 1 through 5 discuss the currently operable generation asset owned by each Railbelt utility.

ML&P Generation Capacity by Unit		
Energy Source	**Capacity (MWe)**	**Year Built**
Natural Gas	48.9	2007
Natural Gas	27	1972
Natural Gas	60.4	2017
Natural Gas	30.9	2017
Natural Gas	102.6	1979
Natural Gas	60.4	2017
Natural Gas	92.6	1984
Diesel	2	2012
Hydroelectric	22.2	1955
Hydroelectric	22.2	1955

Table 1: ML&P Generation Capacity by Unit.
Source: EIA, 2019.

HEA Generation Capacity by Unit		
Energy Source	**Capacity (MWe)**	**Year Built**
Diesel	1.2	2004
Diesel	1.0	2017
Natural Gas	20.7	1971
Natural Gas	28.8	1978
Natural Gas	27.2	1981
Natural Gas	40.8	1986
Natural Gas	40	2013
Natural Gas	50	2014
Hydroelectric	63	1991
Hydroelectric	63	1991

Table 2: HEA Generation Capacity by Unit.
Source: EIA, 2019.

GVEA Generation Capacity by Unit		
Energy Source	**Capacity (MWe)**	**Year Built**
Diesel	18.4	1972
Diesel	23.1	1976
Wind	24.6	2013
Batteries	40	2003
Diesel	1.2	2004
Diesel	1	2017
Natural Gas	20.7	1971
Natural Gas	28.8	1978

Table 3: GVEA Generation Capacity by Unit.
Source: EIA 2019.

Chugach Generation Capacity by Unit		
Energy Source	**Capacity (MWe)**	**Year Built**
Natural Gas	15	1964
Natural Gas	15	1965
Natural Gas	48.8	2013
Natural Gas	48.8	2013
Natural Gas	48.8	2013
Natural Gas	57.5	2013
Natural Gas	16	1968
Natural Gas	16	1968
Natural Gas	59.1	1972
Natural Gas	68.3	1975
Natural Gas	76.5	1976
Natural Gas	76.5	1978
Hydroelectric	9.7	1961
Hydroelectric	9.7	1961

Table 4: Chugach Generation Capacity by Unit. Source: EIA, 2019.

Matanuska Electric Association Generation Capacity by Unit		
Energy Source	**Capacity (MWe)**	**Year Built**
Natural Gas	17.1	2015
Natural Gas	17.1	2015
Natural Gas	17.1	2015
Natural Gas	17.1	2015
Natural Gas	17.1	2015
Natural Gas	17.1	2015
Natural Gas	17.1	2015
Natural Gas	17.1	2015
Natural Gas	17.1	2015
Natural Gas	17.1	2015

Table 5: MEA Generation Capacity by Unit.
Source: EIA, 2019.

A merger is currently underway between two of the Railbelt utilities and was conditionally approved by the RCA in May 2020. Chugach Electric Association (Chugach) is in the process of acquiring Municipal Light and Power (ML&P).[13] When finalized, Chugach will possess 1,035 MWe of capacity or 51 percent of the total utility-owned capacity of the Railbelt.

One utility on the Railbelt system, Golden Valley Electric Association (GVEA) in the Interior, does not have direct access to natural gas and maintains a mix of generation assets which utilize diesel, coal, naphtha, wind, and solar. Coal used for generation is purchased from the nearby Usibelli Coal Mine.[14] The absence of natural gas makes power in GVEA's service area more expensive than other parts of the Railbelt.

While the current resources maintain a low cost of power throughout much of urban Alaska, there are resiliency gaps in a system which relies heavily on two fuel sources. Disruptions in the fuel supply chain would significantly impact the energy systems across the Railbelt. At various times in recent decades, policymakers have raised concerns about dwindling supplies of natural gas in Cook Inlet, a basin that has produced the fuel since the 1950s. This natural gas supplies not only power production but also residential and commercial space heating needs.

The utilities vary in size according to the population in their respective service areas and the outlay of industrial energy users. Chugach, ML&P, and GVEA serve a number of large industrial power users, including mines, hospitals, and military installations, and, therefore, a larger percentage of those utilities' kWh sales are attributed to commercial power usage.[15] Figure 4 breaks down Railbelt utility power sales by customer type.

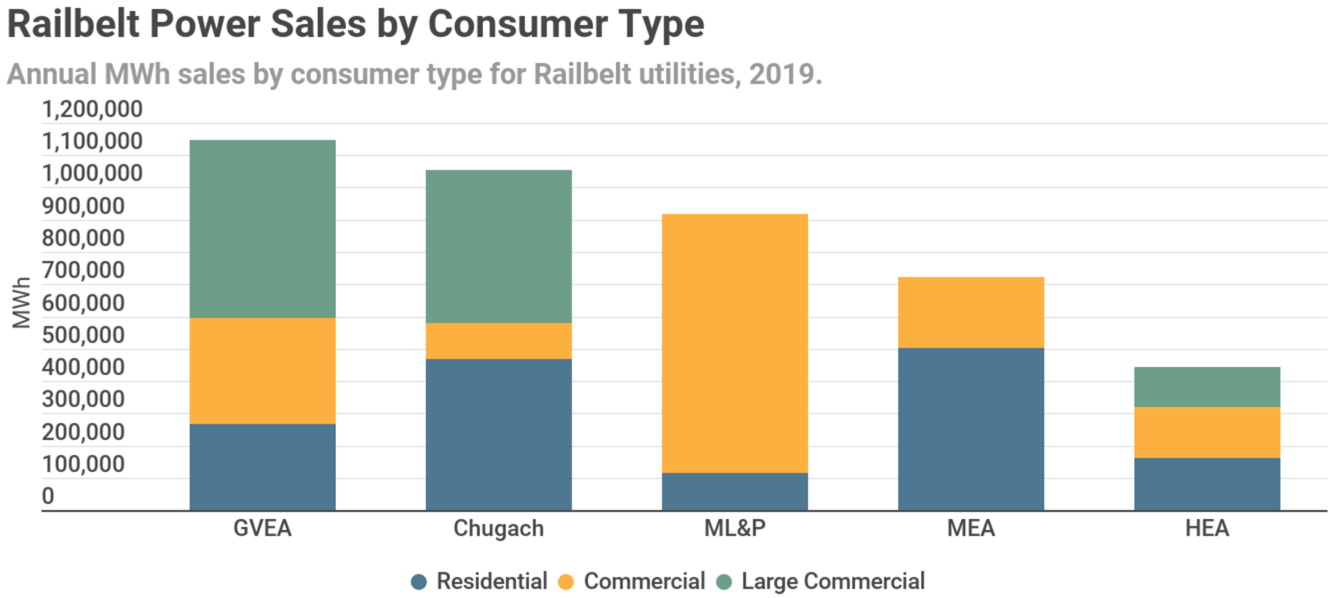

Figure 4: Railbelt Power Sales by Customer Type.
Source: RCA, 2019

Average rates for electric service also vary. Rates for all of the utilities are higher than the U.S. average. Figure 5 compares average residential rates for Railbelt utilities.

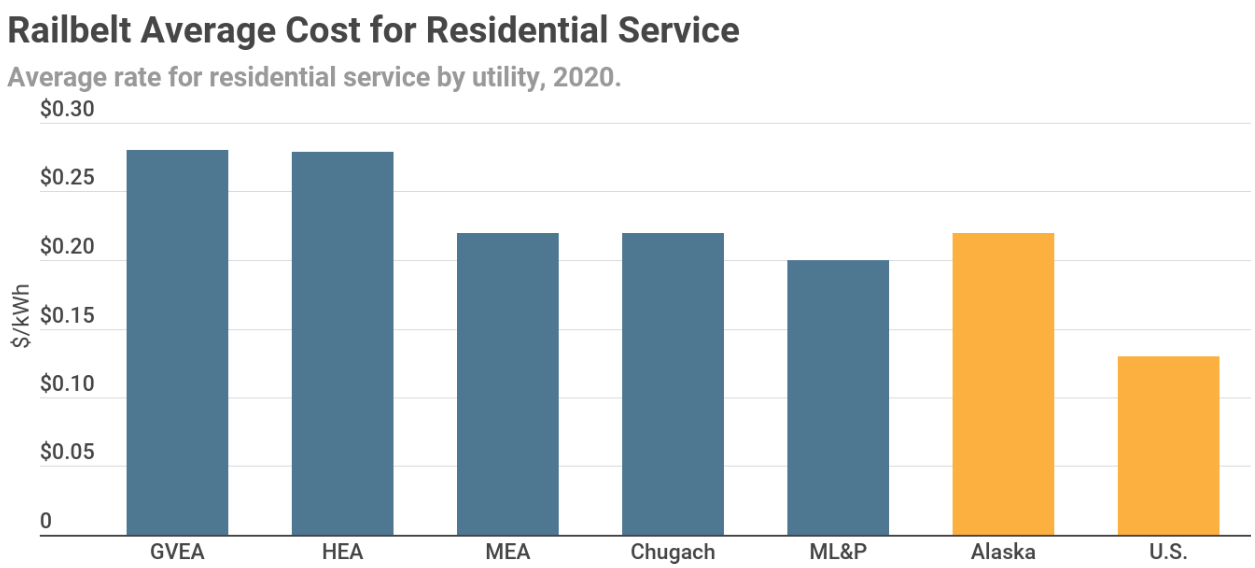

Figure 5: Railbelt Average Rates for Residential Service.
Source: RCA, 2019.

Investigating Alternatives

Each of the Railbelt utilities have clearly identified priorities regarding energy alternatives. Guidance has been given to the utilities from multiple angles to investigate options for decarbonization and resiliency. Most are actively investigating alternative energy systems, including expansion of the Bradley Lake hydro resource, installation of a Battery Energy Storage System (BESS), landfill gas projects, solar projects, and wind projects. It is clear that these efforts are guided by a number of core issues: including cost, decarbonization, reliability, and security.

Reliability and Security: The newly-established Railbelt ERO will likely play a role in determinations on future energy asset integration. As of yet, particulars on how those roles will function within the energy landscape remain unclear, but the ERO will play an important role on the Railbelt. Ensuring reliability includes determining cyber and physical security protocols and guaranteeing the reliability of energy sources.

Decarbonization: The quality of available renewable energy resources remains a challenge for many of the Railbelt utilities integrating large scale solar and wind assets. However, small scale residential and commercial renewable energy adoption has been growing. Net metering capacity grew by 75 percent in 2019, reaching an installed capacity of 5,636 kW.[16] Energy storage solutions are being implemented across the Railbelt, but it is unlikely that renewable energy assets will be able to fully replace base load needs. Therefore, the question of diversification of energy resources is a recurring theme.

Cost: As regulated utilities, the Railbelt utilities act under requirements to minimize costs to consumers.[17] Advanced nuclear technologies would be compared against the costs associated with other alternative energy sources and the current sources. Advanced nuclear reactors are still in the early stages of development and concrete cost information is unavailable. However, with the relatively low cost of power compared to much of Alaska, to be competitive with existing sources of power generation the early costs of microreactors would have to comparable.

Microreactor Themes and Perspectives

Given that full replacement of fossil fuels through renewable integration remains unlikely, nuclear technology may provide one of the few non-carbon alternatives for energy on the Railbelt to fully offset hydrocarbon usage. Furthermore, studies show that Cook Inlet natural gas production has been declining since the mid-2000s and projections show continued declines in production, which may lead to further incentive to seek alternatives to natural gas resources.[18] Figure 6 shows Cook Inlet natural gas production from 1981 to 2020.

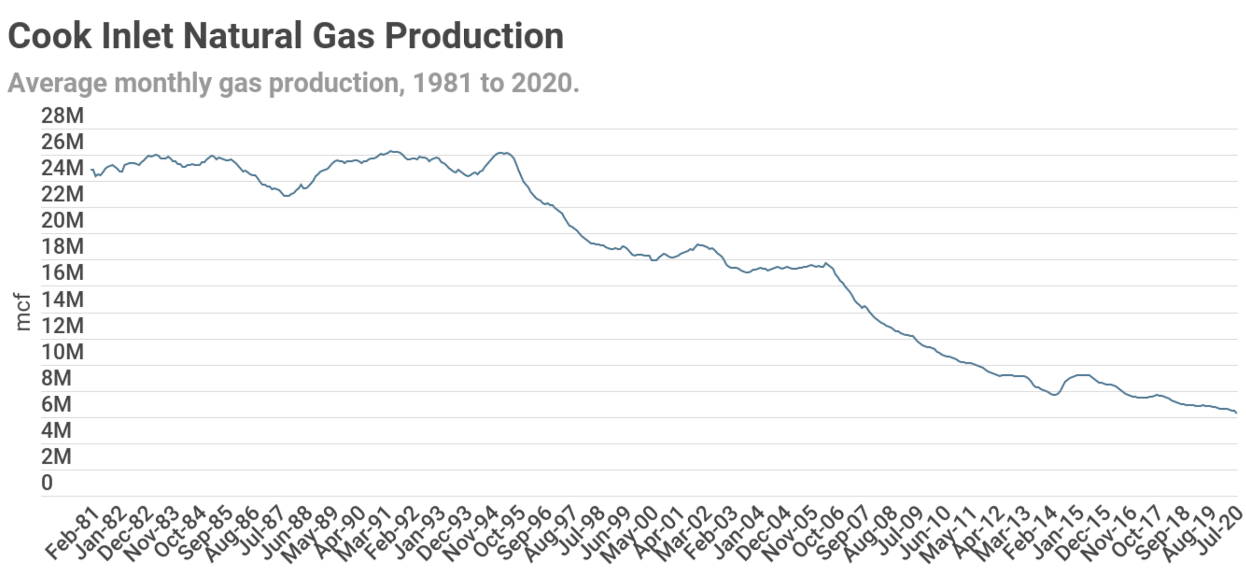

Figure 6: Cook Inlet Natural Gas Production.
Source: Alaska Oil and Gas Commission, 1981-2020.

With its relatively heavy dependence on fossil fuels and consistent base load, it would seem that installation of a microreactor on the Railbelt would offer some of the necessary characteristics of a first user of the technology. To start, the technical capacity of the utility workforce across the Railbelt could enable running and troubleshooting as it moves from initial deployment to wider market adoption. However, cost and public perception are not yet certain.

From the perspective of determining initial users of microreactors, both ends of the Railbelt, in the north and south, have stronger motivation to take actions toward diversification and system resiliency. Both have a higher risk of becoming islanded in the case of a weather event or natural disaster, having to operate solely on their own resources and driving costs higher.

Interviews were conducted with Railbelt utility operators and the results indicated that to fit in the urban Alaskan landscape, microreactors will need to have technical characteristics which include:

- Design specifications accounting for high levels of earthquake activity.
- Comparable or lower cost per kWh produced than the operating norm.
- Siting and security requirements matching the physical land availability and local population density.

Energy stakeholders noted that public perception around microreactor technology is unknown, and a robust education and outreach program could be necessary to ensure public buy-in. However, proven and tested specifics on microreactor operation characteristics, which could ensure both energy stakeholder and public comfort with the technology, remain unknown. These variables could include:

- A robust understanding of lifetime costs and operational processes.
- Established plans for the life of the reactor: including installation, fueling, and disposal.
- Clear processes for fuel transportation and disposal.
- Emergency preparedness and disaster mitigation planning.
- Processes for technology support and system repair and maintenance.
- Understanding of federal and state regulatory requirements.

Use Case: Railbelt Integration

Business models for microreactor integration in urban Alaska could vary. In addition to utility integration, there have been some discussion of integration and operation by an IPP. The model examined here is a microreactor integration by an established utility.

Given the age of existing generation assets, current fuel sources, and power costs, GVEA was used as a hypothetical example, with the Fairbanks North Star Borough (FNSB) serving as the primary setting to analyze workforce, demographic, and other contextual characteristics. System characteristics and microreactor themes which could impact a potential urban technology integration were examined to develop a more robust understanding of the factors which could impact integrating microreactor in an urban Alaskan setting.

Region and Climate

GVEA sits at the northern end of the Railbelt system. GVEA's service area is located in interior Alaska. The transmission system extends from 48 miles north of Fairbanks, south to Cantwell, and east to Delta Junction and Fort Greely. The utility manages over 3,000 miles of transmission line and serves 100,000 customers.

The Interior region is characterized by a continental climate zone, with extreme temperature variation. Winters are extremely cold and summers are hotter than the state average. The average daily low in January is -15 degrees Fahrenheit, but -40 degrees is common.[19] The Fairbanks area has historically struggled with air quality issues in the winter related to wood stove home heating use, burning of fuel oil, and industrial energy users contributing to high levels of particulate pollution exceeding EPA maximums.[20]

One result of the extremely cold seasonal climate is high demand for thermal energy and limited access to economical fuel sources like the natural gas enjoyed in most of Southcentral Alaska.

Demographic and Economic Characteristics

Located in the FNSB, GVEA has access to the second largest workforce in Alaska. In FNSB specifically, not including the surrounding areas, average monthly employment was 38,000 jobs in 2019. The utilities sector (which includes the electric utility) employs 396 individuals. [21]

The median household income is $77,000, slightly higher than the statewide median household income of $76,000. Figure 7 compares FNSB educational attainment to statewide averages. Twenty-two percent of the population is 25 and older has a high school diploma. A further 20 percent of the population 25 and older has a bachelor degree.[22]

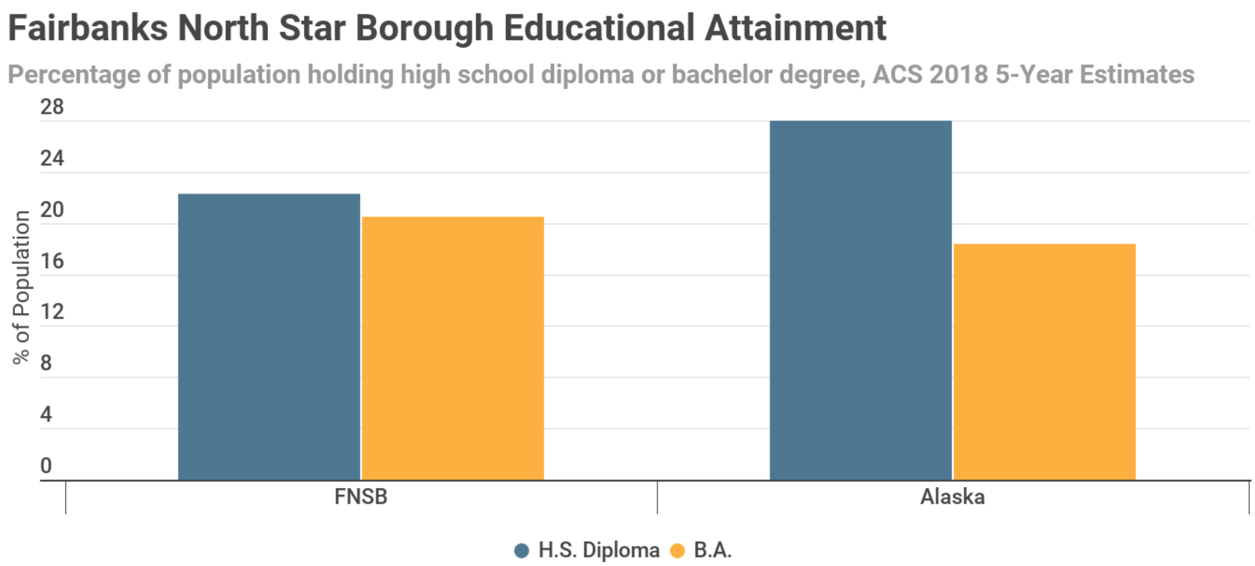

Figure 7: FNSB Educational Attainment.
Source: ACS, 2018 5-Year Estimates.

FNSB hosts one of the three University of Alaska campuses. The university hosted 2,400 students and 544 faculty in fall 2019. The university offers 139 degree programs and 37 certificates in 112 disciplines. Mechanical engineering ranks among the top six degree programs for incoming first-year students.[23]

Eight percent of the population is estimated to live below the poverty line, which is lower than the statewide average of 10.4 percent.[24] Figure 8 compares FNSB cost burdened rates to statewide averages. Housing costs are high and energy costs represent a large portion of household expenditures.

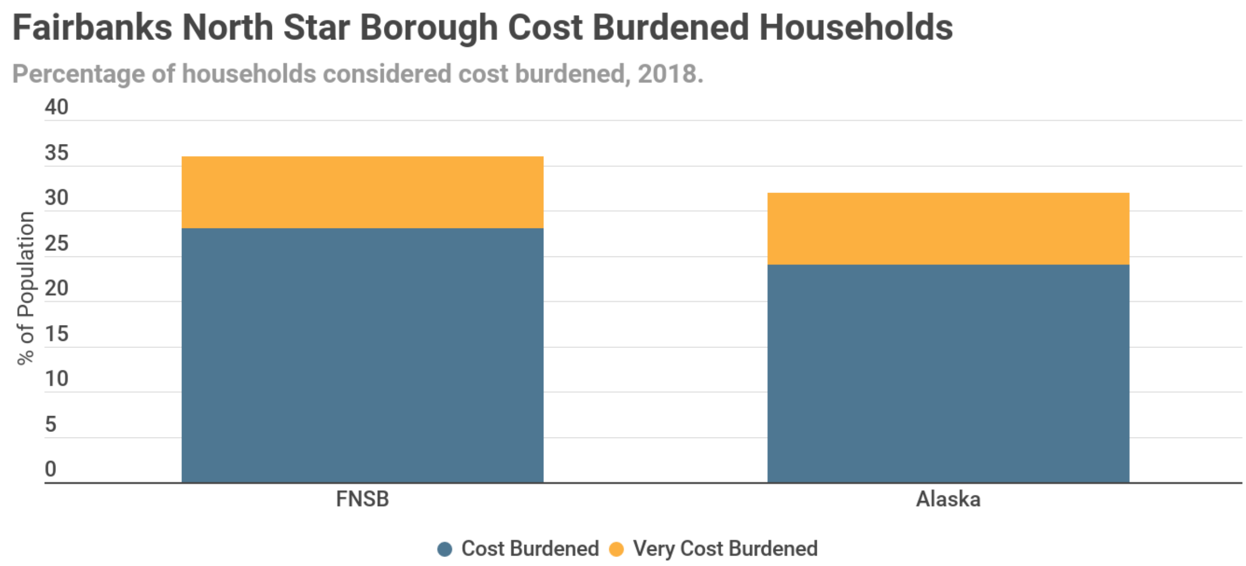

Figure 8: Cost Burdened Households in FNSB.
Source: Alaska Housing Finance Corporation (AHFC), 2018.

Energy Systems

Electric

The local utility operates a variety of assets which vary in age and fuel source. Current utility operated generating assets include 296 MW of installed capacity with an additional 70 MW of additional capacity available from the Railbelt. GVEA's generating assets include:[25]

- 41 MW diesel power plant, est. 1972,
- 27 MW diesel power plant, est. 1976,
- 60 MW Naphtha power plant, est. 2006,
- 120 MW diesel power plant, est. 1976,
- 25 MW wind farm, est. 2012,
- 28 MW coal power plant, est. 1967,
- 50 MW coal power plant, est. 2016,
- 567 kW Solar PV system, est. 2018.

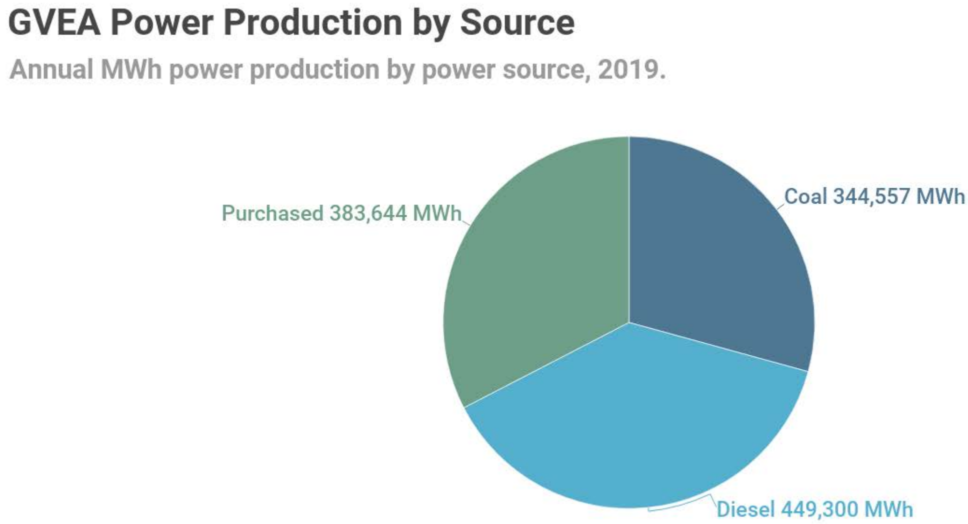

Figure 9: GVEA Annual Power Production by Generation Source.
Source: RCA, 2019.

Figure 9 presents the breakdown of MWh by source. The utility also purchases 27 MW of power from IPPs and owns a 17 percent share in the Bradley Lake Hydroelectric Project, which provides an additional 20 MW of hydro power. GVEA also operates a BESS which can provide 27 MW of power for 15 minutes.

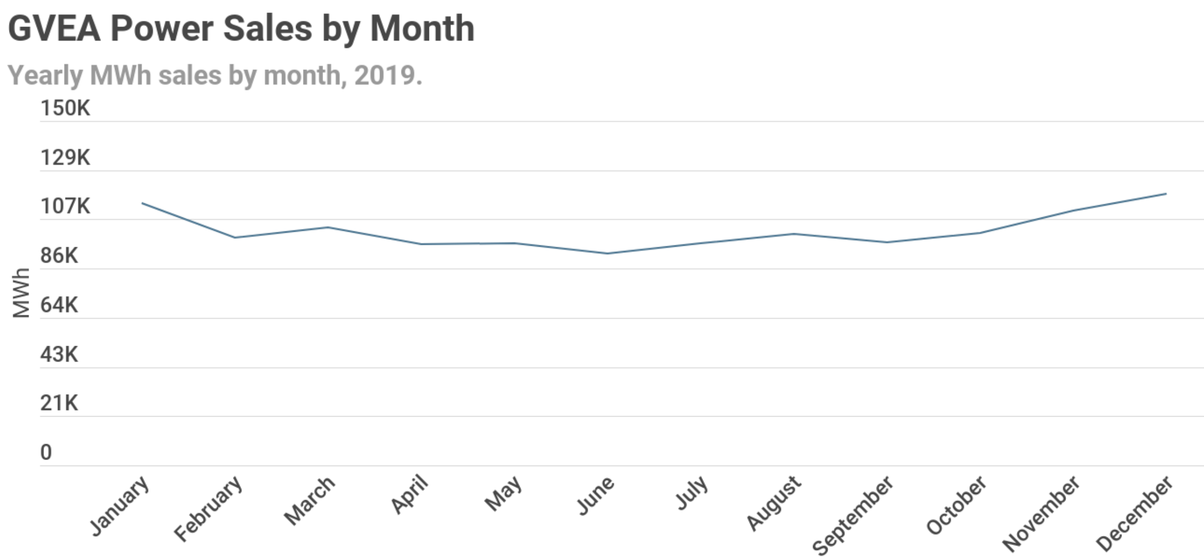

Figure 10: GVEA Annual Energy Sales by Month.
Source: RCA, 2019.

Figure 10 shows GVEA sold 1.2 MWh in 2019, providing service to 44,800 meters.[26] Over the last five years GVEA's sales have declined.[27] Figure 11 shows GVEA power sales from 2014 to 2019.

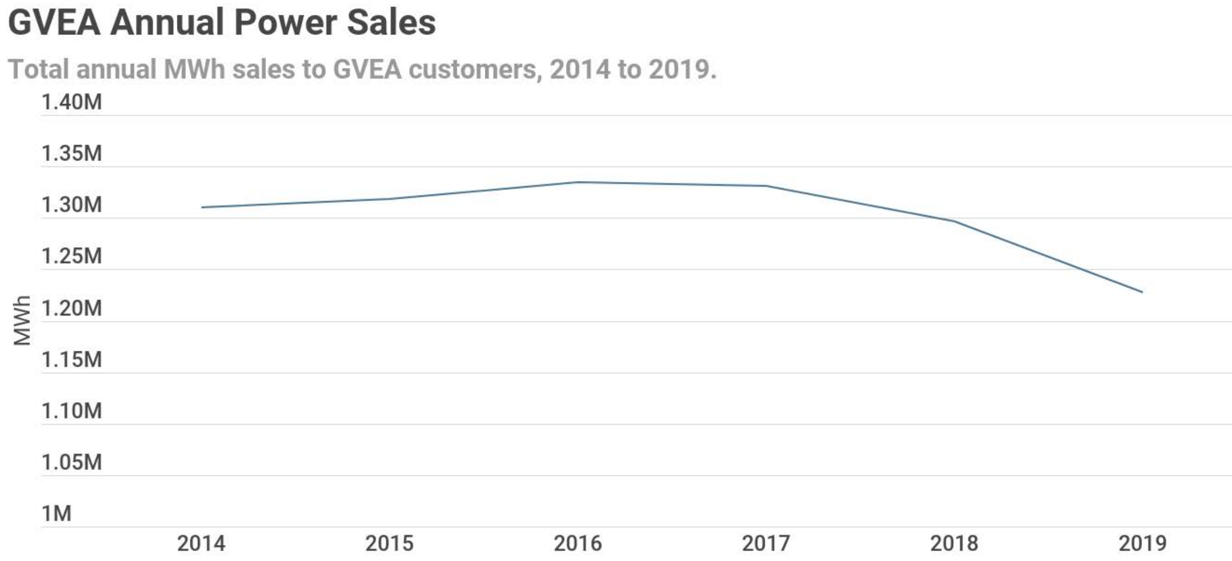

Figure 11: GVEA Power Sales by Year
Source: RCA, 2014-2019.

The system is interconnected with the University of Alaska Fairbanks (UAF) campus, Eielson Airforce Base, Fort Wainwright, Fort Greely, Pogo Mine, Fort Knox Mine, the Trans-Alaska Pipeline, and two refineries. UAF, Eielson Airforce Base, and Fort Wainwright all have generating capabilities of their own, but still draw power from GVEA's system when needed. Each of these large users have energy needs and demand characteristics which are unique and separate from the demand characteristics of residential and business customers.

Heat

Heating sources throughout FNSB are varied. A district heat loop is operated by Aurora Energy, powered by waste heat from power sold to GVEA. Outside of that, residences and businesses are heated with a mix of wood, fuel oil, electricity, and in a limited number of cases, natural gas.[28] Figure 12 shows FNSB home heating fuel usage by fuel type. In the winter, FNSB struggles with air quality issues, mostly caused by inefficient wood heating, fuel oil, and industrial sources.[29] A natural gas storage facility became operational in Fairbanks in 2019, supplied by liquified natural gas (LNG) trucked from Cook Inlet. However, a limited number of homes and businesses are currently connected to the gas distribution grid. Infrastructure to support greater utilization of natural gas should gradually be built in the coming years.[30]

Fairbanks North Star Borough Heating Fuel Sources

Home heating fuel use by fuel type, ACS 2018 5-Year Estimates.

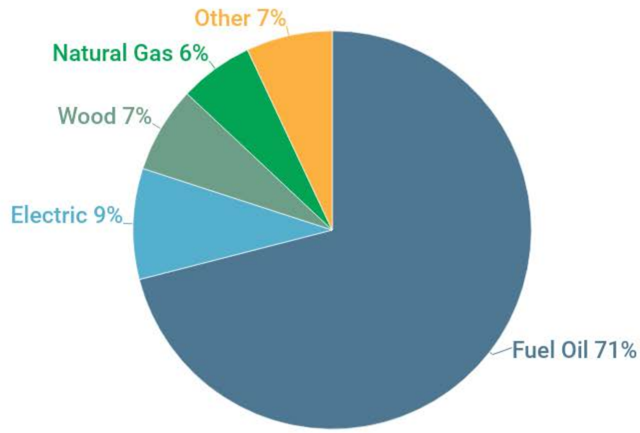

Figure 12: FNSB Household Heating by Fuel Type.
Source: ACS, 2018 5-Year Estimates.

Heating fuel and propane were reported to cost $3.20 and $3.99 per gallon, respectively.[31] With the extreme winters in the Interior, heating degree days are high at 13,815.[32] A 2019 analysis showed that homes in the FNSB which heated with fuel oil spent an average of $2,274 annually to heat their homes.[33]

Energy Technology Market Drivers

As a regulated energy cooperative, GVEA is accountable to its elected board of directors and federal and state regulatory agencies, and, therefore, is expected to adhere to set standards and statutes set by those bodies.

Key concerns for the Railbelt utilities include: cost, reliability, and decarbonization, all of which drive operational and technological decisions. As a regulated utility, costs are one of the clearest drivers of decision-making processes. Utilities are statutorily permitted to set rates at a level which recovers allowable costs with a determined rate of return. Decisions about generation technology are made through considering the upfront capital costs and long-term operations and maintenance costs and fuel costs (if applicable).

Reliability is a major going concern for regulated utilities. Provision of reliable, consistent power is a priority. Reliability is two-fold: generation and transmission. Utilities must ensure that there is no lapse in supply to meet to demand. New technologies must be integrated into the existing system and be designed to fit the existing infrastructure and demand characteristics.

Railbelt utilities have identified decarbonization and diversification of generation assets as a goal over the near term. All of the Railbelt utilities have invested in exploring and implementing renewable energy systems: Chugach purchases power from Fire Island Wind, LLC, a.17.6 MW wind farm, GVEA has invested in a small 563 kW solar PV system and operates a wind farm, and HEA continues to investigate utility scale solar and landfill gas energy projects. The challenge associated with renewable energy sources is variability. There are fewer options for offsetting the baseload provided through fossil fuels.

Market Fit for Microreactors

Technical capacity and system fit

Any one of the Railbelt utilities have characteristics which would be necessary in a first adopter of microreactor. The technical capacity of the utilities on the microgrid allow for testing and diagnosing early stage advanced technology. In addition, each of the individual utilities are of large enough scale to integrate an asset of 1 to 20 MWe size without overhauling the entire system. Furthermore, drivers toward system diversification and de-carbonization show a vested interest in adopting advanced generation technologies. However, other factors such as cost and public perception could play a stronger role in technology decision making.

Specifically, GVEA contains the above-mentioned attributes in addition to experiencing higher costs. GVEA is reliant on aging coal- and diesel-powered systems and can only purchase natural gas-generated power through other utilities in limited supplies as they must serve their own rate-payers. GVEA's coal generation assets are co-located with the only coal mine in Alaska, making GVEA dependent on a single fuel source for almost a third of the power supply. Coal is subject to increasing regulations and an uncertain market. Given comparative or cheaper costs, microreactors could play a role in replacing aging assets and diversifying the utility's energy mix.

Local workforce is another component of system fit. Local labor should have the capacity to operate or be trained to operate a microreactor in adherence to the regulatory requirements. Operational requirements remain an unknown and will likely be established by the NRC. However, with access to a diverse workforce, an urban utility like GVEA would likely be able to meet those requirements with more ease than rural utilities.

Ownership Models

There are a number of ownership models for integration which could provide varying levels of technical fit for nuclear reactors: utility operation and integration and power purchase agreement with commercial operators are two of the more likely scenarios. Table 6 compares the advantages and disadvantages of microreactor ownership models

Ownership Model	Advantages	Disadvantages
Utility operation and integration	• System control • Potential retention of local hire	• Need for retraining and access to qualified workforce. • Additional regulatory liability • High upfront costs.
Power purchase agreement	• Reduced operational liability • Potential costs spread over lifetime of reactor	• Limited community and utility control. • Limited community control • Potentially fewer savings to the rate payer.

Table 6: Microreactor System Ownership Models.

Financial Fit

The cost of power across the Railbelt is low compared to much of Alaska. The average residential rate ranged from \$0.21/kWh to \$0.28/kWh across the five Railbelt utilities in 2019. The average price per kWh for GVEA residential customers was the highest on the Railbelt at \$0.28 per kWh in 2019. Only a portion of that includes variable cost which could be replaced. For example, Figure 13 shows that costs associated with power generation and maintenance made up 68 percent of GVEA's costs in 2019. The remaining 32 percent of GVEA's annual costs are made up of costs associated with transmission, distribution, depreciation and taxes, and administration.[34]

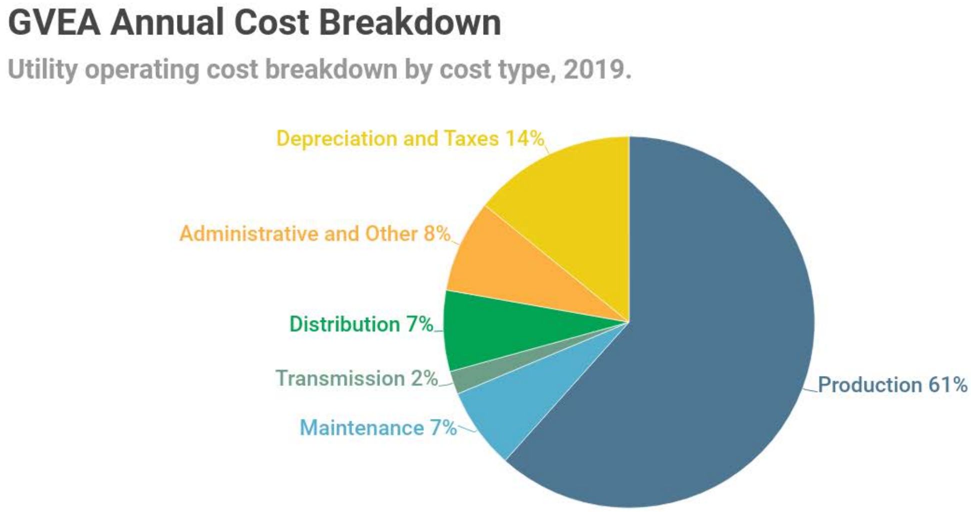

Figure 13: GVEA Annual Costs.
Source: RCA, 2019.

While the comparison of rates and annual costs does not directly translate to cost per kWh for microreactors, a discussion of GVEA's average rates and annual costs does serve as a benchmark. Many costs, including those associated with the operations and maintenance of generation assets, would not be offset with microreactor generation.

There is little published cost information on the cost per kWh to provide a robust analysis for the financial fit, but initial analysis performed by Nuclear Energy Institute (NEI) estimates that the first 50 microreactors deployed could produce energy at costs range as high as $0.40 per kWh in remote communities to $0.10 per kWh in Alaska's Railbelt.

Rudimentary financial modeling using information published by NEI and Alaska energy data, shows that the financial fit of microreactors in remote markets will be sensitive to upfront capital costs and refueling frequency and costs.[35] Financial data on microreactors is still undeveloped, making a thorough analysis for the hypothetical community difficult; however, understanding the key variables helps to reveal potential barriers to technology adoption.

Access to capital to fund large infrastructure projects or even to fund refueling is not a challenge experienced by GVEA to the same degree as smaller rural utilities. However, with lower costs than many rural Alaskan communities, an urban utility like GVEA will be more sensitive to the margins, making other variables such as operations and maintenance costs, and cost of financing more critical.

Perception Fit

Feedback from interviews with energy stakeholders and utility operators across the Railbelt showed that while there was mutual agreement from energy specialists that while microreactor could offer a viable energy alternative, public perception could be a hurdle. Themes in public perception toward nuclear energy are likely to be similar in Alaska as across the U.S. Public awareness over the examples of the worst possible scenarios (i.e. Fukushima and Chernobyl) is likely high, even though microreactors are lower risk than conventional reactors.

There are two questions critical to perception and microreactors. First, does perception of microreactors vary from traditional nuclear energy? Second, does perception around nuclear in Alaska differ from the nation as a whole? Information on public perception specific to Alaska is limited to qualitative observations from interviews, making the second question difficult to answer without a robust investigation. However, some studies on nuclear public perception are beginning to include perspectives around small modular and microreactors, lending some perspective to the first question.

National survey results from the University of Oklahoma Center for Energy, Security and Society (UO) show that 42 percent of individuals find small modular reactors safer than traditional nuclear reactors once the technology is briefly explained to them. Perceptions around siting is another critical study area, with many individuals adopting a "not in my backyard" attitude. Results showed that 47 percent of survey respondents supported small nuclear reactors for civilian usage and 51 percent supported siting on military bases.[36]

UO notes that one of the challenges around public perception of emerging energy technologies is education on the technology and differences from traditional energy. Survey reliability is dependent on the ability of respondents to give informed responses.[37] Similar themes were expressed by energy stakeholders in Alaska, noting that the large number of unknowns influence perception at the technical level and among the general public. In interviews, energy stakeholders noted more comfort with the technology but expressed concerns around perception from the broader public.

Energy stakeholders throughout the interview process noted that public acceptance of a nuclear project could require a broad and thorough education program. Areas of education suggested included understanding of the technology and its difference from traditional nuclear, understanding the environment and physical security risk and mitigation measures, cost differences, carbon offset, and more.

Railbelt Energy Integration Value Propositions

Current Value: • Heavy dependence on fossil fuels. • Availability of workforce and technical skill sets. • Existing energy capacity allowing for testing of new tech without complete reliance. • Strong support of movement away from fossil fuels and energy diversification. • Consistent base load with key industrial sources.	**Barriers:** • High cost per kWh. • General attitudes toward nuclear among the public (co-op model) and not in my backyard mentality. • Concerns over external environmental issues (i.e. earthquakes). • Undetermined regulatory hurdles and security requirements.
Future Opportunities: • Electrification of transportation systems. • Distributed district heating. • Electrification of heating systems.	**Challenges:** • Regulatory obligations to keep costs low. • Overbuilt new capacity across the Railbelt system. • Declining demand.

Table 7: Railbelt Energy Producer Value Propositions

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Special Thanks

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Work Cited

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