Renewable Energy ATLAS of Alaska

A Guide to Alaska's Clean, Local, and Inexhaustible Energy Resources

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Renewable resources

can provide energy at a known cost that can hedge against volatile fuel prices and dampen the effects of inflation. With some of the best renewable energy resources in the country, Alaska has an opportunity to invest locally in sustainable infrastructure, saving communities millions of dollars in energy costs each year. As concerns about fossil fuel prices, energy security and climate change increase, renewable resources play a key role in sustaining communities with local, clean and inexhaustible energy to supply Alaska's demand for electricity, heat, and transportation fuel. Partly due to the challenges associated with importing and transporting fossil fuels, more Alaskans are looking to resources like hydropower, wind, biomass, solar and to a lesser extent geothermal, tides, and waves to generate electricity and heat. Alaskans are also saving heat and electricity through energy efficiency and conservation measures, keeping dollars in their local economy and creating more stable and resilient communities. Efficiency also helps to move toward the state goal of 50 percent renewable energy by 2025 because energy avoided through efficiency is almost always generated using fossil fuels.

The Renewable Energy Atlas of Alaska is designed as a resource for the public, policy makers, advocates, landowners, developers, utility companies and others interested in furthering the production of electricity, heat and fuels from hydro, wind, biomass, solar, geothermal and ocean power resources. Produced with the use of geographic information system (GIS) technology, this Atlas brings together renewable resource maps and data into a single comprehensive document. The maps contained in this Atlas do not eliminate the need for on-site resource assessment. However, they do provide a high level estimate of the available resources. The Atlas is posted on the Alaska Energy Authority (AEA) website, akenergyauthority.org, and the Renewable Energy Alaska Project (REAP) website, alaskarenewableenergy.org.

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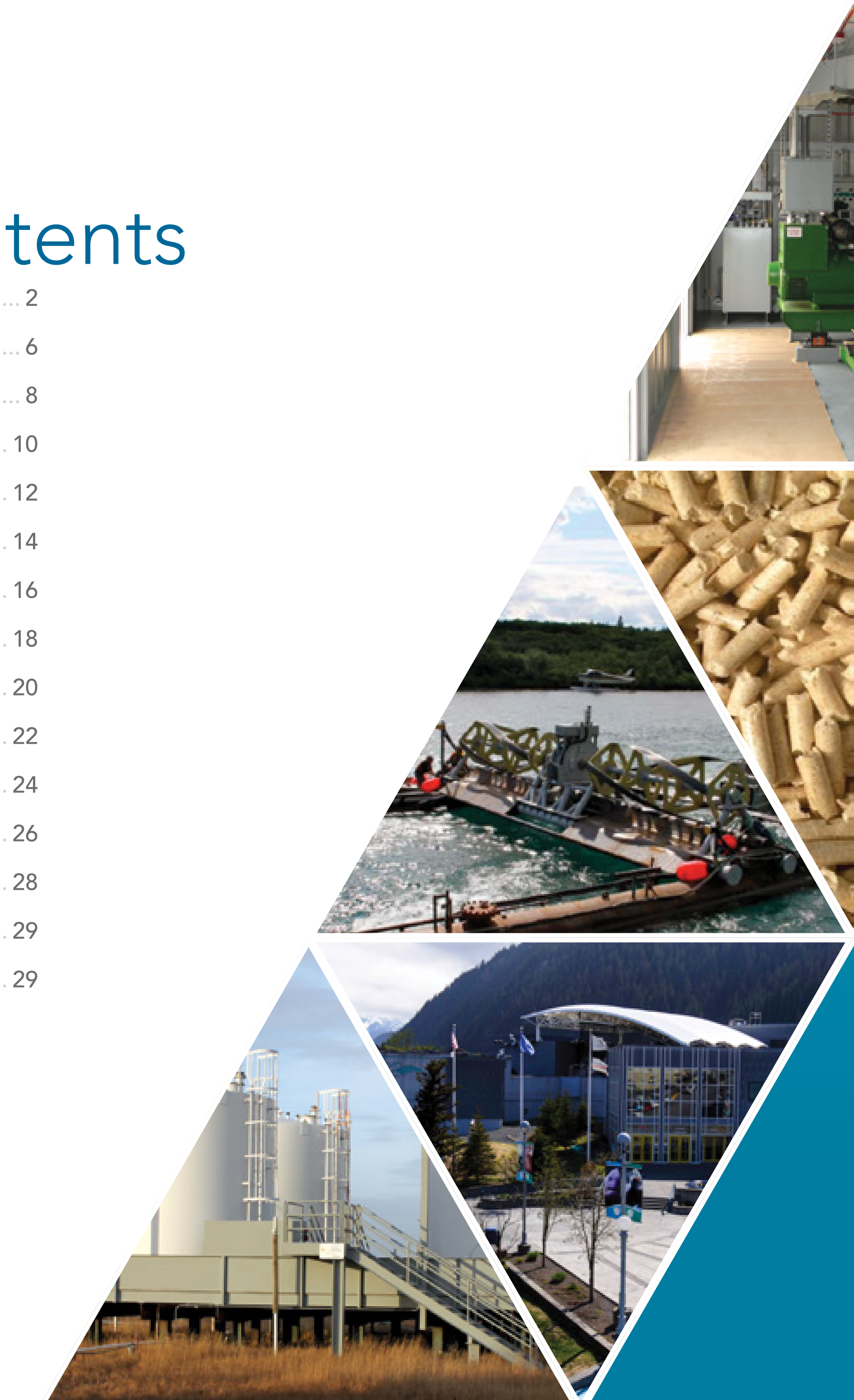


Alaska's Energy Infrastructure

With 16 percent of the country's landmass and less than 0.3 percent of its population, Alaska's unique geography has driven development of its energy supply infrastructure — power plants, power lines, natural gas pipelines, bulk fuel tank farms and related facilities. Alaska has more than 150 islanded, standalone electrical grids serving rural villages, and larger transmission grids in Southeast Alaska and the Railbelt. The Railbelt electrical grid stretches from Fairbanks through Anchorage to the Kenai Peninsula and provides roughly 79 percent of the state's electrical energy.

Powered by wood until 1927, Fairbanks switched to coal after the railroad provided access to the Nenana and Healy coalfields. The Anchorage and Matanuska-Susitna Valley areas have enjoyed relatively low-cost heating and power (by Alaska standards) since the development of the Eklutna Lake hydropower plant in the late 1940's and major Cook Inlet oil and gas discoveries in the 1960s.

Completed in 1986, the AEA-owned Willow–Healy Intertie transmission line now carries power from diverse energy sources to the Fairbanks area.

Nearly 73 percent of the Railbelt's electricity comes from natural gas. Major power generation facilities along the Railbelt include Chugach Electric Association's (CEA) 332-MW natural gas-fired plant west of Anchorage at Beluga, Anchorage Municipal Light and Power's (ML&P) 120 MW natural gas-fired Combined Heat and Power plant in Anchorage, CEA and ML&P's 204 MW natural gas-fired power plant in Anchorage and Golden Valley Electric Association's (GVEA) 181 MW facility near Fairbanks fueled by naphtha from the Trans-Alaska pipeline system. Homer Electric Association (HEA) has three natural gas fired power plants at Nikiski, Soldotna and Bernice Lake that total 204 MW and Matanuska Electric Association's (MEA) 171-MW dual-fuel (gas or diesel) generation station near Eklutna was added in 2015.

The 126 MW, AEA-owned Bradley Lake hydroelectric plant near Homer has been a low-cost source of electricity for the Railbelt since 1991. In 2017, AEA financed an expansion that will boost annual production by an estimated 10 percent.

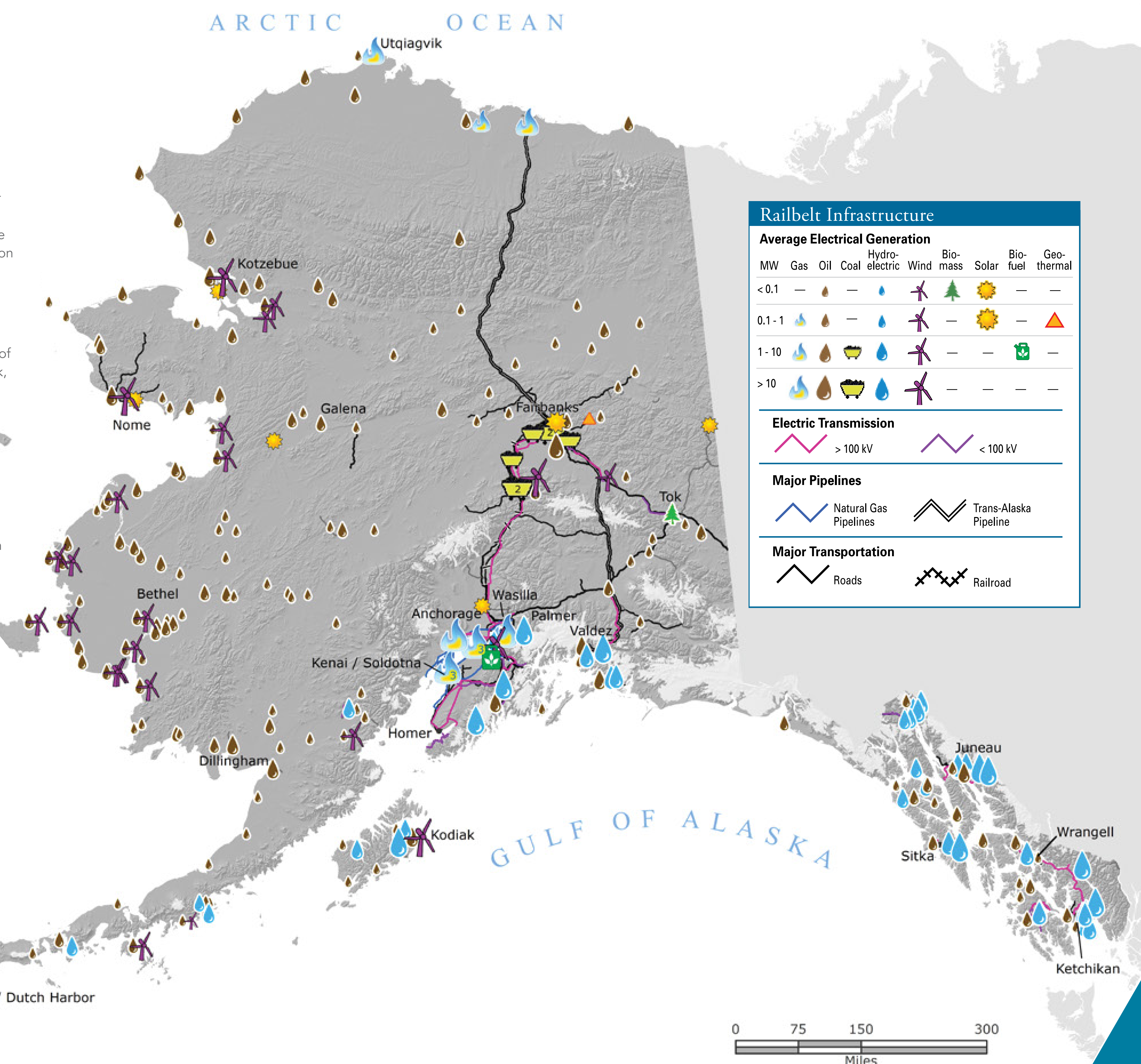
Wind farms have also sprouted up on the Railbelt, including 17.6 MW on Fire Island near Anchorage, 24.6 MW at Eva Creek near Healy and 1.9 MW at Delta Junction.

Today, a little less than 2,000 MW of installed power generation capacity exists along the Railbelt. AEA and the six Railbelt utilities are currently studying the benefits of coordinating dispatch of power generation from all sources to maximize efficiencies and cost-savings. Investments in the Railbelt's transmission system would be required to realize all of those potential benefits.

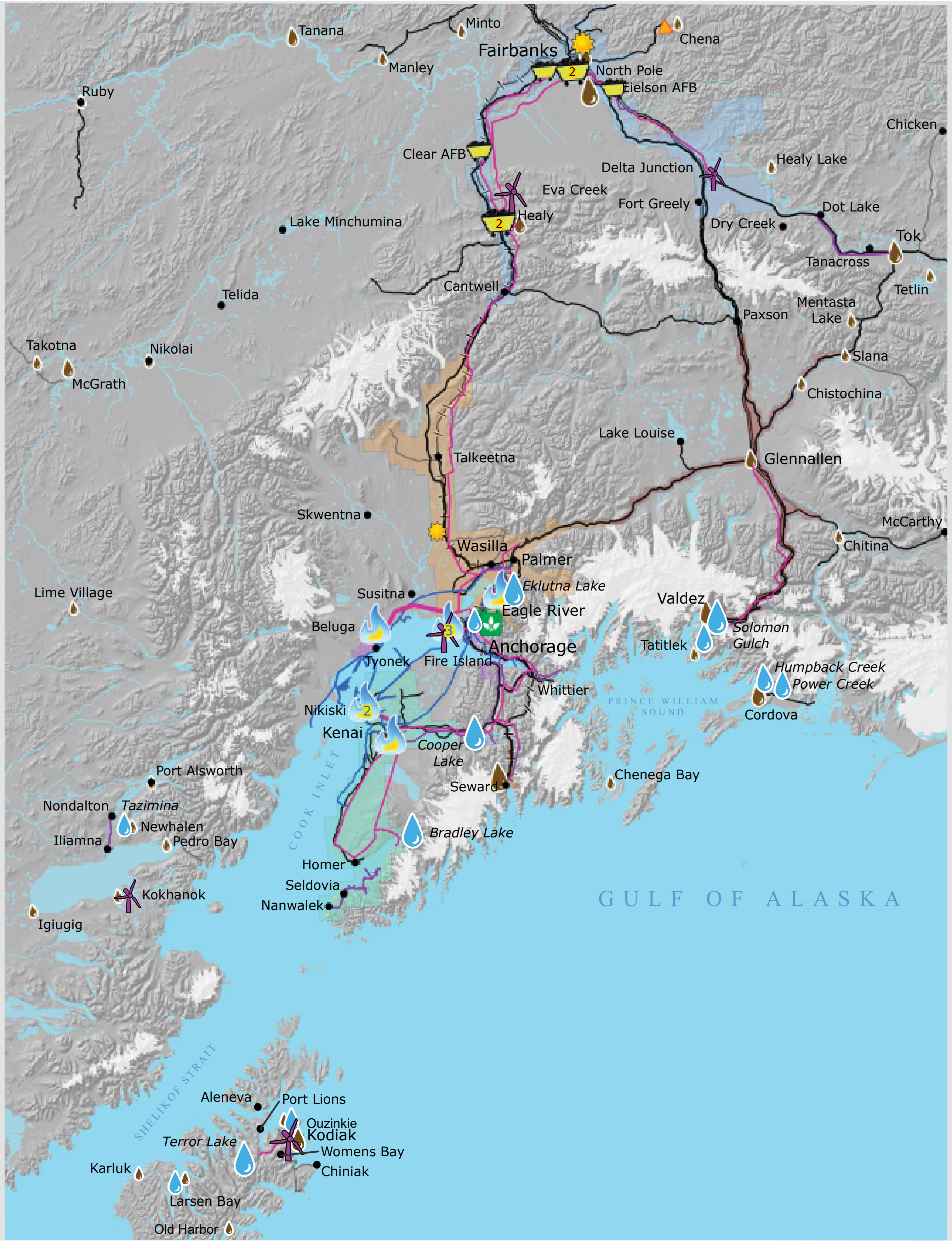
During the early 1980s, the state completed a total of four hydropower projects to serve Ketchikan, Kodiak, Petersburg, Valdez and Wrangell. At 76 MW, the "Four Dam Pool" projects displace the equivalent of about 20 million gallons of diesel for annual power production. Additional southeast hydro facilities are currently being developed in Juneau and Prince of Wales Island communities.

Southcentral Alaska's heating needs are met almost exclusively by ENSTAR Natural Gas Company, which moves gas from the Cook Inlet gas fields through over 300 miles of pipelines, and a little over 3,000 miles of distribution mains to the Kenai Peninsula, Anchorage and Matanuska Valley areas.

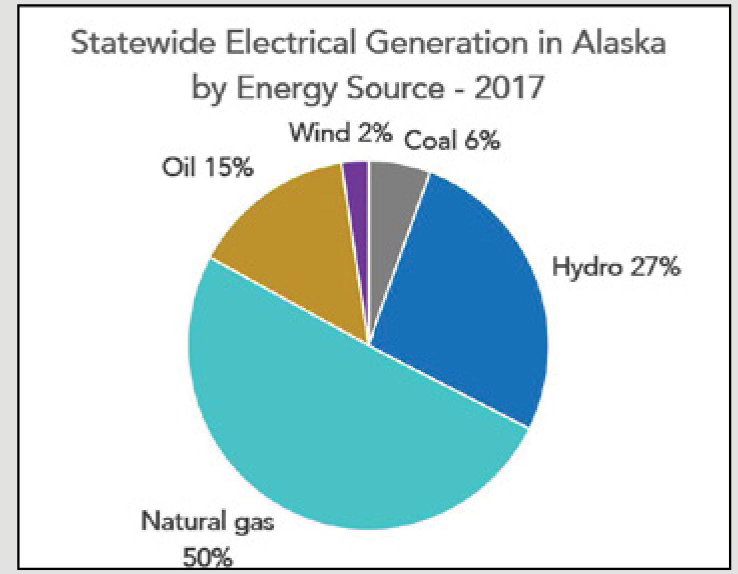
With some notable exceptions, most of Alaska's remaining power and heating needs are fueled by diesel barged from Lower 48 suppliers or transported from refineries in Nikiski, North Pole and Valdez. After freeze-up, many remote communities rely on fuel stored in tank farms, or pay a premium for fuel flown in by air tankers. State and federal authorities continue to support programs to fix leaky tanks, improve power generation, generation efficiency and develop local renewable energy sources such as wind, biomass and hydro.

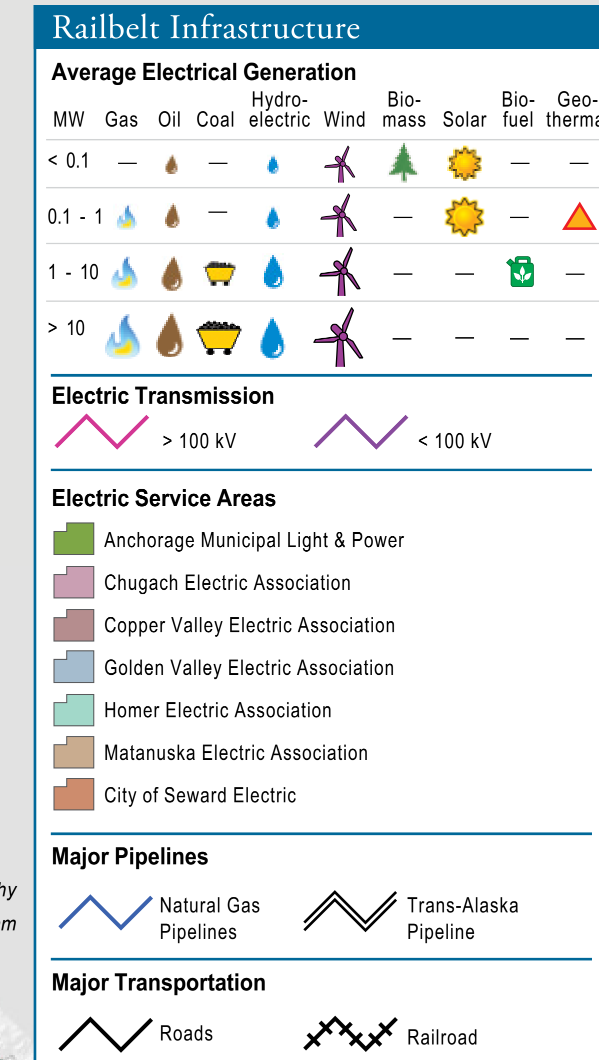


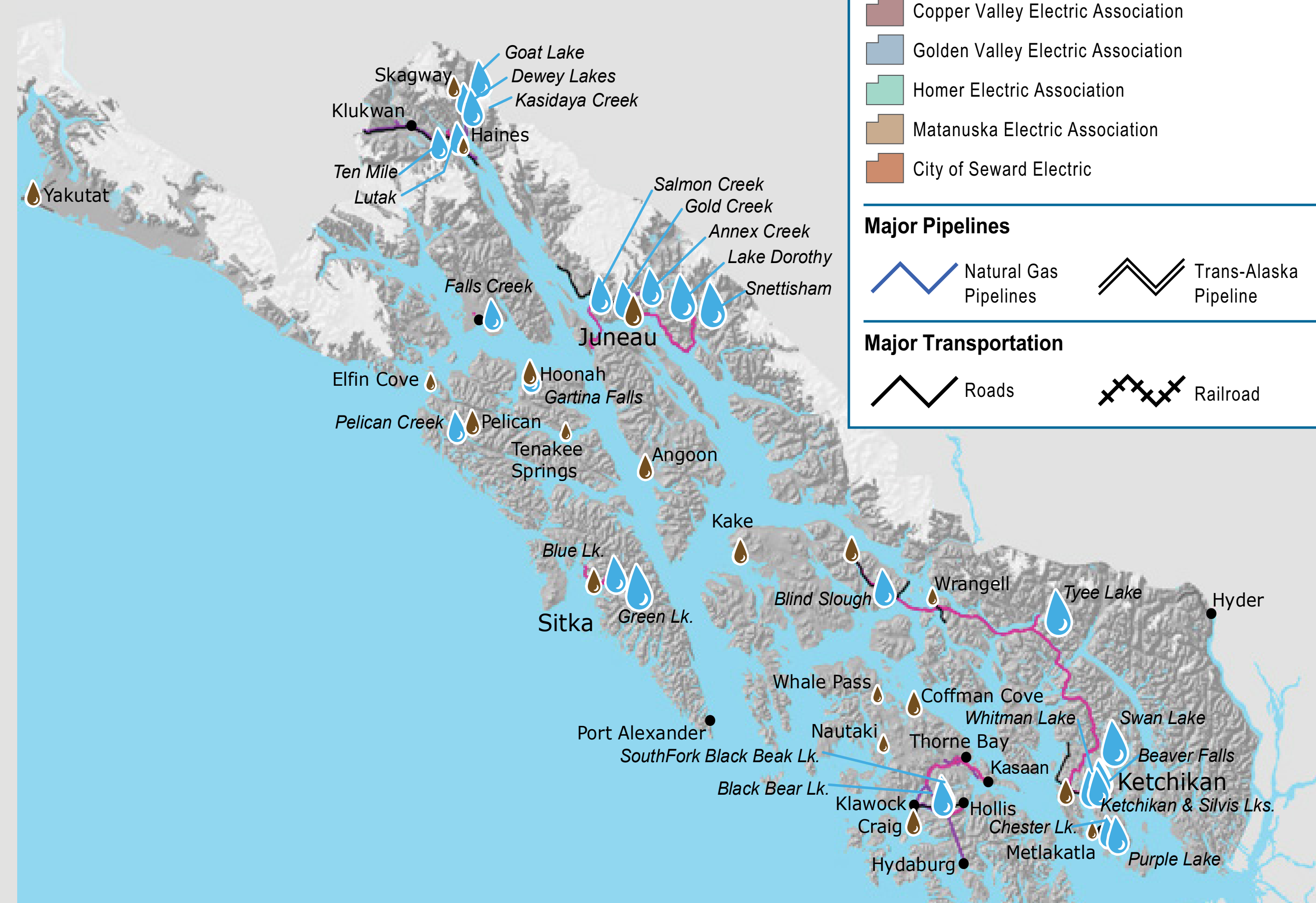
Infrastructure: Fairbanks to Kodiak



Infrastructure: Southeast Alaska







Biomass

Alaska's primary biomass fuels are wood, sawmill waste, fish byproducts and municipal waste.

Wood remains an important renewable energy source for Alaskans. More than 100,000 cords of wood are burned in the form of cordwood, chips and pellets annually. Wood-heating systems in Alaska are creating local jobs and reducing the cost of building heat in remote communities throughout the state.

The closure of major pulp mills in Sitka and Ketchikan in the 1990s ended large-scale, wood-fired power generation in Alaska. However, the price volatility of oil has raised interest in using sawdust and wood wastes for lumber drying, space heating and small-scale power production.

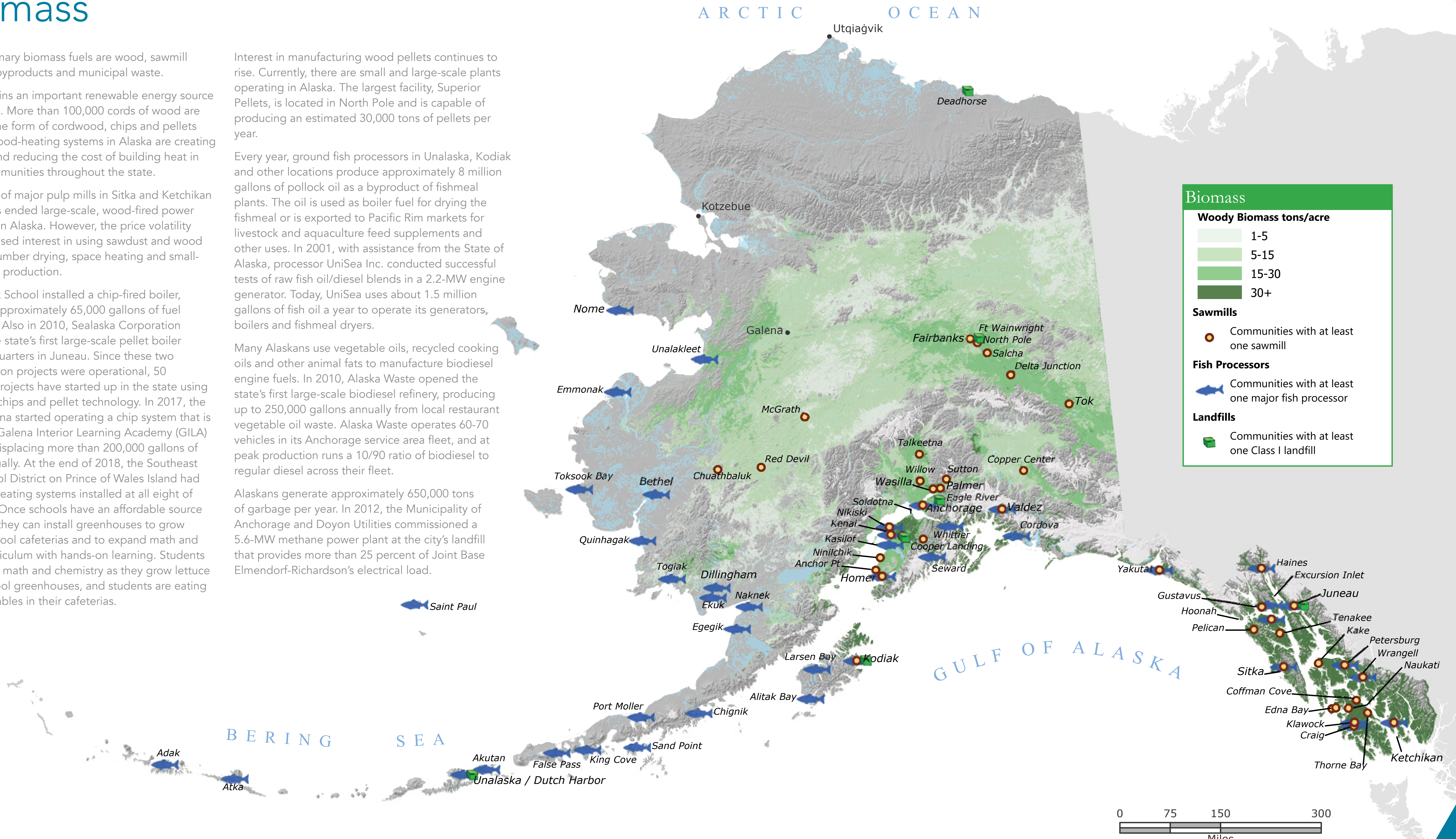
In 2010, Tok School installed a chip-fired boiler, displacing approximately 65,000 gallons of fuel oil annually. Also in 2010, Sealaska Corporation installed the state's first large-scale pellet boiler at its headquarters in Juneau. Since these two demonstration projects were operational, 50 additional projects have started up in the state using cordwood, chips and pellet technology. In 2017, the City of Galena started operating a chip system that is heating 14 Galena Interior Learning Academy (GILA) buildings, displacing more than 200,000 gallons of fuel oil annually. At the end of 2018, the Southeast Island School District on Prince of Wales Island had cordwood heating systems installed at all eight of its schools. Once schools have an affordable source of heating, they can install greenhouses to grow food for school cafeterias and to expand math and science curriculum with hands-on learning. Students are learning math and chemistry as they grow lettuce in their school greenhouses, and students are eating fresh vegetables in their cafeterias.

Interest in manufacturing wood pellets continues to rise. Currently, there are small and large-scale plants operating in Alaska. The largest facility, Superior Pellets, is located in North Pole and is capable of producing an estimated 30,000 tons of pellets per year.

Every year, ground fish processors in Unalaska, Kodiak and other locations produce approximately 8 million gallons of pollock oil as a byproduct of fishmeal plants. The oil is used as boiler fuel for drying the fishmeal or is exported to Pacific Rim markets for livestock and aquaculture feed supplements and other uses. In 2001, with assistance from the State of Alaska, processor UniSea Inc. conducted successful tests of raw fish oil/diesel blends in a 2.2-MW engine generator. Today, UniSea uses about 1.5 million gallons of fish oil a year to operate its generators, boilers and fishmeal dryers.

Many Alaskans use vegetable oils, recycled cooking oils and other animal fats to manufacture biodiesel engine fuels. In 2010, Alaska Waste opened the state's first large-scale biodiesel refinery, producing up to 250,000 gallons annually from local restaurant vegetable oil waste. Alaska Waste operates 60-70 vehicles in its Anchorage service area fleet, and at peak production runs a 10/90 ratio of biodiesel to regular diesel across their fleet.

Alaskans generate approximately 650,000 tons of garbage per year. In 2012, the Municipality of Anchorage and Doyon Utilities commissioned a 5.6-MW methane power plant at the city's landfill that provides more than 25 percent of Joint Base Elmendorf-Richardson's electrical load.



Geothermal

Alaska has three distinct geothermally active regions: the Interior hot springs, running from the Yukon Territory of Canada to the Seward Peninsula; the Southeast hot springs; and the "Ring of Fire" volcanoes, which include the Aleutians, the Alaska Peninsula, the Wrangell Mountains and Mount Edgecumbe on Kruzof Island.

Use of geothermal resources falls into two categories: direct use and electricity production. Direct use includes applications such as district heating, greenhouses, absorption chilling and swimming pool heating.

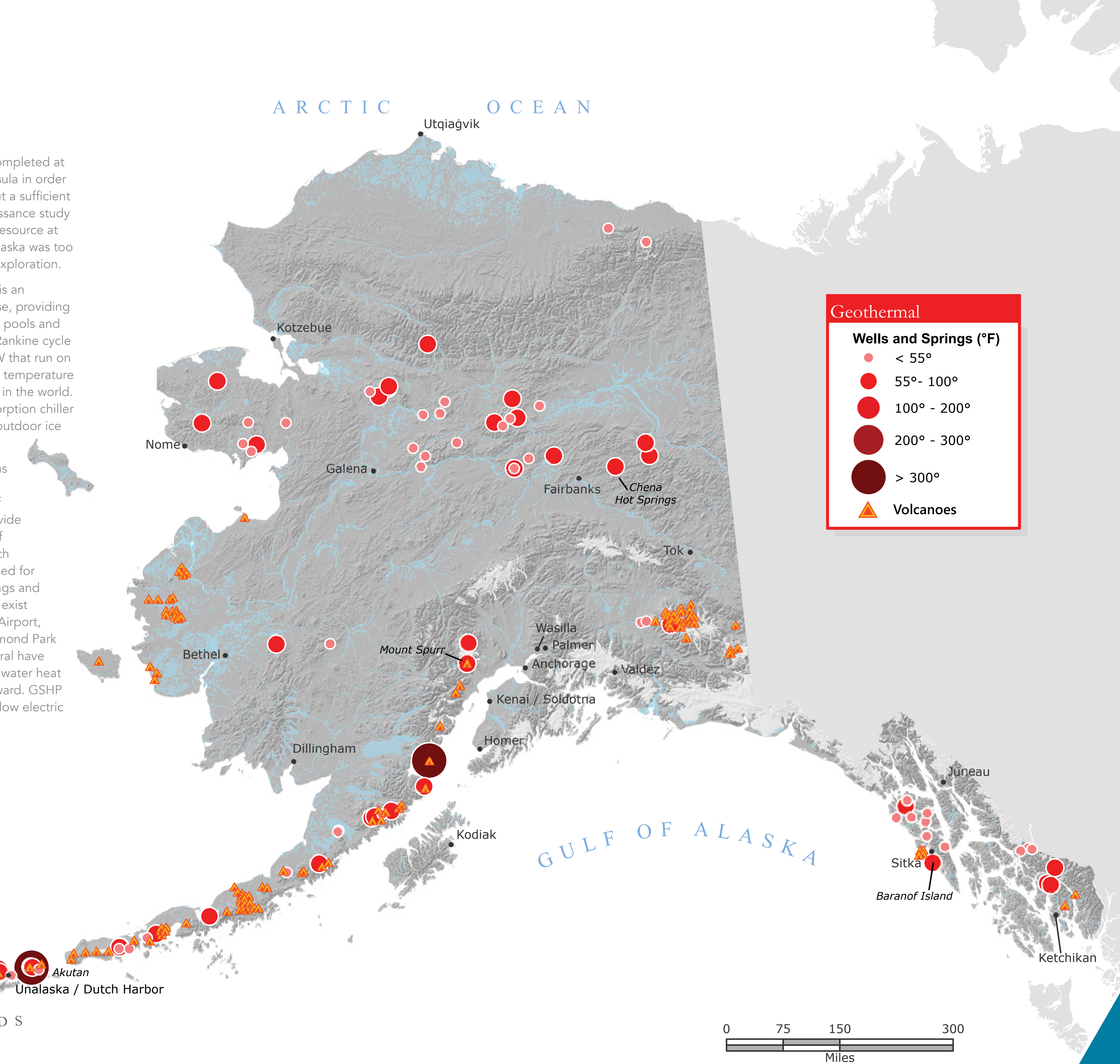
A number of small-scale direct use projects exist across the state, but even though Alaska has locally impressive surface expressions of geothermal energy, attempts to develop Alaska's geothermal resources for community-scale power generation have been unsuccessful to date.

Exploration in the 1980s near Mount Makushin outside of Dutch Harbor indicated that tens of megawatts could be generated from geothermal resources there. Since 2008, several potential geothermal resources have been explored across Alaska with no commercially viable resource found. In 2008, the State awarded geothermal leases to Ormat Technologies, Inc. for tracts 80 miles west of Anchorage at Mount Spurr. After extensive investigations and drilling in 2011, Ormat did not encounter temperatures capable of supporting a power plant. Akutan in the Aleutians is another potential geothermal site investigated since 2008. In 2010 and again in 2017, the City of Akutan drilled exploratory wells in Hot Springs Bay Valley, encountering shallow, hot water over 350 degrees Fahrenheit, but with flow rates insufficient for electricity production.

In 2012, several exploration wells were completed at Pilgrim Hot Springs on the Seward Peninsula in order to assess the area's resource potential, but a sufficient resource was not found. A 2011 reconnaissance study determined that a potential geothermal resource at Tenakee Inlet Hot Springs in Southeast Alaska was too remote and uncertain to warrant further exploration.

In the Interior, Chena Hot Springs Resort is an example of diverse geothermal energy use, providing heat and power to its facilities, swimming pools and greenhouses. The resort utilizes organic Rankine cycle generators with a total capacity of 680 kW that run on 165 degrees Fahrenheit water, the lowest temperature for an operating geothermal power plant in the world. In 2005, the resort installed a 16-ton absorption chiller and uses geothermal energy to keep an outdoor ice museum frozen year-round.

Ground source heat pump (GSHP) systems are electrically powered systems that tap the relatively constant temperature of surrounding earth or water bodies to provide heating and cooling. More than 50,000 of these systems are installed in the U.S. each year. In Alaska, heat pump systems are used for space heating homes, commercial buildings and public facilities. A number of installations exist across the state, including at the Juneau Airport, in operation since 2011, and Juneau's Dimond Park Aquatic Center. Southeast and Southcentral have several other installations, including a seawater heat pump at the Alaska SeaLife Center in Seward. GSHP systems are most beneficial in areas with low electric rates and high heating costs.



Hydroelectric

Hydroelectric power, Alaska's largest source of renewable energy, supplies roughly a quarter of the state's electricity in an average water year. In 2018, 50 hydro projects provided power to Alaska utility customers, including the Alaska Energy Authority-owned 120-MW Bradley Lake project near Homer, which supplies nine percent of the Railbelt's electricity.

Most of the state's developed hydro resources are located in Southcentral, the Alaska Peninsula and Southeast – mountainous regions with moderate to high precipitation. Outside the Railbelt, major communities supplied with hydropower are Glennallen, Haines, Juneau, Ketchikan, Kodiak, Petersburg, Sitka, Skagway, Wrangell, and Valdez.

The Waterfall Creek Hydro project in King Cove, commissioned in 2017, is saving the community about 60,000 gallons of diesel per year. Combined with the community's first hydro project on Delta Creek, King Cove is now saving more than 83,000 gallons of diesel per year and frequently meets their 2 MW demand in the silence of diesels-off.

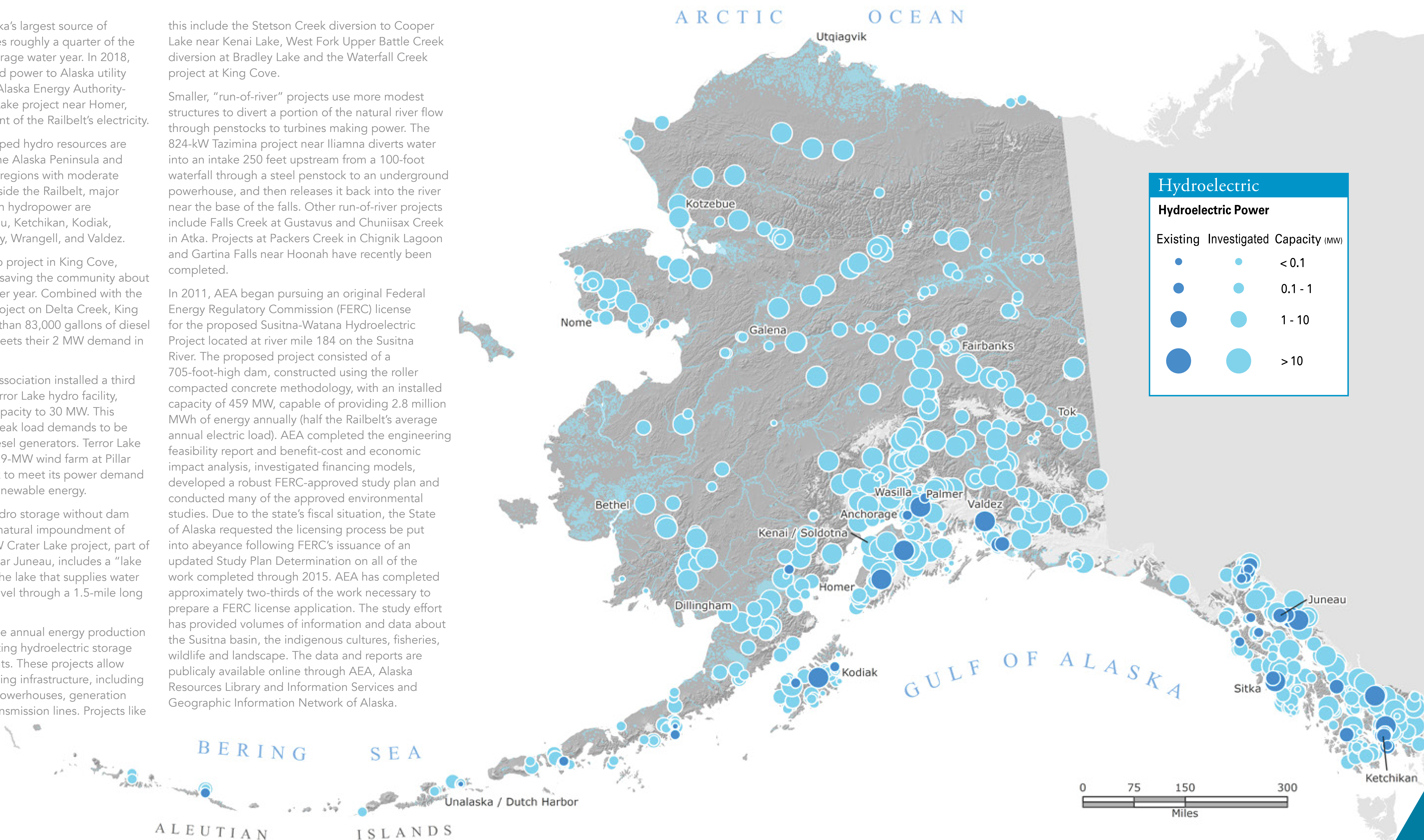
In 2014, Kodiak Electric Association installed a third 10-MW turbine at their Terror Lake hydro facility, increasing powerhouse capacity to 30 MW. This added capacity enables peak load demands to be met without operating diesel generators. Terror Lake also helps to regulate the 9-MW wind farm at Pillar Mountain allowing Kodiak to meet its power demand with nearly 100 percent renewable energy.

Other projects provide hydro storage without dam construction through the natural impoundment of existing lakes. The 31-MW Crater Lake project, part of the Snettisham project near Juneau, includes a "lake tap" near the bottom of the lake that supplies water to a powerhouse at sea level through a 1.5-mile long tunnel.

Still other projects increase annual energy production by diverting rivers to existing hydroelectric storage reservoirs and power plants. These projects allow more efficient use of existing infrastructure, including intake structures, dams, powerhouses, generation equipment, roads and transmission lines. Projects like this include the Stetson Creek diversion to Cooper Lake near Kenai Lake, West Fork Upper Battle Creek diversion at Bradley Lake and the Waterfall Creek project at King Cove.

Smaller, "run-of-river" projects use more modest structures to divert a portion of the natural river flow through penstocks to turbines making power. The 824-kW Tazimina project near Iliamna diverts water into an intake 250 feet upstream from a 100-foot waterfall through a steel penstock to an underground powerhouse, and then releases it back into the river near the base of the falls. Other run-of-river projects include Falls Creek at Gustavus and Chuniisax Creek in Atka. Projects at Packers Creek in Chignik Lagoon and Gartina Falls near Hoonah have recently been completed.

In 2011, AEA began pursuing an original Federal Energy Regulatory Commission (FERC) license for the proposed Susitna-Watana Hydroelectric Project located at river mile 184 on the Susitna River. The proposed project consisted of a 705-foot-high dam, constructed using the roller compacted concrete methodology, with an installed capacity of 459 MW, capable of providing 2.8 million MWh of energy annually (half the Railbelt's average annual electric load). AEA completed the engineering feasibility report and benefit-cost and economic impact analysis, investigated financing models, developed a robust FERC-approved study plan and conducted many of the approved environmental studies. Due to the state's fiscal situation, the State of Alaska requested the licensing process be put into abeyance following FERC's issuance of an updated Study Plan Determination on all of the work completed through 2015. AEA has completed approximately two-thirds of the work necessary to prepare a FERC license application. The study effort has provided volumes of information and data about the Susitna basin, the indigenous cultures, fisheries, wildlife and landscape. The data and reports are publicaly available online through AEA, Alaska Resources Library and Information Services and Geographic Information Network of Alaska.



Ocean and River Hydrokinetic

Alaska has thousands of miles of coastline, providing potential for tidal and wave energy development. Alaska rivers can also be a potential resource; river in-stream and tidal energy technologies could supply some of Alaska's energy needs.

Tidal and river in-stream energy can be extracted using hydrokinetic devices. These devices are placed directly into a river or tidal current and are powered by the kinetic energy of moving water. The available power is a function of the water current's speed and the swept area. In contrast, traditional hydropower uses a diversion structure or a dam to supply a combination of hydraulic head and water volume to a turbine generating power. Hydrokinetic devices require a minimum current and water depth to operate. Speeds of 2-4 knots are the minimum speed required, while 5-7 knots provide for optimum operation. Ideal locations for hydrokinetic devices are those with significant flow throughout the year and that are not susceptible to serious flood events, turbulence, debris or extended periods of low water.

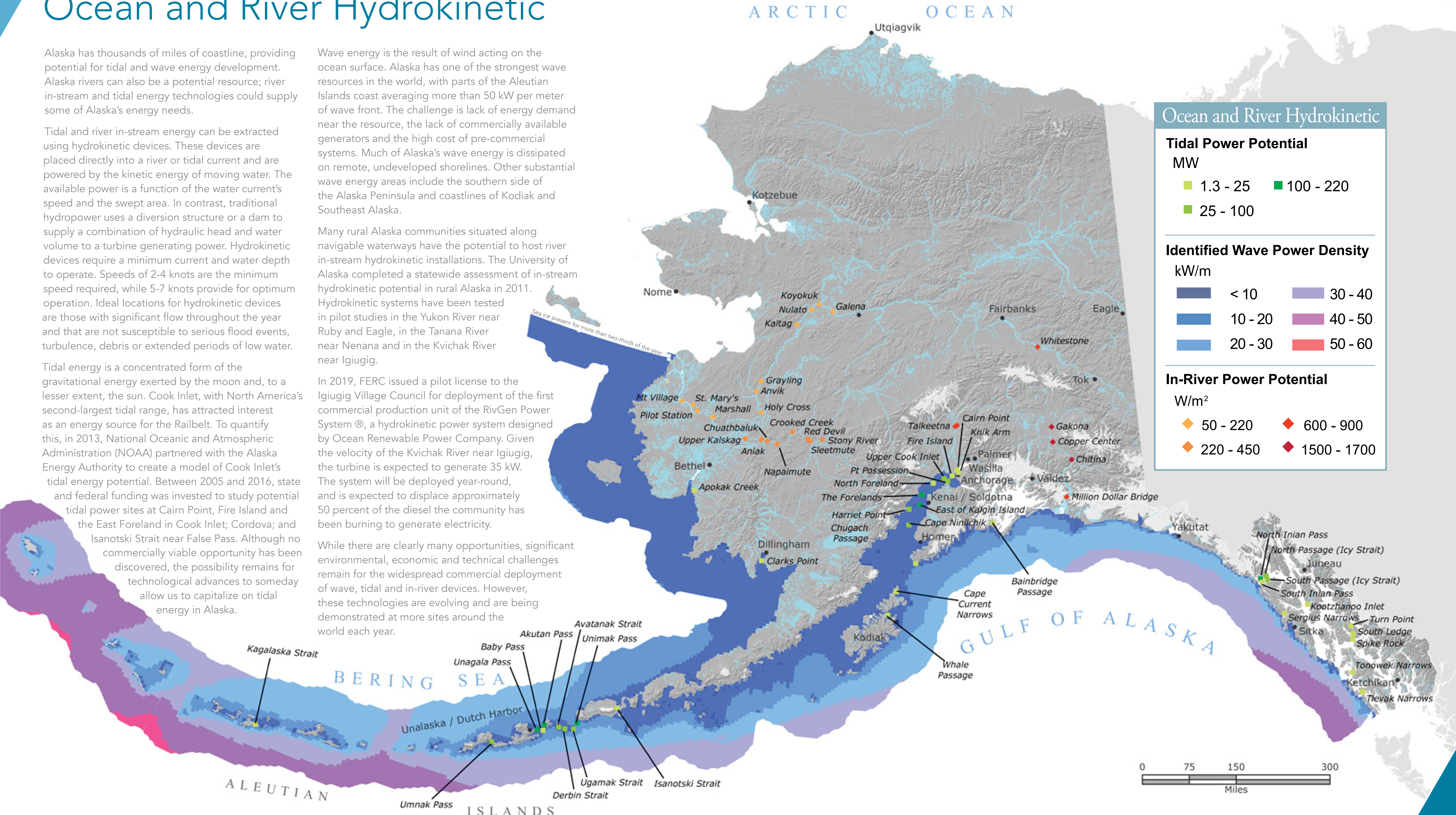
Tidal energy is a concentrated form of the gravitational energy exerted by the moon and, to a lesser extent, the sun. Cook Inlet, with North America's second-largest tidal range, has attracted interest as an energy source for the Railbelt. To quantify this, in 2013, National Oceanic and Atmospheric Administration (NOAA) partnered with the Alaska Energy Authority to create a model of Cook Inlet's tidal energy potential. Between 2005 and 2016, state and federal funding was invested to study potential tidal power sites at Cairn Point, Fire Island and the East Foreland in Cook Inlet; Cordova; and Isanotski Strait near False Pass. Although no commercially viable opportunity has been discovered, the possibility remains for technological advances to someday allow us to capitalize on tidal energy in Alaska.

Wave energy is the result of wind acting on the ocean surface. Alaska has one of the strongest wave resources in the world, with parts of the Aleutian Islands coast averaging more than 50 kW per meter of wave front. The challenge is lack of energy demand near the resource, the lack of commercially available generators and the high cost of pre-commercial systems. Much of Alaska's wave energy is dissipated on remote, undeveloped shorelines. Other substantial wave energy areas include the southern side of the Alaska Peninsula and coastlines of Kodiak and Southeast Alaska.

Many rural Alaska communities situated along navigable waterways have the potential to host river in-stream hydrokinetic installations. The University of Alaska completed a statewide assessment of in-stream hydrokinetic potential in rural Alaska in 2011. Hydrokinetic systems have been tested in pilot studies in the Yukon River near Ruby and Eagle, in the Tanana River near Nenana and in the Kvichak River near Igiugig.

In 2019, FERC issued a pilot license to the Igiugig Village Council for deployment of the first commercial production unit of the RivGen Power System ®, a hydrokinetic power system designed by Ocean Renewable Power Company. Given the velocity of the Kvichak River near Igiugig, the turbine is expected to generate 35 kW. The system will be deployed year-round, and is expected to displace approximately 50 percent of the diesel the community has been burning to generate electricity.

While there are clearly many opportunities, significant environmental, economic and technical challenges remain for the widespread commercial deployment of wave, tidal and in-river devices. However, these technologies are evolving and are being demonstrated at more sites around the world each year.



Solar

Alaska's high latitude presents the challenge of having minimal solar energy during long winter months when energy demand is greatest. At the same time, solar generation in the shoulder months (spring and fall) is often impressive in northern latitudes where clear skies, cool temperatures, dry air and bright, reflective snow all support solar generation: Solar photovoltaic (PV) systems can actually exceed their rated output during these times of year.

Strong competition and advances in the solar panel technology sector have led to a 70 percent decrease in the national average cost of solar PV installations since 2010. In 2018, more than 250,000 people worked in the solar industry in the U.S., more than double the number in 2012. Decreasing cost continues to drive consumer interest and the industry throughout the country.

As with all intermittent renewable energy, integrating solar into the type of small, islanded grids that exist in most rural communities in Alaska can be challenging if not properly planned and managed. For projects that are not being developed by the local utility, it is critical that developers work closely with the utility to ensure proper integration into the local grid. Off-grid applications such as remote fish camps, lodges and cabins, can be ideal applications for solar PV.

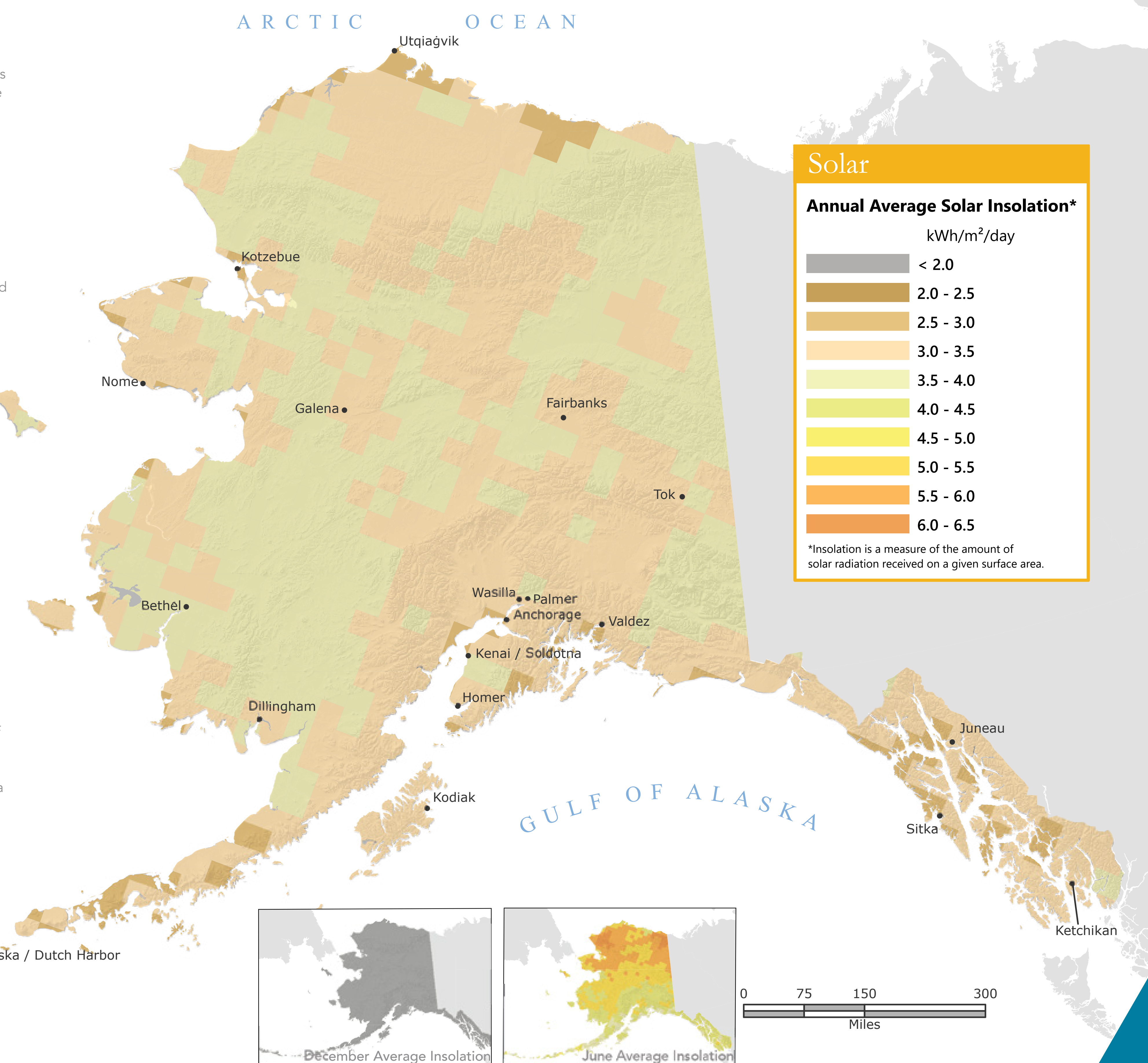
The Native Village of Hughes recently installed a 120 kW solar photovoltaic system. The project is being developed to help advance the community's renewable energy goal of 50 percent by 2025. When the project is completed it will be the largest solar project in a small rural community in the state.

On the Railbelt two noteworthy projects were added in 2018, the first is a 563-kW project owned by Golden Valley Electric Association located in Fairbanks. The project is the largest solar project in the state and is operated by the utility and owned by all cooperative members as a whole. The other is 100 kW solar field was built along the Parks Highway in Willow and a second phase adding generation capacity is planned for 2019. This Railbelt project sells power to Matanuska Electric Association at wholesale rates.

In larger systems, such as the Railbelt energy region which serves most of urban Alaska, there are rules governing distributed generation, and the potential to negatively impact the entire system is of less of a concern. As the cost of solar PV comes down it becomes a more attractive option for homeowners and business owners. In Anchorage, for instance, the Solarize Anchorage campaign helped put 150 systems on rooftops across the city between 2017 and 2018, and work is continuing. Federal tax incentives, paired with the economy of scale provided by the Solarize Anchorage campaign, has motivated a historic number of Anchorage residents to invest in rooftop solar. This trend is consistent with consumer interest elsewhere in the country, and is expected to continue growing throughout the state.

"Solar thermal" heating systems use pumps or fans to move energy to a point of use, such as a domestic hot water tank. Typical homes demand a large amount of fuel year-round for domestic hot water, so using the sun to heat water for even seven or eight months a year can save significant amounts of energy. A larger role for solar thermal hot water systems in Alaska is emerging as heating systems advance – allowing solar-heated fluid to supply in-floor systems currently heated by fuel boilers.

In Alaska, careful building design and construction can minimize the use of heating fuel. "Passive solar" design includes proper southern orientation and the use of south-facing windows that transfer the sun's energy into the building through natural processes of conduction, convection and radiation. Passive solar design employs windows, thermal mass and proper insulation to enable the building itself to function as a solar collector.



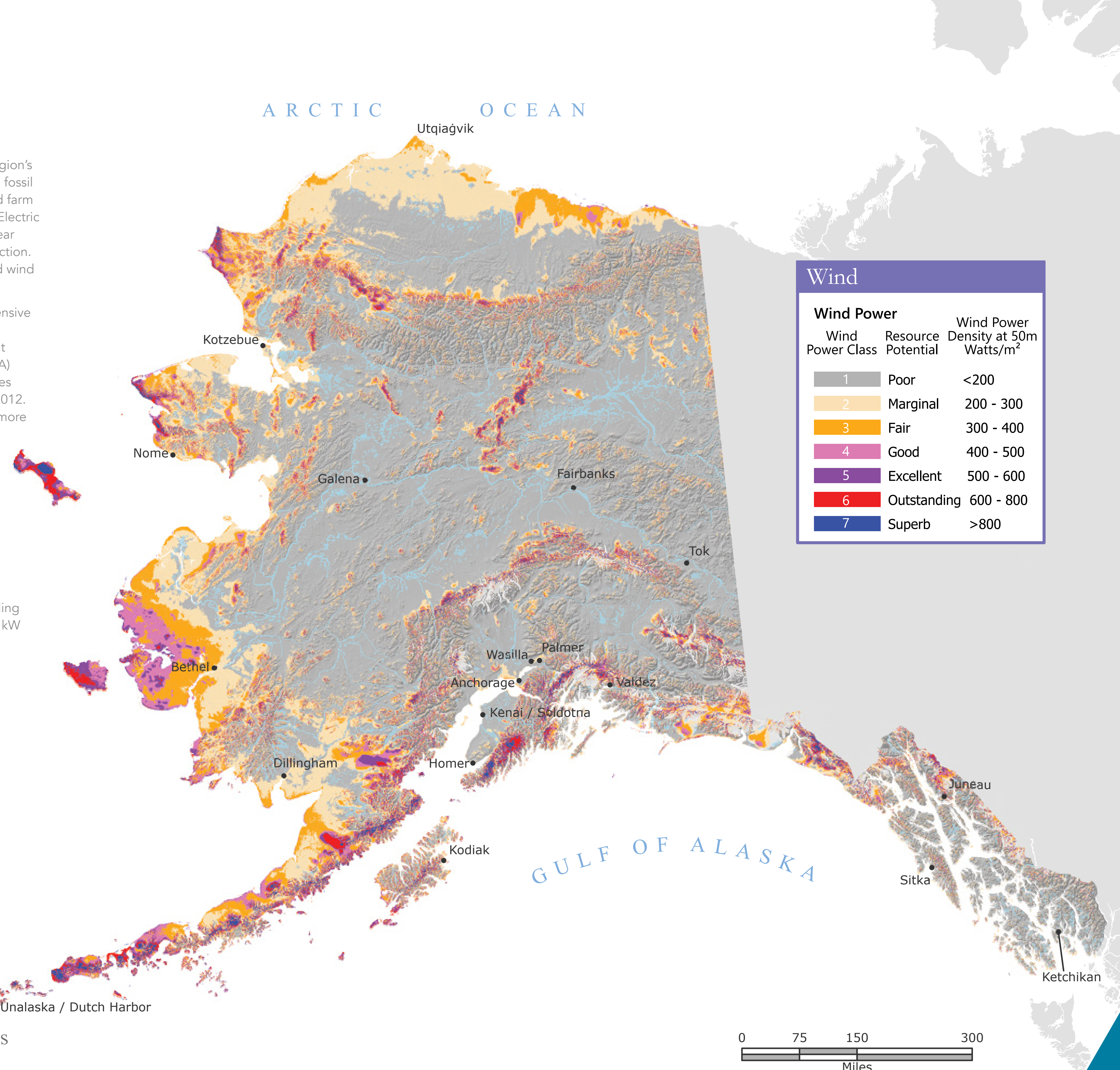
Wind

On a global scale, wind energy is some of the cheapest electricity on the planet. In Alaska, there are abundant wind resources available for energy development. High costs associated with fossil fuel-based generation and improvements in wind power technology make this clean, renewable energy resource attractive to many communities. The wind map on these pages shows the estimated wind resource across the state. The colors represent the estimated Wind Power Class in each area, with Class 1 being the weakest and Class 7 the strongest. The quality of a wind resource is key to determining the feasibility of a project, but other important factors to consider include the size of a community's electrical load, the price of displaced fuels, turbine foundation costs, the length of transmission lines and other site-specific variables.

Alaska's best wind resources are largely located in the western and coastal portions of the state. In parts of Southwest Alaska, turbines may actually need to be sited away from the strongest winds to avoid extreme gusts and turbulence. While average wind speeds tend to be much lower in the Interior, areas such as Healy and Delta Junction have strong wind resources. The quality of the wind resource is very site-specific, so it is critical to measure the wind resource before starting development. Site-specific wind resource data has been collected from around the state and is available on AEA's website at akenergyauthority.org.

Wind power technologies that are used in Alaska range from small systems at off-grid homes and remote camps, to medium-sized, wind-diesel hybrid power systems in isolated villages, to large, megawatt scale turbines along the Railbelt and in communities like Kodiak, Kotzebue, and Nome. On the Railbelt, utilities and independent power producers have installed three wind projects to diversify the region's energy mix and provide a hedge against rising fossil fuel prices. Those projects are a 17.6-MW wind farm near Anchorage on Fire Island, Golden Valley Electric Association's 24.6-MW Eva Creek wind farm near Healy and a 1.9-MW wind farm near Delta Junction. At the end of 2017, Alaska had a total installed wind capacity of 67 MW.

Rural Alaska, which is largely powered by expensive diesel fuel, has seen rapid development of community-scale, wind-diesel systems in recent years. In 2009, Kodiak Electric Association (KEA) installed the state's first megawatt-scale turbines and then doubled the size of its wind farm in 2012. The project's six 1.5 MW turbines now supply more than 18 percent of the community's electricity. Combined with the Terror Lake hydroelectric project, KEA can now shut off their diesel generators almost all year. Alaska Village Electric Cooperative has wind-diesel hybrid systems installed in 12 of the 55 western and interior villages it serves, and is developing projects in at least five other communities. Unalakleet Valley Electric Cooperative added a 600 kW wind farm in 2009. Kotzebue added two 900 kW turbines in 2012, more than doubling its wind capacity. Nome also installed two 900 kW turbines in 2013.



Renewable Energy Grant Fund

Alaska's Renewable Energy Fund (REF), administered by the Alaska Energy Authority, was created by the legislature in 2008 with the intent to lower and stabilize the cost of energy in Alaska through increased use of renewable energy. The program, originally authorized for five years, was extended to 2023 by the legislature in 2012.

Over the last decade, the Renewable Energy Fund, through state investment of nearly $270 million, has acted as a major catalyst for the renewable energy market sector in Alaska. Benefits from renewable energy projects that have been brought online as a result of the fund are felt throughout Alaska; from integrating wind into diesel systems in small, western Alaska villages to investing in wind and hydro generation to serve the Railbelt region which stretches from Fairbanks to Seward and Homer.

Grants have been awarded for reconnaissance and feasibility studies, as well as design and construction projects covering a wide range of technologies and geographic areas. State investment in all stages of project development have supported local financial participation far exceeding total grant funded amounts.

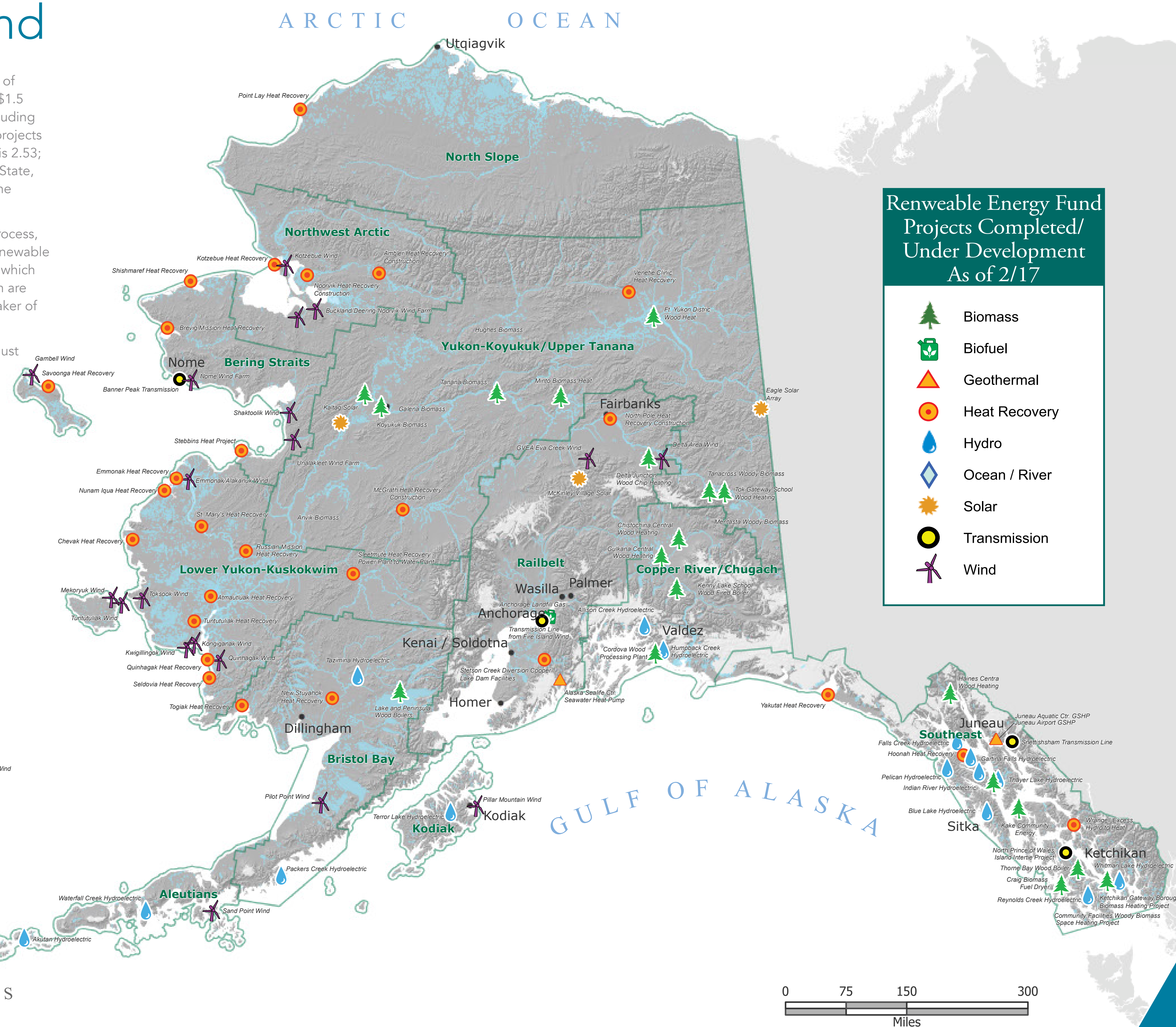
The program is helping communities stabilize energy prices by reducing their dependence on diesel fuel for power generation and space heating.

In 2017, 79 projects displaced roughly 30 million diesel-equivalent gallons of fuel worth more than $74 million. These numbers will continue to grow as more projects that have received state support come into operation. As of June 2019 there are more than ten projects to be constructed through the program.

The estimated present value of the benefits of currently operational REF projects is nearly $1.5 billion, with $583 million in capital costs including $171 million of REF investment. If, overall, projects operate as expected, the benefit-cost ratio is 2.53; this means for every dollar invested (by the State, community, or other project contributors), the community should see a benefit of $2.53.

The program is a competitive application process, administered by AEA and guided by the Renewable Energy Fund Advisory Committee (REFAC), which is comprised of nine members, five of whom are appointed by the governor, two by the speaker of the house and two by the senate president.

To qualify for funding, project developers must submit applications to AEA during an open solicitation. AEA then ranks the proposed projects based on economic and technical feasibility, local support, matching funding and the community's cost of energy. These rankings are vetted by the REFAC and then submitted to the legislature, which approves the projects and appropriates funding.



Renewable Energy Policies

State and federal policies that encourage renewable energy projects play a crucial role in their development.

For the last quarter century, the federal Production Tax Credit (PTC) has been the primary incentive tool for renewable electricity in the United States. Congress passed the PTC in 1992 to even the playing field between the renewable energy industry and the fossil fuel and nuclear industries. The subsidy provides a credit for each kilowatt-hour (kWh) a project produces over the first 10 years of its operation, incentivizing efficient operations and maintenance. In late 2015, Congress introduced a five-year extension of the PTC that included a gradual phasing down of the 2.4 cent/kWh credit for wind energy, beginning in 2017. Projects that start construction in 2019, the final year of the credit, will receive just 40 percent of the 2.4 cents/kWh credit for 10 years. The PTC for geothermal, closed-loop biomass and solar energy all ended at the beginning of 2018. The bipartisan deal also called for an extension and phasing out of the other major federal incentive for wind developers, the Investment Tax Credit (ITC). The ITC is a separate incentive that has allowed project developers to elect to take a one-time tax credit of 30 percent of the total cost of the project's construction, instead of the PTC. Wind projects that begin construction in 2019 will receive a 12 percent tax credit, before the ITC goes away completely. The 30 percent ITC for solar was extended through 2019, when it begins to ratchet down. After 2023, the residential credit will drop to zero while the commercial and utility credit will drop to a permanent 10 percent.

Because of the uncertainty surrounding federal policy, individual state policies have historically been the primary drivers of renewable energy development in the United States. The three primary policies used across the country have been net metering, renewable portfolio standards and various forms of innovative public financing. As the threat of climate change intensifies, an increasing number of jurisdictions are also considering pricing carbon emissions to encourage renewable energy development, both directly and indirectly.

ACEP's bifacial solar test site, Fairbanks

Net Metering

State net metering rules provide an incentive for individuals and businesses to invest in their own small renewable energy systems by allowing them to sell excess power that they produce back into the grid. More than 40 states, including Alaska, offer some form of net metering. Different rules in each state determine the maximum amount of power individual producers can sell back to the utility, the price at which the utility must purchase the power and the length of time an individual producer can "bank" the power they produce before a "net" bill must be calculated.

Alaska's net metering regulations, promulgated in 2010, apply to renewable energy systems of 25 kW or less and require large utilities to purchase up to 1.5 percent of the utility's average load from customers who install projects. Customers receive an amount equal to what the utility is able to avoid spending on fuel and operations to generate the electricity. The number of customer-built projects, particularly solar photovoltaic, is beginning to grow rapidly and at least one utility is projected to reach the 1.5 percent cap set by the Regulatory Commission of Alaska (RCA) sometime around 2022.

Renewable Portfolio Standards

A Renewable Portfolio Standard (RPS) is a state law requiring utility companies to generate a specified percentage of their electricity from renewable resources by a certain date. RPS requirements in the US vary widely on a number of factors, including the percentage and end-date. In 2015, Hawaii became the first state to require 100 percent of its electricity to be generated by renewables (by 2045). California, the fifth largest economy in the world, now has an RPS that requires 100 percent of all of that state's electricity to be produced by renewables by 2030. Utilities are typically given interim milestones and must pay a fine if they do not reach those milestones. Most states allow utilities to purchase Renewable Energy Credits (REC's) to meet these standards and avoid paying fines. Each REC represents the production of one megawatt-hour of renewable energy and the displacement of approximately 1,400 pounds of CO_2 emissions. Buyers of REC's include utilities trying to meet state RPS requirements and a growing number of corporations, agencies and municipalities committed to supporting increased renewable energy production. The RPS approach forces different entities and renewable energy resources to compete to meet the standard.

Twenty-nine states, Washington, DC and three U.S. territories currently have RPS's. An additional eight states and one territory have renewable portfolio goals. In 2010, Alaska set a non-binding goal to generate 50 percent of the state's electricity from renewable sources by 2025. Bills have been proposed in Congress to create a mandatory national Renewable Electricity Standard (RES) but so far all have failed to pass both the House and Senate.

Clean Energy Funds

Clean energy funds support the development of renewable energy and energy efficiency by helping remove market barriers and educating the public. State clean energy funds are supported through small, mill-rated utility surcharges called system benefit charges. Programs that are supported through these funds support research and development, provide low-income energy assistance and develop infrastructure and clean energy financing mechanisms. For example, system benefit charges in Oregon are deposited into the independent Energy Trust of Oregon to fund eligible efficiency, wind, solar electric, biomass, small-scale hydro, tidal, geothermal and fuel cell projects through grants, loans, rebates, equity investments and other financing mechanisms.

Today several states, nations and even one county are forming "green banks" that specifically finance energy efficiency and renewable energy projects. These entities pioneer programs that reduce project risk and induce the private banking sector to partner on investments. The Connecticut Green Bank receives a significant portion of its annual working capital from a system benefit charge of $0.001/kWh of electricity sold in the state each year. The bank now leverages eight private sector banking dollars for every $1 the state loans for clean energy development through the Green Bank.

Alaska's Renewable Energy Fund (REF) was established in 2008 to support renewable energy development and is funded through annual legislative appropriations. So far, the Alaska legislature has appropriated $270 million to the REF, attracting additional private and federal dollars to fund many reconnaissance and feasibility studies as well as the construction of over 80 projects, mostly in rural Alaska.

Property Assessed Clean Energy (PACE) programs allow local tax assessment districts to loan money to property taxpayers for energy efficiency and renewable energy development. The municipality or tax assessment district is then repaid by a special voluntary tax assessment on the property. In this way, the loan goes with the building, not the individual who initiated the transaction. In 2017, the Alaska legislature passed a bill to authorize PACE loans to be made to commercial building owners. Three large boroughs and municipalities in the state are working together with other stakeholders to develop local Commercial PACE (C-PACE) programs and a single statewide program administrator. In states like Connecticut, the Green Bank provides the dollars that municipalities use for PACE loans. These municipalities pay the Green Bank back as the special tax assessments on the improved properties are collected. A similar set-up could work in Alaska as well.

Carbon Pricing

Carbon pricing schemes generally fall into two categories: cap and trade systems and carbon taxes. Revenue-positive pricing schemes accrue new revenue for the state, province or nation which can be reinvested in renewable energy development or other programs or funds. Several state legislatures in the US are now considering carbon pricing systems, while other states are considering setting up study commissions to better understand the potential economic and policy impacts of carbon pricing.

Carbon trading systems set a cap on the allowable Greenhouse Gas (GHG) emissions in a jurisdiction and then distribute permits that can be purchased and traded among emitters. Cap and trade systems use market forces to determine the price of the GHG emissions. Nine states in the Northeastern US are part of the Regional Greenhouse Gas Initiative (RGGI) which was put in place in 2009. California established its own cap and trade system in 2006 that also allows emitters subject to the system to comply by supporting carbon mitigation projects in other states. In 2018, Sealaska Corporation was issued 11 million carbon credit offsets by the California Air Resources Board to set aside 165,000 forested acres for use as a carbon bank for 100 years. Other Alaska Native Corporations are working on similar mitigation projects as well. In 2008, British Columbia established a revenue-neutral carbon tax that is rebated back to the citizens of the province through income and business tax cuts and a low-income tax credit.

Recent Alaska clean energy policy

In 2008, the Cold Climate Housing Research Center published the first of two reports outlining recommended state programs, initiatives, and goals to reduce end-use energy demand and keep hundreds of millions of dollars in the state's economy each year. The state legislature appropriated the first $360 million of an eventual $600 million for home weatherization and rebate programs that year. Since then, over 45,000 Alaskan homes have been weatherized, with an average energy bill savings of 30 percent.

In 2010, the Alaska State Legislature passed two other important bills – SB 220 and HB 306. House Bill 306 established non-binding goals to produce 50 percent of the state's electricity from renewable resources by 2025 and reduce energy use 15 percent per capita by 2020. Among other provisions, SB 220 mandated that 25 percent of the state's public facilities over 10,000 square feet be energy retrofitted by 2020, a goal met by 2015. Efficiency improvements to state facilities since 2010 are now achieving a cumulative annual cost avoidance of approximately $3.4 million.

As market demand and scientific innovation continues to drive down the price of technologies like wind and solar, governments are increasingly considering a wide range of policies to encourage renewable energy and energy efficiency and reduce greenhouse gases emissions. In Alaska, the Regulatory Commission of Alaska (RCA) and the legislature are both considering grid reform measures in the Railbelt such as mandating a regional approach to reliability, interconnection, protocols, economic dispatch and region-wide generation and transmission planning that would lead to greater renewable energy investment.

Energy Efficiency

Energy efficiency first! Energy efficiency is a common-sense first step in realizing renewable energy targets. It's also a critical component of an effective climate change adaptation and mitigation strategy. Energy efficient buildings, lighting, heating systems and appliances provide the same level of service as less efficient ones, but use less energy. Energy efficiency is typically the least expensive, most cost-effective and quickest energy improvement that can be made, and it should be the very first thing done when looking at cost-savings opportunities within a community energy system. Efficiency translates to saved energy and money, and it creates a strong foundation for renewable energy. For these reasons, the Alaska Energy Efficiency Partnership, a working group of over 50 organizational members from the public, private and non-profit sectors, is guided by a vision that Alaska can be the most energy efficient state in the nation.

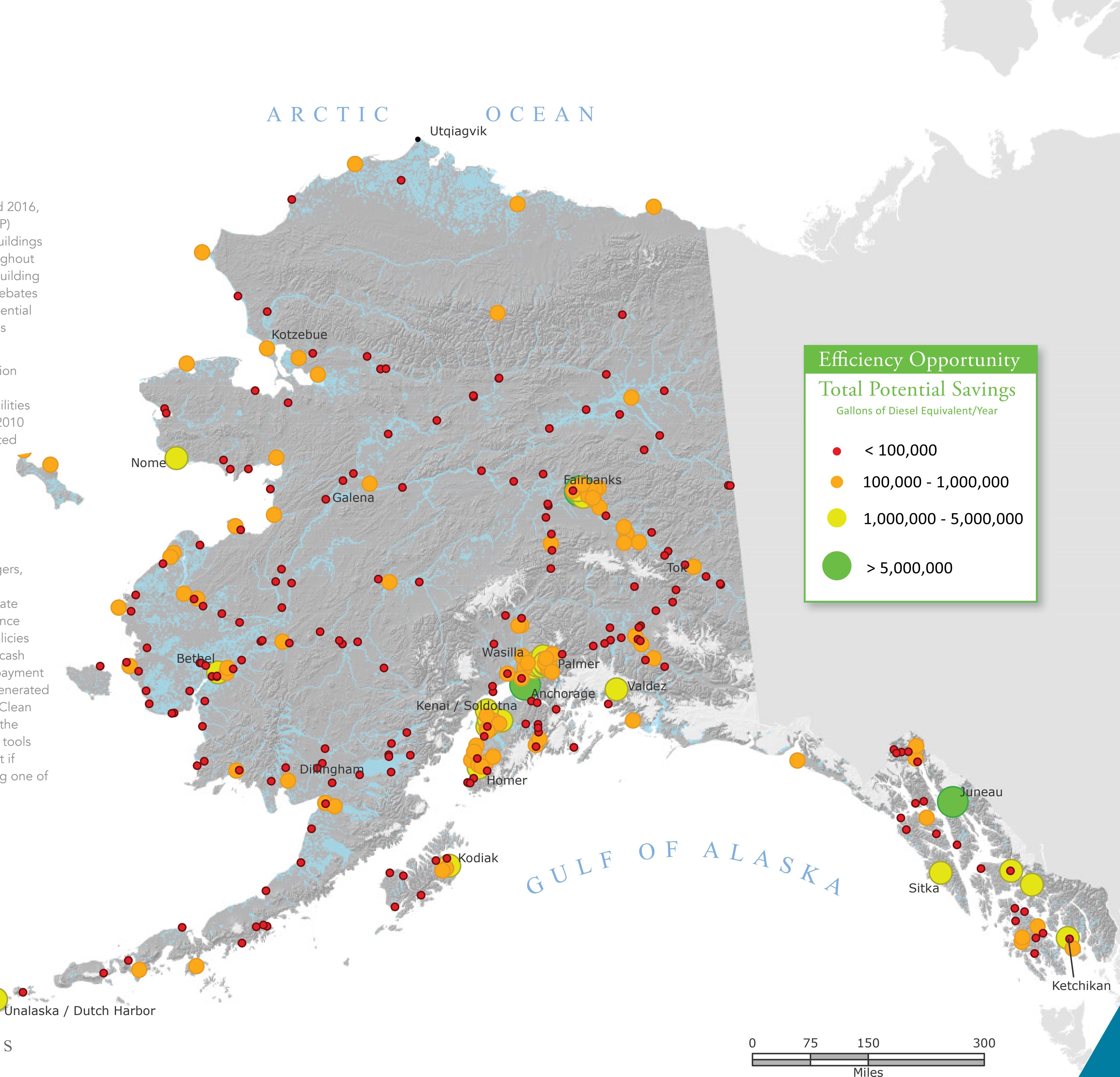
Each year, Alaska's residential and commercial sectors use an estimated 118 trillion BTUs of energy for power and space heat. Of this, approximately 45 percent is used in residential buildings and 55 percent is used in public and private commercial buildings/facilities. Reducing building energy use by 15 percent would save nearly 18 trillion BTUs annually. At $2 per gallon for diesel fuel, a 15-percent energy efficiency improvement in residential, commercial and public buildings could save $260 million each year.

Alaska has had great success with energy efficiency programs over the last decade. In the residential sector, Alaska Housing Finance Corporation (AHFC) has led the way with Low Income Weatherization as well as the now dormant Home Energy Rebate Program. Between 2008 and 2018, these two programs provided efficiency improvements to more than 50,000 households across Alaska, resulting in an average energy savings of 30 percent, the creation of more than 4,000 jobs, and an estimated $56 million in energy savings to Alaska households per year.

AEA administered two programs for the non-residential building sector. Between 2006 and 2016, AEA's Village Energy Efficiency Program (VEEP) implemented efficiency measures in public buildings and facilities in nearly 150 communities throughout rural Alaska. Since 2011, AEA's Commercial Building Energy Audit (CBEA) program has provided rebates for more than 230 privately owned, non-residential buildings in both urban and rural communities throughout the state.

Finally, the Alaska Department of Transportation and Public Facilities works to improve the efficiency of State of Alaska buildings and facilities through its Energy Program office. Between 2010 and 2019, DOT&PF's Energy Program facilitated efficiency improvements to over 25 percent of state-owned facilities, achieving a cumulative annual cost avoidance of more than $3.4 million.

The most important path forward for energy efficiency efforts in Alaska is working with homeowners, business owners, facility managers, regional organizations, lending institutions, policymakers and others to develop appropriate policies and effective, accessible tools to finance building efficiency projects. With the right policies and tools in place, efficiency projects can be cash flow positive from day one, allowing for the payment of project costs simply through the savings generated each month. Commercial Property-Assessed Clean Energy (C-PACE), utility on-bill financing and the establishment of a green bank are policy and tools under development and/or consideration that if utilized, could put Alaska on the path to being one of the most energy efficient states in the nation.

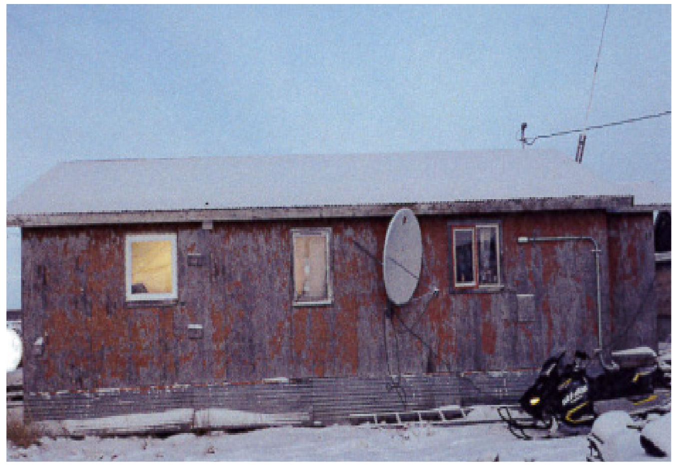


Energy Efficiency Program Highlights

Energy efficiency improvements help individuals, businesses and governments use less energy, save money and strengthen local economies. Efficiency measures also help achieve the state's energy efficiency and renewable energy goals. While the availability of natural resources used to generate electricity and heat varies by location, energy efficiency is available in every corner of the state.

Residential Energy Efficiency Case Study

Alaska Housing Finance Corporation (AHFC) administers the Weatherization at No-Cost program with the goal of assisting homeowners as well as renters in achieving energy efficiency at no cost to qualified applicants. In 2018, the program helped a customer in Quinhagak realize a 70 percent reduction in air leakage. After an initial audit revealed numerous gaps in the sheeting and several missing sheets of plywood, AHFC added two-inch extruded styrene and covered it with plywood, reducing exterior heat loss. By using spray foam on the seams and edges, the floor was effectively sealed, increasing the R-value of the home. Exterior walls, windows and door seams were caulked, and a fresh coat of paint was applied to seal the walls from the outside. Since many of the windows were either broken or inoperable, new windows were installed, dramatically reducing air leakage. Overall, the home retrofit resulted in a reduced airflow of an impressive 70 percent, improving efficiency, comfort and safety for the occupants, while also reducing heating costs.



Quinhagak home before Weatherization program Energy Efficiency measures.

Quinhagak home after Weatherization Program Energy Efficiency measures.

Commercial Energy Efficiency Case Study

The Department of Transportation and Public Facilities (DOT&PF) continues its mission of energy efficiency upgrades to state public facilities and infrastructure. In 2018, the Department implemented an energy efficiency project at the Anton Anderson Memorial (Whittier) Tunnel using an Energy Savings Performance Contract (ESPC) with an Energy Services Company (ESCO). The project is expected to save over $150,000 annually. This type of energy efficiency project improves existing infrastructure, reduces costs of operations and creates quality jobs for Alaskans.

DOT&PF's energy program works with other State of Alaska departments and agencies to facilitate energy efficiency improvements in public facilities. Projects have been completed throughout Alaska with cumulative annual energy savings of over $3.4M. DOT&PF administers an ongoing ESPC Term Agreement to implement these energy efficiency projects.

Whole Community Case Study

In 2008, AEA and several project partners undertook an intensive energy efficiency improvement effort in the small, rural community of Nightmute. An extension of the Village Energy Efficiency Program (VEEP), the "Whole Village Retrofit" (WVR) included energy efficient lighting and weatherization upgrades in 13 community buildings and four teacher-housing units. The effort was intended to maximize possible energy savings and mitigate the effects of rising heating oil prices. With state and federal funding complemented by significant local cash and in-kind matching, the project reduced electricity use by an estimated 59 percent and displaced nearly 5,000 gallons of heating oil in the weatherized buildings.

Across the state, energy efficiency consistently rises to the top of local and regional energy project priority lists. The 2017 Alaska Affordable Energy Strategy (AkAES), a comprehensive research, analysis and recommendations initiative looking at ways to make energy more affordable in all but Railbelt Alaska, identified energy efficiency as the single most cost-effective resource for addressing the high cost of energy throughout the state. One of the studies done for the AkAES was an analysis of how Alaska's portfolio of energy efficiency delivery programs and financing tools can be improved, including the WVR model. The study found that although direct state funding is still needed to capture the opportunity in rural Alaska, a suite of policies--including building codes, minimum product standards and promoting regional solutions--could help to further capture the energy efficiency opportunities in communities.

Additional Savings Through Energy Efficiency: outreach, education & financing

Outreach and Education

The Alaska Energy Efficiency Partnership began in 2010 with the explicit purpose of working collaboratively to improve public awareness about the abundant savings opportunities through efficiency and conservation, and to help move the needle toward adoption of technology and behavior to save energy and money through energy efficiency and conservation. This ad hoc working group includes participants from public, private and nonprofit sector organizations that continue to meet quarterly to discuss collaborative opportunities in program development, project implementation and coordinated outreach. One example of the latter is the annual Power Pledge Challenge.

In 2018, Alaska Electric Light and Power (AEL&P), Alaska Energy Authority (AEA), Alaska Housing Finance Corporation (AHFC), Alaska Village Electric Cooperative (AVEC), City of Seward, Chugach Electric Association (CEA), Homer Electric Association (HEA), Matanuska Electric Association (MEA), Municipal Light and Power (ML&P) and Renewable Energy Alaska Project (REAP) teamed up to put on the fifth annual Power Pledge Challenge (PPC). The PPC educates middle school students across the state about energy efficiency and conservation. Through a presentation and hands-on activities, students learn about calculating electricity use and ways to reduce personal energy consumption. The students then go online and pledge to do three things to reduce their energy use to enter to win a regional prize for their class. If more than 75 percent of a class completes the online pledge, then their class is entered to win the state prize. In 2018 over 3,000 students from grades six through eight participated in the PPC.

Financing

Energy efficiency is an investment opportunity. It's more than swapping out lightbulbs and adding insulation – it creates economic opportunity while improving comfort all without compromising convenience. Using electricity and heat is an unavoidable reality in our state, where the associated costs for these critical services are double or triple the cost outside Alaska. And, despite relatively short-lived trends to the contrary, energy prices generally only go up over time. The longer a person or community waits to take action, the longer energy and money is wasted unnecessarily. Energy efficiency investment grows incrementally, generating savings that can be continuously reinvested in homes, businesses and communities. An investment in energy efficiency is an investment in the future.

Like any good investment, investing in efficiency requires a financial commitment. The savings opportunity, however, can be significant enough that it's worth taking a loan to make this commitment. The cost of repaying that loan is often smaller than the savings generated by the efficiency improvements the loan affords. We're talking about energy efficiency financing, and it's the way of the future.

To finance an efficiency investment, start with information. First, have the building or facility audited to see what kind of savings are possible. Then, have the project cost and savings estimates verified to develop a scope of work. To complete the project, consider working with a project developer. Make sure to initiate negotiations with a lender, public or private. Make sure you get the savings that were promised. And then reap the rewards of the hard work with lower energy bills, a healthier indoor air quality and more money to spend on other, more important things.

Power Pledge Challenege winner's tour of the Matanuska Electric Association powerplant. Photo curticy of REAP.

Glossary

Absorption Chiller - A device that uses heat energy rather than mechanical energy to cool an interior space through the evaporation of a volatile fluid.

Active Solar - A solar water or space-heating system that use pumps or fans to circulate the heat transfer medium (water, air or heat-transfer fluid like diluted antifreeze) from the solar collectors to a storage tank subsystem or conditioned space.

Alternative Fuels - A term for "non-conventional" transportation fuels derived from natural gas (propane, compressed natural gas, methanol, etc.) or biomass materials (ethanol, methanol, or biodiesel).

Anemometer - An instrument for measuring the velocity of wind; a wind gauge.

ASTM - Abbreviation for the American Society for Testing and Materials, which is responsible for the issue of many standard methods used in the energy industry.

Availability - It refers to the number of hours that a power plant is available to produce power divided by the total hours in a set time period, usually a year.

Avoided Cost - The incremental cost to an electric power producer to generate or purchase a unit of electricity or capacity or both.

Biodiesel - A domestic, renewable fuel for diesel engines derived from natural oils like fish and vegetable oil; produced by a chemical process that removes the glycerin from the oil and meets a national specification (ASTM D 6751).

Biomass - Organic matter that is available on a renewable basis, including agricultural crops and agricultural wastes and residues, wood and wood wastes and residues, animal wastes, municipal wastes and aquatic plants.

Bioenergy – Electrical, mechanical, or thermal energy or fuels derived from biomass.

Capacity Factor - The ratio of the average power output of a generating unit to the capacity rating of the unit over a specified period of time, usually a year.

Co-firing - Using more than one fuel source to produce electricity in a power plant. Common combinations include biomass and coal, biomass and natural gas, or natural gas and coal.

Cogeneration - The generation of electricity and the concurrent use of rejected thermal energy from the conversion system as an auxiliary energy source.

Conduction - The transfer of heat through a material by the transfer of kinetic energy from particle to particle; the flow of heat between two materials of different temperatures that are in direct physical contact.

Convection - The transfer of heat by means of air or fluid movement.

Dam - A structure for impeding and controlling the flow of water in a water course that increases the water elevation to create hydraulic head. The reservoir creates, in effect, stored energy.

District Heating System - Local system that provides thermal energy through steam or hot water piped to buildings within a specific geographic area. Used for space heating, water heating, cooling and industrial processes. A common application of geothermal resources.

Distributed Generation - Localized or on-site power generation, which can be used to reduce the load on a transmission system by generating electricity close to areas of customer need.

Distribution Line - One or more circuits of an electrical distribution system on the same line or poles or supporting structures, usually operating at a lower voltage than a transmission line.

Domestic Hot Water - Water heated for residential washing, bathing, etc.

Electrical Energy - The amount of work accomplished by electrical power, usually measured in kilowatt-hours (kWh). One kWh is 1,000 watt hours and is equal to 3,413 Btu.

Energy - The capability of doing work; different forms of energy can be converted to other forms, but the total amount of energy remains the same.

Energy Conservation - Reducing energy consumption by changing a behavior or level of service.

Energy Crop - A plant grown with the express purpose to be used in biomass electricity or thermal generation.

Energy Efficiency - Applying better technology and practices to get the same level of service while using less energy.

Energy Storage - The process of converting energy from one form to another for later use. Storage devices and systems include batteries, conventional and pumped storage hydroelectric, flywheels, compressed gas, hydrogen and thermal mass.

Ethanol - A colorless liquid that is the product of fermentation used in alcoholic beverages, in industrial processes, and as a fuel.

Feedstock - A raw material that can be converted to one or more products.

Fossil Fuels - Fuels formed in the ground from the remains of dead plants and animals, including oil, natural gas and coal. It takes millions of years to form fossil fuels.

Fuel - Any material burned to make energy.

Fuel Oil - Any liquid petroleum product burned for the generation of heat in a furnace or firebox, or for the generation of power in an engine. Domestic (residential) heating fuels are classed as Nos. 1, 2, 3; Industrial fuels as Nos. 4, 5, and 6.

Generator - A device for converting mechanical energy to electrical energy.

Geothermal Energy - Energy produced by the internal heat of the earth; geothermal heat sources include: hydrothermal convective systems; pressurized water reservoirs; hot dry rocks; thermal gradients; and magma. Geothermal energy can be used directly for heating and cooling or to produce electric power.

Head – A measure of fluid pressure, commonly used in water pumping and hydro power to express height that a pump must lift water, or the distance water falls. Total head accounts for friction and other head losses.

Heat Pump - An electricity powered device that extracts available heat from one area (the heat source) and transfers it to another (the heat sink) to either heat or cool an interior space or to extract heat energy from a fluid.

Hybrid System - An energy system that includes two different types of technologies that produce the same type of energy; for example, a wind turbine and a diesel system combined to meet electric power demand.

Hydroelectric Power Plant - A power plant that produces electricity by the force of water moving through a hydro turbine that spins a generator.

Hydrogen - A chemical element that can be used as a fuel since it has a very high energy content. Although it is often thought of as a fuel, hydrogen is better classified as an energy storage medium because it requires energy, typically from electricity or natural gas, to produce it.

Insolation - A measure of the amount of solar radiation energy received on a given surface area.

Landfill Gas - Naturally occurring methane produced in landfills that can be burned in a boiler to produce heat or in a gas turbine or engine-generator to produce electricity.

Large-scale or Utility-scale - A power generating facility designed to output enough electricity for purchase by a utility.

Load - Amount of electricity required to meet customer demand at any given time.

Meteorological (Met) Tower - A structure instrumented with anemometers, wind vanes and other sensors to measure the wind resource at a site.

Ocean Energy Systems - Energy conversion technologies that harness the energy in tides, waves, and thermal gradients in the oceans.

Organic Rankine cycle (ORC) – A closed system that uses an organic working fluid instead of water to spin a turbine, and therefore can operate at lower temperatures and pressures than a conventional steam process.

Panel (Solar) - A term applied to individual solar collectors, and typically to solar photovoltaic collectors or modules.

Passive Solar Design - Construction of a building to maximize solar heat gain in the winter and minimize it in the summer without the use of fans or pumps, thereby reducing the use of mechanical heating and cooling systems.

Peak load – The amount of electricity required to meet customer demand at its highest.

Penstock - A component of a hydropower plant; a pipe that delivers water to the turbine.

Photovoltaics (PV) - Devices that convert sunlight directly into electricity using semiconductor materials. Most commonly found on a fixed or movable panel; also called solar panels.

Power - Energy that is capable of doing work; the time rate at which work is performed, measured in horsepower, Watts, or Btu per hour.

Production Tax Credit (PTC) – An incentive that allows the owner of a qualifying energy project to reduce their taxes by a specified amount. The federal PTC for wind, geothermal, and closed-loop biomass is 1.9 cents per kWh.

Radiation - The transfer of heat through matter or space by means of electromagnetic waves.

Railbelt - The portion of Alaska near the Alaska Railroad, including Fairbanks, Anchorage and the Kenai Peninsula.

Renewable Resource - Energy sources which are continuously replenished by natural processes, such as wind, solar, biomass, hydroelectric, wave, tidal and geothermal.

Run-of-River Hydroelectric - A type of hydroelectric facility that uses a portion of the river flow with minimal impoundment of the water.

Small-scale or Residential-scale - A generating facility designed to output enough electricity to offset the needs of a residence, farm or small group of farms, generally 250 kW or smaller.

Solar Energy - Electromagnetic energy transmitted from the sun (solar radiation). The amount that reaches the earth is equal to one billionth of total solar energy generated, or the equivalent of about 420 trillion kilowatt-hours.

Solar Radiation - A general term for the visible and near visible (ultraviolet and near-infrared) electromagnetic radiation that is emitted by the sun. It has a spectral, or wavelength, distribution that corresponds to different energy levels; short wavelength radiation has a higher energy than long-wavelength radiation.

Tidal Power - The power available from either the rise and fall or flow associated with ocean tides.

Transmission Grid - The network of power lines and associated equipment required to deliver electricity from generating facilities to consumers through electric lines at high voltage, typically 69kV and above.

Turbine - A device for converting the flow of a fluid (air, steam, water, or hot gases) into mechanical motion.

Wave Energy - Energy derived from the motion of ocean waves.

Wind Energy - Energy derived from the movement of the wind across a landscape caused by the heating of the atmosphere, earth and oceans by the sun.

Wind Turbine - A device that converts energy in the wind to electrical energy, typically having two or three blades.

Windmill - A device that converts energy in the wind to mechanical energy that is used to grind grain or pump water.

Wind Power Class - A class based on wind power density ranging from 1 (lowest) to 7 (highest).

Wind Power Density - The amount of power per unit area of a free windstream.

Wind Resource Assessment - The process of characterizing the wind resource and its energy potential, for a specific site or geographical area.

UNITS

Ampere - A unit of measure for an electrical current; the amount of current that flows in a circuit at an electromotive force of one Volt and at a resistance of one Ohm. Abbreviated as amp.

Amp-Hours - A measure of the flow of current (in amperes) over one hour.

Barrel (Petroleum) - Equivalent to 42 U.S. gallons (306 pounds of oil, or 5.78 million Btu).

British Thermal Unit (Btu) - The amount of heat required to raise the temperature of one pound of water one degree Fahrenheit; equal to 252 calories.

Cord (of Wood) - A stack of wood 4 feet by 4 feet by 8 feet.

Gigawatt (GW) - A unit of power equal to 1 billion watts, 1 million kilowatts, or 1,000 megawatts.

Gigawatt-hour (GWh) - One million kilowatt-hours or 1 billion watt-hours.

Hertz - A measure of the number of cycles or wavelengths of electrical energy per second; U.S. electricity supply has a standard frequency of 60 hertz.

Horsepower (hp) - A measure of time rate of mechanical energy output; usually applied to electric motors as the maximum output; 1 electrical hp is equal to 0.746 kilowatts or 2,545 Btu per hour.

Kilowatt (kW) - A standard unit of electrical power equal to one thousand watts, or to the energy consumption at a rate of 1000 Joules per second.

Kilowatt-hour (kWh) - A common measurement of electricity equivalent to one kilowatt of power generated or consumed over the period of one hour; equivalent to 3,412 Btu.

Megawatt (MW) - One thousand kilowatts or 1 million watts; standard measure of electric power plant generating capacity.

Megawatt-hour (MWh) - One thousand kilowatt-hours or 1 million watt-hours.

Mill - A common monetary measure equal to one-thousandth of a dollar or a tenth of a cent.

Quad - One quadrillion Btu.

Therm - A unit of heat containing 100,000 British thermal units (Btu).

Terawatt (TW) - A unit of electrical power equal to one trillion watts or one million megawatts.

Tonne - A unit of mass equal to 1,000 kilograms or 2,204.6 pounds, also known as a metric ton.

Volt (V) - A unit of electrical force equal to that amount of electromotive force that will cause a steady current of one ampere to flow through a resistance of one ohm.

Voltage - The amount of electromotive force, measured in volts, that exists between two points.

Watt (W) - Instantaneous measure of power, equivalent to one ampere under an electrical pressure of one volt. One watt equals 1/746 horsepower, or one joule per second. It is the product of Voltage and Current (amperage).

Watt-hour - A unit of electricity consumption of one Watt over the period of one hour.

Watts per Square Meter (W/m^2) - Unit used to measure wind power density, measured in Watts per square meter of blade swept area.

Data Sources

Common Map Layers
Communities: Alaska Department of Commerce, Community and Economic Development. Community Database Online. https://www.commerce.alaska.gov/dcra/DCRAExternal/

Lakes, Streams and Glaciers: Alaska Department of Natural Resources. www.asgdc.state.ak.us

Grayscale Elevation Hillshade Image: Resource Data Inc. The elevation image was developed using a 300-meter digital elevation model from U.S. Geological Survey EROS Alaska Field Office. agdc.usgs.gov/data/usgs/erosafo/300m/dem/metadata/dem300m.html

Canada and Russia: Alaska Department of Natural Resources. www.asgdc.state.ak.us

Infrastructure
Coal, Gas Turbine, Hydro and Diesel Sites*: Average generation from Alaska Energy Statistics, 1960-2013, Alaska Energy Authority, 2013. https://akenergygateway.alaska.edu/

Average oil, gas and hydro electrical generation data augmented via personal communication with AEA staff, operating utilities, Alaska Energy Statistics 1960-2013, preliminary tables.

Pie chart data from: Non Utility Data: U.S. Department of Energy, Energy Information Administration, Form 923 Data File F923 www.eia.gov/electricity/data/eia923/

Existing Utility Hydroelectric sites: Alaska Energy Authority hydroelectric database. Spatial location and attribute data updated by HDR Alaska Inc. in 2006 and AEA in 2018

Wind Sites*: Average wind generation from the Statistical Report of the Power Cost Equalization Program, FY2011 and augmented by AEA. Includes projects currently under commissioning and expected to be in operation by the end of 2012. http://www.akenergyauthority.org/Programs/PCE

Electrical Interties: Interties aggregated from data provided by Alaska Electric Light & Power Company, Alaska Power & Telephone Company, Alaska Village Electric Cooperative, Chugach Electric Association, City of Sitka Electric Department, Copper Valley Electric Association, Four Dam Pool Association, Golden Valley Electric Association, Homer Electric Association, Naknek Electric Association, Nushagak Cooperative and AEA.

Natural Gas Pipelines: ENSTAR Natural Gas Company.

Electric Service Areas: Chugach Electric Association.

Trans-Alaska Pipeline: Alaska Department of Natural Resources. www.asgdc.state.ak.us

Roads: Alaska Department of Natural Resources & Alaska Department of Transportation. www.asgdc.state.ak.us

Energy Efficiency
Data outside of the Railbelt are based on estimates from the Alaska Affordable Energy Model (AAEM); values for the values are extrapolated from the AAEM on a per capita basis. The AAEM is a tool developed by the Alaska Energy Authority and coded by UAF's Geographic Information Network of Alaska (GINA).

Biomass
USDA Forest Service Forest Inventory and Analysis, Remote Sensing Applications Center 2008 based on J.A. Blackard, et.al. Mapping U.S. forest biomass using nationwide forest inventory data and moderate resolution information. Remote Sensing of Environment 112:1658-1677

Shore-based Seafood Processors*: Alaska Department of Fish and Game. 2010 Commercial Operators Annual Report, data compiled by the Alaska Fisheries Information Network (AKFIN).

Class I Landfills*: Alaska Department of Environmental Conservation.

Sawmills*: Alaska Wood Products Manufacturers Directory, September 2004. Juneau Economic Development Council Wood Products Development Service. Dataset augmented via personal communication with Dan Parrent, USFS.

Geothermal
Volcanic Vents, Wells and Springs by Temperature and Potential Geothermal Resources: Geothermal Resources of Alaska, Motyka, R.J., Moorman, M.A. and Liss, S.A., 1983. Geothermal Resources of Alaska: Miscellaneous Publication MP 8, Alaska, Department of Natural Resources, Division of Geological & Geophysical Surveys, Fairbanks, Alaska – USA www.dggs.dnr.state.ak.us/pubs/pubs?reqtype=citation&ID=671

Wells and Springs by Temperature: Kolker, Amanda, Stelling, Pete and Cumming, William. Geothermal Exploration at Akutan, Alaska: Favorable Indications for a High-Enthalpy Hydrothermal Resource near a Remote Market. Geothermal Resources Council (GRC) Annual Meeting, October 14-17, 2018 Reno, NV. https://geothermal.org/home.html

Hydroelectric
Existing and Potential Hydroelectric sites: Alaska Energy Authority hydroelectric database. Spatial location and attributed data updated by HDR Alaska Inc. in 2006 and AEA, 2013.

Ocean & River Hydrokinetic
Tidal Electric Generation Potential: Brian Polagye, 2007. Tidal resource was quantified for 35 transects across tidal channels, perpendicular to the flow. The analysis used NOAA time series of currents and tidal range, as well as bathymetric data. Due to map scale, each study site is depicted as a point location rather than a linear transect https://depts.washington.edu/nnmrec/docs/20090820_GoochS_conf_SiteCharacterization.pdf.

The Wave Energy Resource Assessment Project is a joint venture between NREL, EPRI and Virginia Tech. EPRI is the prime contractor, Virginia Tech is responsible for development of the models and estimating the wave resource and NREL serves as an independent validator and also develops the final GIS-based display of the data. GIS data from National Renewable Energy Laboratory (NREL) 2011 http://en.openei.org/datasets/files/868/pub/wave_power_density.zip

In-Stream Hydrokinetic: Jacobson, Paul T., Ravens, Thomas, Cunningham, Keith. Assessment of U.S. In-Stream Hydrokinetic Energy Resources. Electric Power Research Institute Presentation. February 8, 2011. Power density estimates based on the cross-section average velocity at the open-water average flow rate at the given site. Open-water power density at the fast flowing portions of the river are several times greater than levels reported here https://www.osti.gov/biblio/1092058.

Solar
Solar Insolation: U.S. Department of Energy, National Renewable Energy Laboratory, 1999. Data layer provides annual average daily total solar resource averaged over surface cells of approximately 40 km by 40 km in size. https://rredc.nrel.gov/solar/old_data/nsrdb/

Wind
Wind Power: AWS Truepower, LLC Wind Resource Maps of Alaska using the MesoMap® system and historical weather data prepared for the Alaska Energy Authority, September, 2010. Although it is believed to represent an accurate overall picture of the wind energy resource, estimates at any location should be confirmed by measurement. All datasets were masked to the coastline http://www.akenergyauthority.org/Programs/AEEE/Wind/map

*For data sources with descriptive point locations, the spatial positions were derived by matching the descriptive location to the community location using the U.S. Geological Survey Geographic Names Information System.

For More Information

Alaska
Alaska Energy Authority
www.akenergyauthority.org
Renewable energy resource maps, reports, programs, planning and financing information.

Alaska Energy Efficiency Partnership
www.akenergyefficiency.org
State-run clearinghouse for information on energy efficiency in Alaska.

Alaska Housing Finance Corporation
www.ahfc.state.ak.us
Residential and community building energy efficiency programs, energy resources library, programs and financing information.

Denali Commission
www.denali.gov
Independent federal agency created by Congress to provide basic facilities to remote Alaskan communities.

Renewable Energy Alaska Project
www.realaska.org
A coalition of over 70 utilities, developers, Alaska Native corporations, conservation groups and other NGOs that educate the public and policy makers about renewable energy and energy efficiency.

University of Alaska Center for Energy and Power at the University of Alaska Fairbanks
www.uaf.edu/acep/
Applied energy research focused on lowering energy costs and developing economic opportunities

University of Alaska Fairbanks Cooperative Extension Service
www.uaf.edu/cesces/
Provides housing technology information to Alaskan home owners and builders.

Efficiency
American Council for an Energy Efficient Economy
www.aceee.org
A nonprofit that acts as a catalyst to advance energy efficiency policies, programs, technologies, investments and behaviors through in-depth technical and policy analysis

Clean Energy States Alliance
www.cesa.org
A national, nonprofit coalition of public agencies and organization working together to advance clean energy.

Nationwide and Regional
National Renewable Energy Laboratory
www.nrel.gov
USDOE's premier laboratory for renewable energy research and development.

US Department of Energy
www.energy.gov
USDOE home page provides information on federal programs relating to energy.

Rocky Mountain Institute
www.rmi.org
An independent, non-partisan nonprofit that drives the efficient and restorative use of resources by engaging businesses, communities and institutions to cost-effectively shift to efficiency and renewables.

Policies Supporting: Renewable Energy
Database of State Incentives for Renewables & Efficiency
www.dsireusa.org
Information on tax incentives, rebate programs, portfolio standards, green power programs and other state-level policies.

National Association of State Energy Officials
www.naseo.org
Represents governor-designated officials from each state.

RE100
www.there100.org/
RE100 is a collaborative, global initiative of influential businesses committed to 100percent renewable electricity, working to massively increase corporate demand for renewable energy.

Biomass
National Biodiesel Board
www.biodiesel.org
National trade association representing the biodiesel industry.

Bioenergy Technologies Office
www.energy.gov/eere/bioenergy/bioenergy-technologies-office
USDOE's biomass energy program.

Pacific Regional Biomass Energy Partnership
www.pacificbiomass.org
Promotes bioenergy development in Alaska, Hawaii, Idaho, Montana, Oregon and Washington.

Geothermal
Geothermal Resources Council
www.geothermal.org
International association for geothermal education including industry, researcher, and government.
Geothermal Technologies Program
www.energy.gov/eere/renewables/geothermal
USDOE's geothermal energy program.

Ocean
Electric Power Research Institute: Ocean Energy Program
www.epri.com/oceanenergy/
Tidal and wave energy webpage for independent, nonprofit energy research center.

Solar
Alaska Sun
www.uaf.edu/ces/energy/alaskasun
Alaskans supporting solar energy with link to Solar Design Manual for Alaska.

American Solar Energy Society
www.ases.org
A national association dedicated to advancing the use of solar energy.

Solar Energy Technologies Program
www1.eere.energy.gov/solar
USDOE's solar energy technology website.

Wind
Wind Exchange
www.energy.gov/eere/wind/windexchange
Leads the U.S. DOE's efforts to accelerate the deployment of wind power technologies through improved performance, lower costs and reduced market barriers by working with national laboratories, industry, universities, and other federal agencies to conduct research and development activities.

National Wind Technology Center
www.nrel.gov/wind
USDOE's wind energy research and development facility.

American Wind Energy Association
www.awea.org
National trade association representing wind developers, manufactures, utilities, and others involved in the wind industry.

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