MICROREACTORS IN ALASKA

Use Case Analysis: Military Installations

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Alaskan Defense Installations Customer Analysis

Alaska's military installations have been celebrated for their strategic importance for the U.S. military. Alaska occupies a geopolitically important position on the Pacific Rim and within the Arctic; the state is home to a Long-Range Discrimination Radar (LRDR), a missile defense installation, and fifth-generation fighter aircraft, the F-22s and F-35s. Maintaining mission readiness in harsh and relatively isolated conditions is of critical importance. Energy is at the center of that objective as enabler of military operations across vast distances and in cold climates.

Defense installations in Alaska are large energy users with complex energy needs, from residential heat and power to transportation and base operations. Alaska is home to nine major military installations shown in Table 1: a mix of Army, Air Force, and Coast Guard bases. A host of other minor military sites are scattered across the state, including remote air stations and radar sites. There is limited naval presence in the state.

Major Alaskan Military Bases	
Military Installation	**Branch**
Joint Base Elmendorf Richardson (JBER)	Airforce/Army
Fort Wainwright	Army
Fort Greely	Army
Eielson Air Force Base	Air Force
Clear Air Force Station	Air Force
Kodiak Coast Guard Base	Coast Guard
Juneau Coast Guard Base	Coast Guard
Ketchikan Coast Guard Base	Coast Guard
Sitka Coast Guard Base	Coast Guard

Table 1: Major Alaskan Military Bases
Source: U.S. Department of Homeland Security, 2020; U.S. Department of Defense, 2020.

Energy security is critical to the Department of Defense (DOD) and Department of Homeland Security (DHS) missions.[i] Resiliency and independence are two areas of focus for the military with regard to energy. This is the case across all of the DOD and DHS installations, but it is especially critical in Alaska with a greater need for self-sufficiency. In many ways, including with energy, Alaska is at the end of the supply chains. This adds additional nuance to priorities around defense resiliency and independence in Alaska as these supply chains are subject to disruption.

Power generation, heat, and transportation capabilities at Alaska's military installations are dependent on a handful of local fuel resources—coal and natural gas in Interior and Southcentral Alaska—and imported diesel fuel and heating oil. Military installations across the state pull together a number of resources to meet power and heat need. Bases purchase power from local utilities, contract with Doyon Utilities to provide heat and power services, and maintain and operate their own heat and power systems as circumstances and operational needs demand. Table 2 discusses the power sources utilized at each installation.

Military Installation Power Sources	
Military Installation	**Power Source**
JBER	Purchased Power/Landfill Gas
Fort Wainwright	Purchased Power/Coal
Fort Greely	Purchased Power/Diesel
Eielson Air Force Base	Purchased Power/Coal

Table 2: Military Installation Power Sources.
Source: U.S. Army Corps of Engineers, 2005.

The focus of this analysis is the four larger military installations located in urban Alaska: JBER, Eielson AFB, Ft. Wainwright, and Ft. Greely. These installations were chosen for analysis as a result of data availability. Each of the installations purchase power from Fairbanks and Anchorage utilities and have some independent generation capacity. Figure 1 below presents the capacity of independent generation assets specific to Railbelt military installations, not including the capacity used from utilities in Anchorage and Fairbanks.[ii]

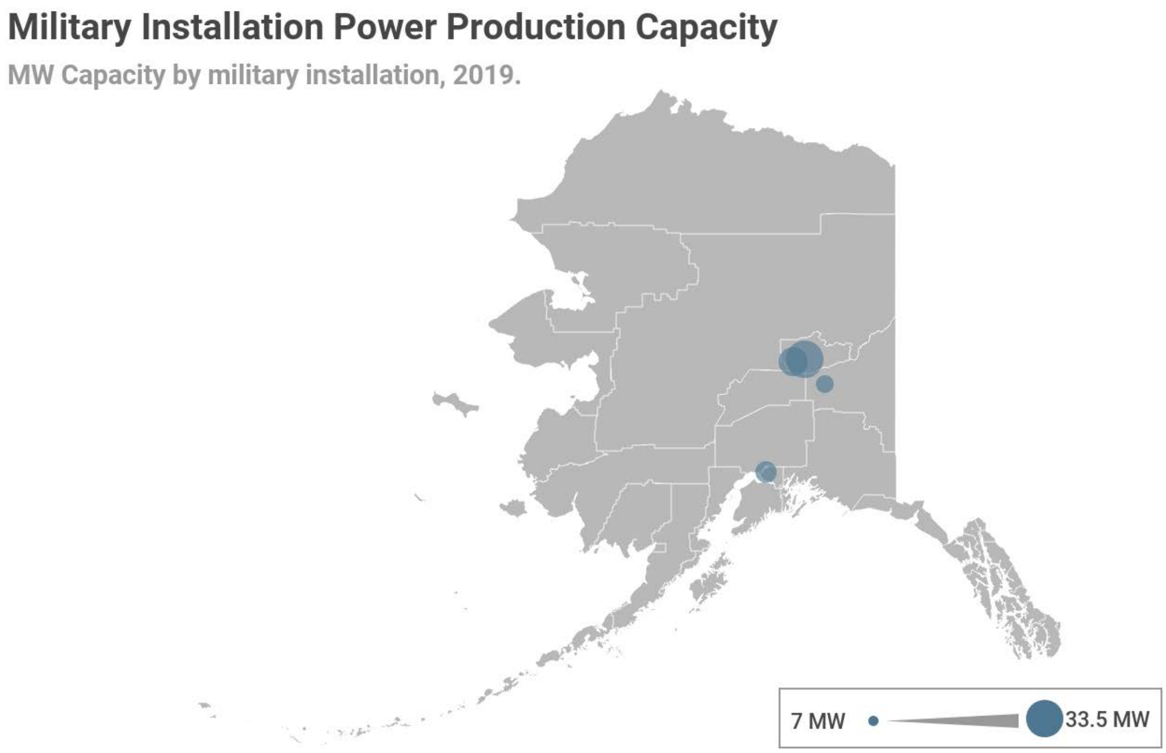

Figure 1: Alaska Defense Generation Capacity.
Source: EIA, 2019.

Population and Demographics

Military installations host a large workforce segment in Alaska. As shown in Figure 2, in 2019 the state was home to over 21,000 active-duty military personnel.[iii] This number has mostly stayed steady over the last 10 years, with a slight increase beginning in 2016 related to the addition of the F35 squadrons to Fairbanks.[iv] These personnel are primarily located in Anchorage and Fairbanks. Military personnel spouses and families provide additional contributions to the workforce in Alaska.[v] Defense and Coast Guard contracting activity and civilian employment also make important economic contributions to the state.

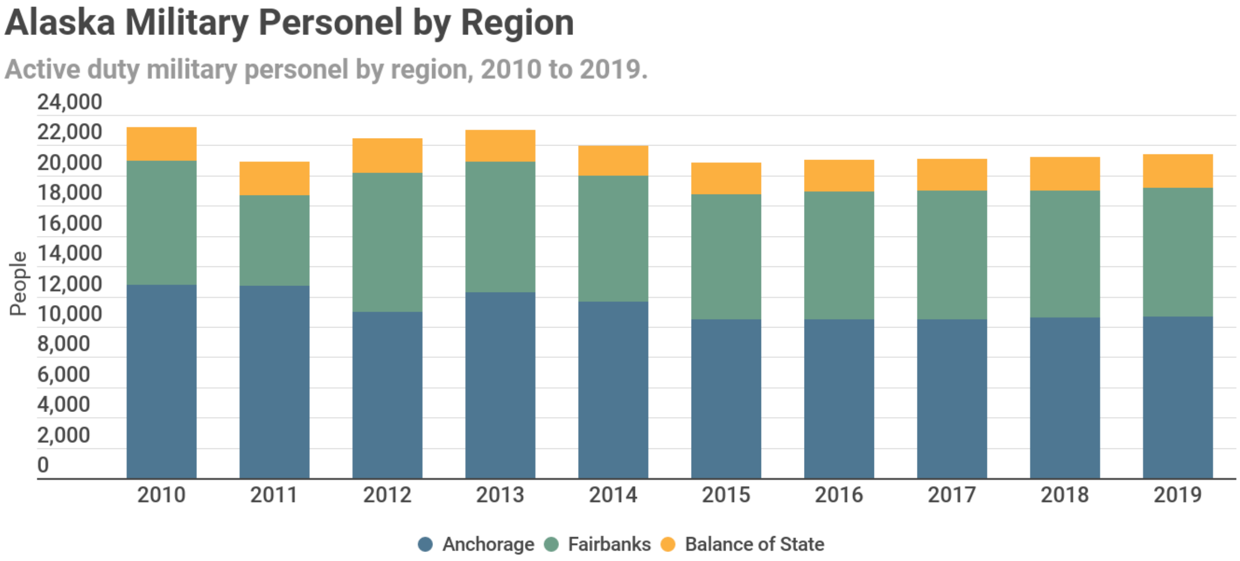

Figure 2: Alaska Military Personnel, 2010 to 2019.
Source: Alaska Department of Labor and Workforce Development, 2010-2019.

Current Energy Systems

Electricity

Alaska's military installation energy demands vary in size depending on base size, operational activities, and climate. Table 3 compares installed power capacity of the four major military installations.

Military Installation Power Capacity Requirements		
Installation	**Installed Capacity (MW)**	**Historical Peak Capacity (MW)**
Eielson AFB	33.5	17.1
Ft. Wainwright	20	18.4
Ft. Greely	7.4	2.4
JBER	11.5	Not Available

Table 3: Alaska Military Installation Power Capacity Requirements.
Source: EIA, 2019; US Army Corps of Engineers, 2005.

Generation facilities at Ft. Wainwright, Ft. Greely, and JBER are operated by Doyon Utilities, an Alaska Native Corporation subsidiary. Ft. Wainwright's generation assets are powered by local coal resources, only when the power demand from the base exceeds the 2.5 MVA transformer rating at the GVEA substation. Power demand below that is provided by GVEA.[vi] Ft. Greely is similarly situated, predominantly powered by GVEA. However, when demand exceeds the substation transformer rating, additional power is provided by diesel generators on base.[vii]

A portion of JBER energy demand is met by power from a landfill methane gas power plant. The plant is capable of meeting 26 percent of JBER's electrical load.[viii] The remaining 74 percent of the base's energy demand is met by ML&P, which is soon to be merged with Chugach.

Eielson operates a coal-fired combined heat and power (CHP) system which provides the majority of the power to the air force base. During peaking periods, additional power demands are met by GVEA. The coal used to power Eielson and Wainwright's CHP systems is sourced from Usibelli coal mine.[ix]

Electric cost information is limited for all military installations. Energy production data is also limited; however, Table 4 below details kWh purchased from GVEA by the Fairbanks area military installations.

Military Power Purchases	
Installation	**Annual kWh Purchased**
Eielson AFB	9,624,000
Ft. Wainwright	8,412,300
Ft. Greely	16,857,600

Table 4: Military kWh Purchases from GVEA.
Source: U.S. Army Corp of Engineers, 2005.

Eielson AFB purchases a relatively constant amount of power from GVEA, with Ft. Wainwright and Ft. Greely experiencing larger variations in demand. Demand cycles slightly seasonally, but extreme peaks are met by local installation sources.

Heat

Heating needs at all of JBER, Ft. Wainwright, Eielson, and Ft. Greely are all served by distributed heating sources. The distribution systems and, where applicable, generation facilities are operated by Doyon Utilities and powered by coal or diesel CHP systems or natural gas furnaces.[x] Table 5 below compares the heating systems installed at each installation.

Military Heating Systems and Sources	
Installation	**Heat Source**
Eielson	Coal-Fired CHP Plant
Ft. Wainwright	Coal-Fired CHP Plant
Ft. Greely	Diesel-Fired CHP Plant
JBER	Natural Gas

Table 5: Military Installation Heat Systems.
Source: Doyon Utilities, 2020; U.S. Army Corp of Engineers, 2005.

Data on heating costs and capacity needs is limited. However, all of the installations are located in a sub-arctic climate. The Interior region especially, home to all of the above installations except JBER, experiences extreme variations in temperature from the summer to winter. It is not uncommon for temperatures to reach negative 50 degrees Fahrenheit in the winter.[xi] The Interior also lacks ready access to the economical natural gas available in Southcentral. This places a premium on heat recovery systems working in concert with installation power plants.

Investigating Alternatives

While cost is the most obvious driver for adoption of new power technologies for most energy operators in Alaska, that is apparently less true for the military installations. Energy security and independence appears to be a more critical driver of installation energy planning and decision making. Energy is especially important for ensuring installation mission readiness.[xii] Energy is connected with nearly every aspect of military operations and ensuring delivery of heat, power, and transportation capabilities enables installations to conduct both daily activities and critical operations.

Security is referred to as one of the critical drivers of energy decision making for the military. However, this is a layered variable which includes: power and fuel availability, infrastructure capabilities, independent operations, and physical and cyber security. Installation energy values can be broken into the following categories:

- **Fuel Security:** Fuel source security and fuel transportation security both contribute to analysis of potential fuel sources.[xiii] Fuel must be available from any given source when needed and must be capable of being transported securely. In addition, power received from the utilities and produced at the installations is dependent on a handful of fuel sources and the supply chains which deliver them: predominantly, natural gas, coal, diesel, and landfill gas. Supply chain interruption of any one of those sources would have impacts on installations power and heat production capabilities.
- **Power Availability:** While each of the military installations discussed here have backup generation capabilities, each are dependent to some extent on power provided by local utilities. The possibility of power curtailment from utility sources presents a risk. Installed generation infrastructure, in some cases, is aging and is not always reliable
- **Infrastructure Capabilities:** The capabilities of power and heat generation assets and delivery systems to reliably deliver energy to the end user represents a critical infrastructure concern for military installations. Aging infrastructure can present a risk to energy delivery capabilities. However, new energy infrastructure must also be capable of integrating into the current systems.
- **Independent Operations:** While each of the military installations are interconnected to the urban Alaska energy system, the ability to operate independent of those systems has been a goal and planning objective. This is a critical component of ensuring installation mission readiness under extra ordinary conditions.[xiv]
- **Physical and Cyber Security:** Related to the goal of mission readiness, characteristics of an energy system's physical security are important. This can relate to location characteristics, resilience from natural disaster, and ability for the installation or a qualified contractor to operate the system independently. In addition, cyber security is a growing concern in the energy field and within Defense installations. Energy producers are paying attention to resistance to cyber-attacks.
- **Cost:** While cost is not the leading variable in considering energy technology at installations, life-cycle costs of a given technology do play a role.

Microreactor Themes and Perspectives

The topic of nuclear energy is not new to the military, or even to the military in Alaska. DOD has been investigating using small nuclear reactors to independently power military installations for decades. In Alaska, Ft. Greely operated a small nuclear-powered energy system, which was shut down in the 1972.[xv] The Navy has been testing and operating nuclear marine propulsion systems for 75 years, in nuclear-powered submarines, aircraft carriers, and other vessels.[xvi]

More recently, Congress passed legislation in 2019 for advanced nuclear reactor demonstrations. One specific goal is to see a microreactor demonstration at a military site in the next decade.[xvii]

With an established comfort level with nuclear technology and access to a robust, qualified workforce, system compatibility remains one barrier to adoption. Microreactor developers are moving into the permitting and development, and specifics on technical components are being confirmed. Developers note that the microreactors being deployed are expected to be between 1 and 10 MWe and have characteristics which include:

- Modular and rapid deployment capabilities,
- Load following,
- Ability to pancake reactor units to scale up or down in size,
- CHP characteristics,
- Remote or autonomous operation,
- Small footprint and minimal emergency planning zone,
- High reliability and minimal moving parts,
- 40-year design life with 3+ year refueling intervals.

Use Case: A Hypothetical Military Installation

Consider a military installation in the greater Fairbanks area in interior Alaska. The region is considered part of urban Alaska, and is home to nearly 100,000 individuals. The local economy is heavily tied to the military presence in the region, including approximately 8,500 military personnel.

The installation's power system is interconnected with the regional power grid and purchases most of its power from the local utility. Installation power demands in excess of the capacity the local utility can provide is generated by the installation's coal-fired CHP plant.

Installation heating needs are met by the CHP plant. Heat is delivered through a steam distribution system. Coal used to meet the installations heat and power needs is sources from Usibelli coal mine, located south of Fairbanks on the rail system.

The system infrastructure was installed in the 1960's. While updates and repairs have been made through the years, the basic infrastructure for generation, transmission, and distribution of heat and power is dated.

Energy costs in the region are high, related to the remoteness, availability of resources, and level of energy output needed to heat and power facilities.

The military installation is continuously reviewing its options for heating and powering its system. Costs play a role in this; however, the leading driver of this is mission readiness in independent operating capabilities.

Region and Climate

Interior Alaska is characterized by extremes, with hotter than average temperatures in the summer and extreme low temperatures in the winter. The Fairbanks area struggles with air quality issues, driven by extreme inversion events and high concentrations of PM-2.5 in the winter months, caused by residential wood burning, coal burning, and industrial activities.[xviii]

Energy System

Electricity

Installation power demand is met through a mix of power purchased from the local utility and power provided by the base's CHP plant. Demand on the installation has grown over the last 15 years. In addition, new facilities and a new hospital have added to the energy load of the installation. The projected peak in 2020 is approximately 30 MWe.

The CHP plant operated at the installation has a 20 MW capacity. In addition, the installation purchases approximately 6,000,000 kWh annually from the local utility at a cost of $1.12 million. Table 6 details power statistics for the installation.

Installation Capacity and Power Statistics	
Installed Capacity (MW)	20
Annual Power Purchases (kWh)	6,000,000
Purchased Power ($/kWh)	$0.19
Purchased Power total Annual Cost	$1,122,700

Table 6: Hypothetical Installation Power Characteristics.

Renewable energy options have been reviewed in the past. The local utility incorporates wind resources from purchased and installed sources and operates a small solar farm. An analysis of renewable energy options on the base showed that minimal operating levels for the installations' existing boilers could limit the ability to utilize renewable resources.

Immediate access to natural gas resources does not currently exist, although long-range plans for natural gas supply from either Cook Inlet or the North Slope have been contemplated. Local coal resources are valued as an immediately accessible resource which is easy to transport and store.

Heat

The installation operates a 20 MW coal-fired CHP plant which generates heat for a steam distribution system. The distribution system includes 24 linear miles of steam distribution lines.[xix] Energy technology alternatives will need to consider the CHP needs of the installation.

Energy Technology Market Drivers

Key energy concerns for installation energy planners focus mostly on security and mission readiness: fuel security and availability, physical and cyber security, and infrastructure fit and operational capabilities, all of which drive technological decisions. While costs do play a role in decision making, it is not the sole driver of technology implementation.

Fuel security and availability: Power systems are clearly dependent on the fuel source and supply chain which supply them. The installation discussed here is largely dependent on the coal purchased from Usibelli coal mine and diesel backup sources. Dependence on a single fuel source presents a security challenge for the installation's energy systems. However, given the size of the installation's energy system, diversification of fuel sources is a challenge.

Physical and Cyber Security: Management of the physical security of the installation's energy infrastructure remains a going concern; however, cybersecurity represents a growing concern. Resilience to cyber-attacks is critical to keeping the installation operational and mission ready.

Infrastructure and operational fit: The installation currently operates an energy system which uses incumbent distribution and transmission infrastructure for power but is primarily used for heat. Technology solutions are expected to be compatible with the current infrastructure without significant overhaul. Operationally, the installation has the goal of being able to accommodate its own local power and heat demand without relying on outside power purchases.

Cost: As an installation which functions in a remote region with climatic extremes, energy costs are high. While costs are not the only driver of energy technology decision, life-time costs are considered as part of the decision-making process.

Market Fit for Microreactors

Technical Capacity and System Fit

As a system currently reliant on CHP applications, the installation is seeking technology applications which could provide heat and power capabilities. The microreactors currently being developed are expected to have heat and power production capabilities. In theory, a single microreactor at the installation discussed here could be intertied with the existing heat and power distribution and supplement coal-fired heat and power. However, any specifics on thermal output from microreactors are unavailable. Additionally, modular reactors could be intertied in a chain to supplement or replace coal technology and/or power purchased from the local utility.

DOD has a history of nuclear energy capabilities and applying the technical capacity to operate a microreactor is not expected to be a challenge. The installation also assumes it has access to the expertise required to implement an early stage technology, which could require a period to work through operational kinks in system design and integration.

One characteristic of microreactors which could be attractive to the installation discussed here is the refueling frequency. Reactor developers are expecting systems to require a three-year or greater refueling frequency.[xx] An energy system which is capable of operating for three or more years independent of a fuel supply chain could provide benefits to the mission readiness of the installation.

Financial Fit

There is limited information of the installation's current energy costs. Estimates of the cost of purchased power from the local utility approximate that the installation pays is $0.19 per kWh. The installation experiences additional costs for heat and power provided by the CHP plant.

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.[xxi] As microreactors move through the development stages, more concrete estimates on costs will likely become available. Presently, it is not certain if a microreactor would save money compared to the current arrangements. However, the installation would be willing to accept the technology even if it provided no cost savings, or cost slightly more. The potential to operate self-sufficiently may justify adopting microreactors even in the absence of cost savings.

Perception Fit

Public perception has proven to be a challenge for nuclear energy implementation in the U.S. Themes in public perception are largely influenced by examples of disasters (i.e. Chernobyl and Fukushima). Opposition to implementation of nuclear technology largely stems from fear over technology safety.[xxii] While perception of nuclear on the military installation is not expected to be a hurdle, perception in the larger Fairbanks area could differ.

There is little information on public perception of nuclear energy specific to Alaska. However, work conducted by the University of Oklahoma (UO) indicates two areas that could be relevant to a nuclear project at the military installation discussed here.

First, safety of nuclear technology is one of the key areas of public perception study. Survey results show that 42 percent of individuals find small modular reactors safer than traditional nuclear reactors. Perceptions around siting is another critical study area, with many individuals adopting a "not in my backyard" attitude. Surveys conducted by UO showed that 47 percent of survey respondents supported small nuclear reactors for civilian usage and 51 percent supported siting on military bases.[xxiii]

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.[xxiv] 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.

Defense Installation Energy Value Propositions

Current Value • Current dependence on purchased power. • Heat and power production capabilities. • Reduced supply chain dependence and infrequent refueling. • Medium to large sized year-round load.	**Barriers:** • General attitudes toward nuclear among the public and fear over risk from larger regional community. • Uncertainty about timelines and readiness of the technology.
Future Opportunities: • Electrification of installation transportation systems. • Potential to start with small nuclear system and scale up to meet installation system demand.	**Challenges:** • Limitations of existing infrastructure. • Unforeseen variables which could impact lifetime costs.

Table 7: Military Installation Energy Value Propositions.

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