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Resilient Homes

Alaskans Building for Climate Change

PREPARED FOR

The Nature Conservancy

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Executive Summary

Transitioning all forms of infrastructure, including energy production, transportation, housing, and community facilities, and increasing energy efficiency will be necessary to address the impacts of climate change. This briefing paper describes the critical nexus in Alaska between housing, energy efficiency, and climate change. Investment in quality, energy efficient housing is timely and especially important for Alaska for several compelling reasons:

- Rural Alaska communities are on the front lines of climate change. Coastal erosion, flooding, and permafrost degradation are already forcing community relocation. The cost of developing energy efficient, culturally appropriate, and healthy housing in relocated communities is expected to total hundreds of millions of dollars.
- Housing in Alaska is energy intensive. Harsh climates and poor-quality housing contribute to statewide residential energy use that is 2.5 times the average consumption of similarly cold climates in the United States.
- Rural Alaska families face disproportionately high home energy costs, paying nearly twice what other households across the U.S. pay to heat and power their homes due to reliance on high-cost fossil fuel.
- State of Alaska spending deficits mean that funding for energy efficiency programs is likely to be unavailable. Program support will be required from other sources.

Energy Efficiency and Conversion

Investment in Alaska Residential Energy Projects, 2010-2020

$750 million Invested

25% of Homes Participating in Energy Audit or Retrofit

Over $444 million in Cost Savings to Households

Over 460 million Pounds of CO2 Offset Annually

7-15 Jobs per million Invested

Over the past decade, state and federal grants have provided energy efficiency upgrades or audits to 25% of Alaska's homes. At the same time, advances and in some cases lower costs, in residential-scale renewable technology have increased home energy conversions around the state.

More than $750 million in public, private, and household investments were made in the last decade across Alaska to increase residential energy efficiency and integrate renewable technology. Overall investment in energy efficiency has declined in recent years against a backdrop of state fiscal constraints, while the trajectory of spending on renewable energy integration is solidly upwards.

Opportunities

Investment in improving the energy efficiency of Alaska housing is one tool for reducing the state's carbon footprint. An estimated 41,000 homes in rural Alaska alone have yet to receive energy efficiency services, and an estimated $36 million annually over the next decade will be required to serve those homes. Efforts to further fund this work should consider the following:

- Regional Housing Authorities (RHAs) and other mission-specific organizations are best positioned to deploy funding in an environment where **energy raters and contractors** are in short supply.
- **Cost-sharing measures** can be important to achieve buy-in but leave many families who cannot cover all costs up-front with no functional program access.
- **High construction costs** pose a real challenge to RHAs, other organizations offering upgrades, and households. The cost to perform comprehensive home weatherization in rural Alaska can easily exceed state spending limits.

The tools for home energy conversion to renewable technology are available but the transition is in its infancy. Additional public investment will stem the intense use of fossil fuels which contribute to climate change:

- Advances in technology have made heat pumps viable in Alaska. However, in regions with high electricity costs, the risk of exceeding monthly **PCE limits** slows adoption of this technology. Reexamining residential PCE kWh limits may increase heat pump use in rural Alaska.
- **Net metering** provides a strong incentive for households to add solar panels. Greater opportunity for net metering would go far in incentivizing solar installations, but impacts to small, rural utilities and their ratepayers must be carefully considered.
- **Financing mechanisms** like the creation of a "Green Bank", on-bill financing, or Property Assessed Clean Energy programs may be promising mechanisms to help households overcome high upfront energy conversion costs, especially in urban Alaska. These forms of financing may require enabling legislation and/or capitalization.

Several additional factors will be important to increase the energy efficiency of Alaska's housing:

- Continued support of **applied research and development** efforts to identify new, lower cost building materials and test emerging technology will be important to bring down the building costs that constrain investment.
- **Comprehensive policy** and funding to address relocation of communities already impacted by climate change will be necessary to construct energy-efficient, quality, and culturally appropriate housing in new communities.
- Federal residential **energy tax credits** provide additional incentive for household investment and should be preserved to induce further energy efficiency and conversion efforts.

Introduction

Alaska's communities are on the front lines of climate change. Melting permafrost, coastal erosion, and flooding have already impacted community infrastructure, especially in the state's most rural, remote villages. The state's already poor housing infrastructure is facing further impacts from these results of the warming climate.

In addition, Alaska's residential energy needs are intensive. The state's varied climates include some of the harshest arctic, sub-arctic, and maritime conditions in the world. Home heating needs are great and with much of Alaska's housing stock of low quality and unsuited to these challenging climates, energy needs are compounded. Residential energy use in Alaska is still highly reliant on expensive and carbon-intensive petroleum products, particularly in islanded communities where high transportation costs and access barriers drive up energy costs.

State and federal programs to weatherize and rehabilitate homes for greater energy efficiency have been widely used across Alaska. These efforts are increasingly integrating renewable energy technology. However, the primary drivers of these efforts – high energy costs – remain a burden on families. The need for further investment to create quality, energy efficient and culturally appropriate housing while addressing the impacts and causes of climate change in Alaska remains great.

This paper describes the investments made in home energy efficiency and renewable resource integration across Alaska over the past decade and presents opportunities for further investment. The following data sources and reports were especially important to this research:

- *2018 Alaska Housing Assessment* (Alaska Housing Finance Corporation)
- *Energy Efficiency Program Evaluation and Financing Needs Assessment* (Alaska Energy Authority)
- *Home Energy Rebate Program Impacts Report* (Cold Climate Housing Research Center)
- *Weatherization Program Impacts Report* (Cold Climate Housing Research Center)

Special thanks to the following organizations, which provided information for this research:

- Alaska Heat Smart
- Alaska Housing Finance Corporation
- Cold Climate Housing Research Center
- NANA Regional Inc.
- Northwest Inupiat Housing Authority
- Northwest Arctic Borough

Front cover photo courtesy of Cold Climate Housing Research Center.

Alaska's Housing Landscape

From harsh arctic winters to coastal climates with significant precipitation, Alaska encompasses a wide array of climates which all pose different challenges for developing and maintaining the state's housing infrastructure. Across these varied climates, Alaska's housing stock is aging, and the pace of new construction has slowed in many areas. Half of the state's housing stock was constructed during Alaska's oil boom days in the 1970s and 1980s, with one-third before 1980.[1] Harsh climates can quickly degrade housing, exacerbating the challenges associated with already inefficient homes.[2] Housing quality can be especially poor in Alaska's most rural, remote communities.

Against this backdrop, investments to mitigate the impacts of climate change on Alaska's housing stock and increase residential energy efficiency must be made to bring equitable housing to families and reduce disproportionately high cost burdens.

Climate Change Impacts

Effects of climate change, including erosion, flooding, and permafrost degradation, are already impacting community and housing infrastructure across Alaska. These effects impact the structural integrity of soil, undermine building foundations, and threaten access to homes and other community facilities.

A 2019 U.S. Army Corps of Engineers report evaluated the severity of climate change impacts to rural Alaska communities. The report identified 29 communities with imminent threats from erosion, 38 with imminent threads from flooding, and 35 with high risk of damage due to thawing permafrost.[3] Communities facing these high, immediate threats are generally remote, and many have predominantly Alaska Native populations.

Village Relocation

As of 2019, at least 12 communities facing imminent threats from climate change were exploring relocation. The Denali Commission is designated as the lead coordinating agency for federal, state, and Tribal resources to address the impacts of climate change. The Commission operates

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[1] U.S. Census Bureau, American Community Survey
[2] Alaska Housing Finance Corporation. *Alaska Housing Assessment*. 2018.
[3] U.S. Army Corps of Engineers Cold Regions Research and Engineering Laboratory. *Statewide Threat Assessment: Identification of Threats from Erosion, Flooding, and Thawing Permafrost in Remote Alaska Communities*. November 2019.

the Village Infrastructure Protection (VIP) program to assist rural Alaska communities threatened by erosion, flooding, and permafrost degradation. The Commission has deployed nearly $100 million in funding through the VIP program, yet hundreds of millions more will be required to address community relocation needs. As of 2017, the U.S. Department of the Interior was coordinating an effort to develop an Adaptive Village Relocation Framework for Alaska to define a relocation process more clearly; to date, no Framework has been published.

Development of quality, energy-efficient, and culturally appropriate housing will play an important role in village relocation efforts. In 2016, the Cold Climate Housing Research Center (CCHRC) constructed an energy-efficient, moveable prototype home in Mertarvik, including a small water treatment plant and generator for use in advance of development of public utilities. While an additional $15 million in federal funding was allocated to the Denali Commission in 2018 to assist villages harmed by climate change, this sum stands in contrast to the estimated $100 to $120 million in funding required for the Newtok to Mertarvik relocation alone.[4]

Poor Quality Housing

While Alaska has no statewide mandatory building energy codes, the Alaska Housing Finance Corporation (AHFC) maintains the Building Energy Efficiency Standards (BEES), ranking homes from 1-star (very inefficient) to 6 stars. On average, a home with a 1.5-star rating uses four times as much energy as a 5-star home, the minimum BEES standard for new construction. An estimated 14,600 housing units in Alaska are considered very inefficient, and inefficiency is most pronounced in the state's rural communities.[5]

A high percentage of homes in the state are considered drafty or very draft (about one-third), a condition which increases energy intensity. Statewide, an estimated 12,635 homes lack complete kitchen and/or plumbing facilities. Due to lack of appropriate ventilation, about 26% of Alaska's housing stock are at high risk of indoor air quality issues.

Limited Access to Capital and High Building Costs

Logistics, costs, and financing related to housing construction, renovation or replacement are starkly different between Alaska's urban communities and those that are rural, remote, and oftentimes very small. This includes more than 200 communities that are not connected to a road system and are distant from a regional hub. These communities face multifaceted challenges such as very expensive materials and construction costs, an absence of local financial

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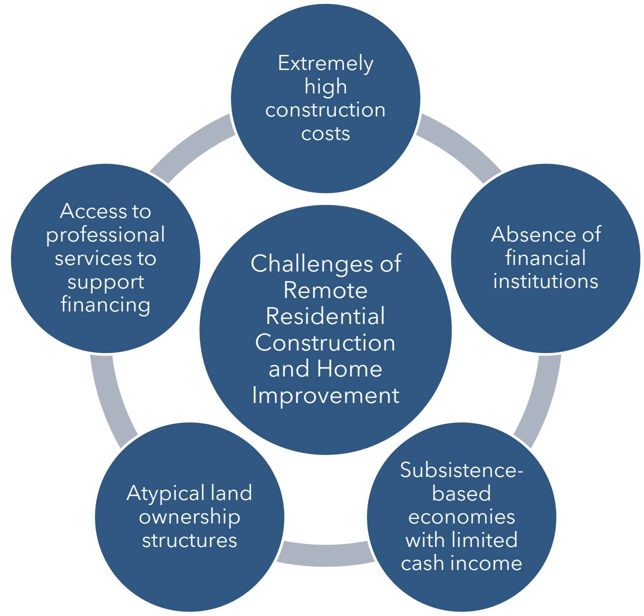
[4] Naomi Klouda, Alaska Journal of Commerce. *Federal fund injection boosts effort to relocate Newtok*. May 23, 2018.
[5] Alaska Housing Finance Corporation. *Alaska Housing Assessment*. 2018.

services firms, limited access to building and construction professionals such as assessors who are critical inputs to traditional financing and, in some cases, atypical land ownership structures. High costs relative to market value, and lack of income opportunities, leave rural Alaska with limited access to traditional financing which might otherwise be used to improve housing. In addition, many of Alaska's rural and remote communities have limited cash economies, relying instead on subsistence harvests of food and related trade and barter. These factors mean that privately financed home construction is often not financially feasible in rural communities across Alaska. As a result, much of rural Alaska's new housing is constructed by the state's Regional Housing Authorities (RHAs) or other organizations deploying public funding.

Figure 1. Barriers to Residential Improvements in Rural Alaska



Regional Housing Authorities

Alaska has a network of 14 regional housing authorities (RHA) which play a vital role in housing construction, weatherization, and rehabilitation across the state. These organizations act as Tribally Designated Housing Entities (TDHE), administering housing programs on behalf of Alaska Native tribes which receive federal funding under the Native American Housing Assistance and Self Determination Act (NAHASDA). Through this funding, RHAs provide housing services to low-income families; develop, update, and maintain housing stock across rural Alaska; and offer additional services like crime prevention and safety. Providing quality housing is a primary goal, and 100% of new housing built by the RHAs complies with Alaska Building Energy Efficiency Standards (BEES). As subgrantees to AHFC, the RHAs play an important role in deploying State weatherization funding. In 2019, the RHAs built, improved, or managed about 4,800 housing units across Alaska, impacting around 11,600 residents.

Residential Energy in Alaska

Home heating and electricity use play a significant role in statewide energy consumption, accounting for 18% of Alaska's non-industrial energy use.[6] The state's harsh climate and poor housing infrastructure drive residential energy intensity; Alaska home energy use is more than double the national average for states with comparable climates.[7] In some regions with particularly cold conditions, like Alaska's North Slope, energy intensity is more than 3.5 times the comparable national average.

On average, households spend $4,186 annually on energy use, over 1.8 times the national average.[8] Electricity rates too are nearly double the U.S. average at 20.22 cents per kilowatt hour (kWh), the second highest in the nation.[9] Rural Alaska's reliance on petroleum-based fuel for home heating and electricity is the principal contributor to overall very high cost of living.

Residential Energy Sources

Natural gas accounts for the largest share of residential energy consumption in Alaska, followed by oil products. Over the past decade, renewable energy's share of residential consumption has grown. Solar consumption increased eight-fold. Despite this progress, residential energy in the state is largely derived from non-renewable resources.

Table 1. Residential Energy Consumption in Alaska by Fuel, 2010 and 2019

	2010		2019		% Change
	Billion BTUs	% of Total	Billion BTUs	% of Total	2010 – 2019
Natural Gas	18,806	49%	17,698	47%	-6%
Petroleum	9,359	24%	6,971	19%	-26%
Electricity	7,142	19%	6,579	18%	-8%
Wood	2,302	6%	5,536	15%	140%
Propane	589	2%	398	1%	-32%
Geothermal	79	<1%	101	<1%	28%
Solar	3	<1%	28	<1%	833%
Total	**38,280**	**100%**	**37,311**	**100%**	**-3%**

Source: U.S. Energy Information Administration, Alaska SEDS All Consumption Estimates 1960-2019

[6] U.S. Energy Information Administration. *State Energy Data Systems: 1960-2019*. 2020.
[7] Alaska Housing Finance Corporation. *Alaska Housing Assessment*. 2018
[8] Ibid
[9] U.S. Energy Information Administration. *State Electricity Profiles*. 2019.

RESIDENTIAL HEATING

Residential heating in Alaska is subject to regional variation, with major differences driven primarily by access to natural gas or lack thereof. The price differentials between heat produced from natural gas and diesel are significant. The result is that rural communities and those outside the state's urban core experience higher costs that further reinforce financial disparities between urban and rural communities.

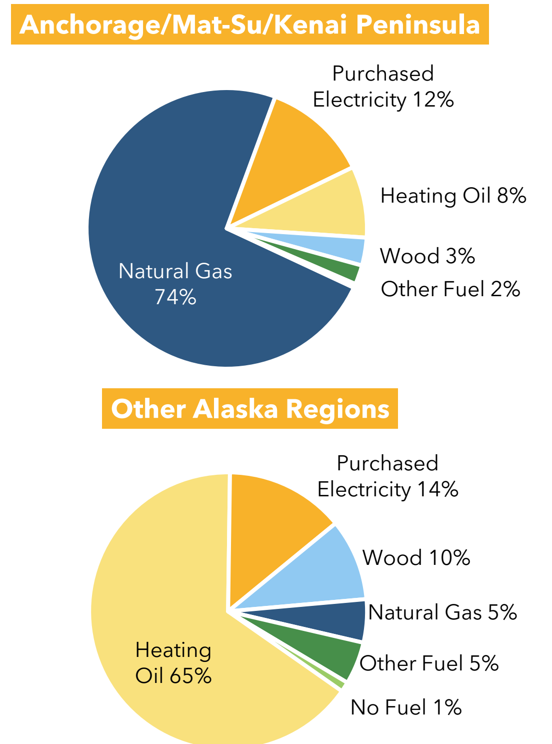
Natural gas is the primary source of home heat in Southcentral Alaska. Gas from the Cook Inlet basin is transported via pipeline for distribution in Anchorage, the Matanuska-Susitna Valley, and on the Kenai Peninsula. Outside of Southcentral, heating oil is a primary source of home heat. Across the state, high transportation costs drive up the cost of this heating source. Wood is used to heat 5% of homes statewide but remains an important heating source in parts of Alaska.

Heating Intensity

The state's cold climate drives high household energy needs. Heating degree day data provide a measure of days per year home heating is generally required. In Alaska, average heating degree days per year range from 7,000 in Southeast Alaska to 20,000 on the North Slope, compared to the national average of 9,000 to 12,600 for all very cold climates across the country.[10]

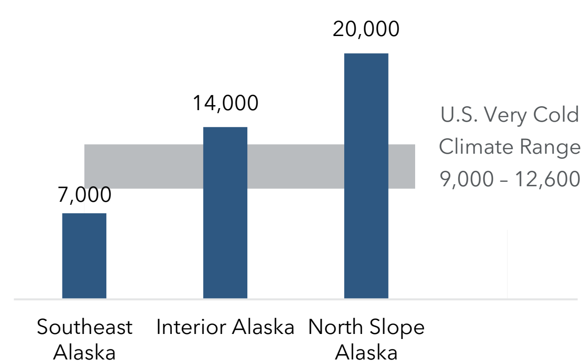
The home heating index (HHI) is a measure of energy used for space heating, controlling for home size and climate. The index serves as a proxy for comparing energy efficiency of homes across different regions. Lower HHI scores are preferable. For reference, a HHI score of 10 or greater has

Figure 2. Primary Home Heating Source, Alaska, 2019



Source: U.S. Census Bureau, American Community Survey

Figure 3. Heating Degree Days



Source: Alaska Housing Finance Corporation

[10] Alaska Housing Finance Corporation. *Alaska Housing Assessment*. 2018.

energy efficiency equivalent to a home built in the 1970s. Statewide the average HHI is 8.8 for single-family units and 8.3 for multifamily units. The Sealaska (Southeast) region has the highest average HHI score of 10.6 while the Arctic Slope region has the lowest average at 6.5.

RESIDENTIAL ELECTRICITY

Electricity generation in Alaska is characterized by one major transmission system and more than 150 standalone grids. Along the Railbelt, running from Fairbanks in the north through Anchorage and to the Kenai Peninsula, 73% of electricity is generated using natural gas. Hydroelectric resources are also an important source of electricity. Outside of the Railbelt, rural standalone grids often rely on diesel fuel for electricity generation.

Net Metering

In 2010, the Regulatory Commission of Alaska (RCA) adopted net metering regulations under which grid-tied customers of participating utilities could sell back to the grid excess electricity generation from installations like solar panels. Customers receive a credit on their energy bill for sales back to the utility beyond their own demand, priced at the "avoided power cost", the utilities' avoided cost of burning natural gas or diesel fuel. Other utility expenses like infrastructure, maintenance, and administrative costs are not included in the avoided power cost. Per the RCA regulation, utilities can cap net metering on their system when overall capacity reaches 1.5% of the utility's average demand. As of 2021, Golden Valley Electric Association and Homer Electric Association had both filed petitions with the RCA to increase their net metering cap, to 3% and 7%, respectively.[11]

Residential Energy Costs

Petroleum-based fuels like diesel and heating oil figure prominently in Alaska's residential energy use and leave households and communities vulnerable to spiking worldwide petroleum prices. The high cost of transporting these fuels to remote communities contributes significantly to the overall high cost of living for many rural residents.

Across Alaska, household spending on energy varies based on climate, access to lower cost energy sources like natural gas and hydroelectric energy, among other factors. Yet, the average household in a single-family home pay $4,186 in annual energy costs, nearly twice the national average of $2,307.[12] Costs are highest in the Northwest Arctic Borough and Nome Census Area, both in northwestern Alaska, where the annual single-family energy costs of $6,223 and $6,420 are about 2.75 times the national average.

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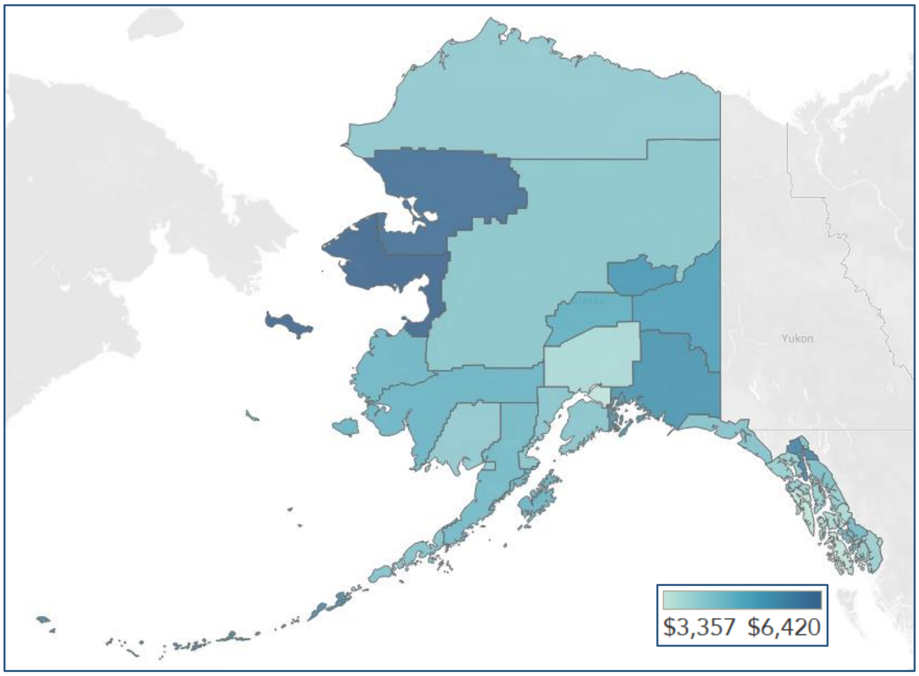
[11] Alaska Center for Energy and Power, University of Alaska Fairbanks. *2021 Alaska Railbelt Net Metering Update*. 2021.
[12] Ibid.

Energy costs represent a higher share of median household income in Alaska (6%) compared to the national average (4%). Yet statewide average is significantly skewed by costs in the state's urban centers. In many rural Alaskan regions like Haines Borough or the Yukon-Koyukuk Census Area energy costs represent one-tenth of median family income.

Figure 4. Average Annual Single-Family Home Energy Cost, 2018



Source: Alaska Housing Finance Corporation

HOME HEATING COSTS

In rural Alaska, transportation costs drive up heating oil prices, particularly in communities which lack road access and rely on water or air transportation of fuel. These additional costs are reflected in Alaska's average heating oil cost of $4.52 per gallon as of March 2020. The U.S. average is $2.82 per gallon.[13] Costs vary widely across regions and communities in Alaska. In 2020, North Slopes prices were lowest, averaging $1.83 per gallon after subsidies by the North Slope Borough. Among unsubsidized regions, costs are generally lowest along Alaska's Railbelt in communities like Nenana ($2.58/gallon) and highest in the Yukon-Koyukuk region where prices in Arctic Village are $12.00/gallon.

[13] Alaska Division of Community and Regional Affairs. *Fuel Price Report*. 2021. U.S. Energy Information Administration. *No. 2 Heating Oil Residential Price*.

HOME ELECTRICITY COSTS

Just as transportation costs drive up home heating expenses, these logistics challenges contribute to high electricity costs in Alaska, especially for communities not connected to Alaska's road system. On average, retail electricity consumers in Alaska, 20.22 cents per kilowatt hour (kWh), nearly double the U.S. average and second highest in the nation after Hawaii.[14]

Energy Subsidies

Given the high energy costs borne by residents, programs subsidizing costs are vital to Alaska households. These programs are particularly important to the state's most rural, remote communities, many of which are also traditional Alaska Native villages and bear the highest cost burdens.

POWER COST EQUALIZATION

The State of Alaska's Power Cost Equalization (PCE) program was established in 1985 to equalize rural electricity rates with those of more urban areas that benefit from infrastructure such as the State-funded Alaska Intertie. Under this program, residential ratepayers in eligible communities receive a per kWh subsidy on electricity consumption up to 500 kWh per month.

In state fiscal year (SFY) 2020, more than 30,000 ratepayers, representing nearly 82,000 Alaskans, received PCE credits on their electricity bills. Over the past decade, cumulative PCE disbursements totaled nearly $360 million, including $29 million disbursed in SFY2020.[15]

Over the program's history, the residential PCE-eligible limit has dropped several times; between FY1985 and FY1992, the monthly limit was 750 kWh. The limit dropped to 700 kWh in FY1993, and again to 500 kWh in FY2000. While average electricity consumption in rural Alaska generally falls within the 500-kWh limit, rural residential consumption in some regions does exceed this limit particularly in winter months when demand is highest.[16] Even at the statewide monthly average electricity consumption of 555 kWh, the PCE limit presents a challenge to converting to heat pumps, which rely on electricity.[17]

HEATING FUEL SUBSIDIES

There is no ongoing, statewide heating fuel or heating energy cost subsidy program akin to PCE. Funded by federal Low Income Home Energy Assistance Program grants, the State's Heating Assistance Program (HAP) offers energy cost assistance through one-time utility payments made on behalf of low-income families, the elderly, and individuals with disabilities. In SFY2020, $9.3

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[14] U.S. Energy Information Administration. *State Electricity Profiles*. 2019.
[15] Alaska Energy Authority. Power Cost Equalization Program Statistical Report FY2020. March 2021.
[16] Alaska Housing Finance Corporation. *2018 Housing Assessment: Census Area Energy Characteristics*. 2018.
[17] U.S. Energy Information Administration. *Average Monthly Bill – Residential*. 2019.

million was granted to offer heating assistance to 5,870 households through the State program.[18]

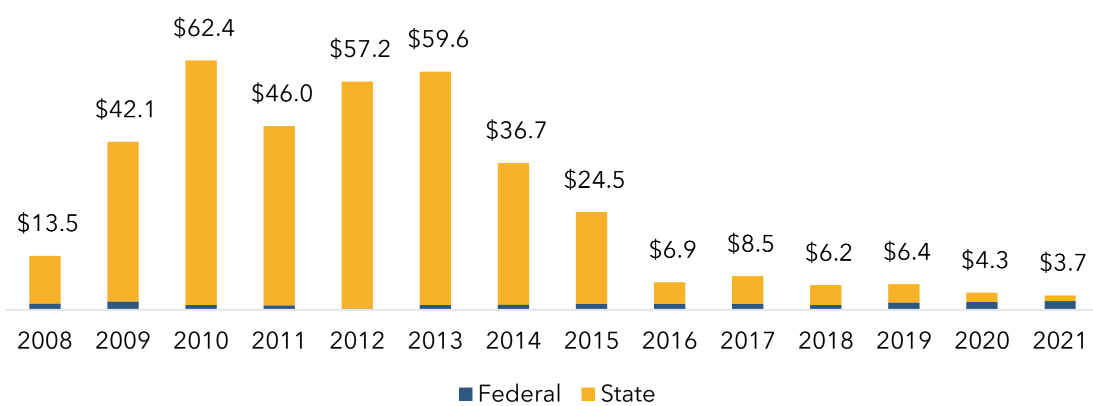
Other regions and organizations offer limited home energy assistance programs, and many are offered on an emergency basis. The North Slope Borough is an exception; the Borough offers both electricity and heating fuel subsidies to residents.

Residential Energy-Efficiency and Conversion Spending

Over the last decade, more than $750 million in public and private investment was made to increase residential energy efficiency and integrate renewable energy technology into homes across Alaska. Most of this spending was on home weatherization, rehabilitation, and other energy efficiency measures. Significant investments made by the State of Alaska through the Alaska Housing Finance Corporation (AHFC) were the biggest catalyst of these efforts: AHFC's Home Energy Rebate Program (HERP) stimulated household spending on energy efficiency. Further, weatherization funding deployed through subgrantees brought needed additional investment to rural Alaska.

With these programs playing an outsized role, total spending varied year-to-year between 2010 and 2020 and was highly dependent on the State's financial position. Following sharp oil price declines in 2015, the state's available budget for capital improvements and programs decreased significantly. Weatherization program funding clearly demonstrates this relationship: in 2010 state and federal weatherization funding in Alaska totaled over $62 million but had dropped to $4 million by 2020.[19]

Figure 5. State and Federal Weatherization Program Funding, Alaska, FY2008-FY2021



Source: Alaska Housing Finance Corporation

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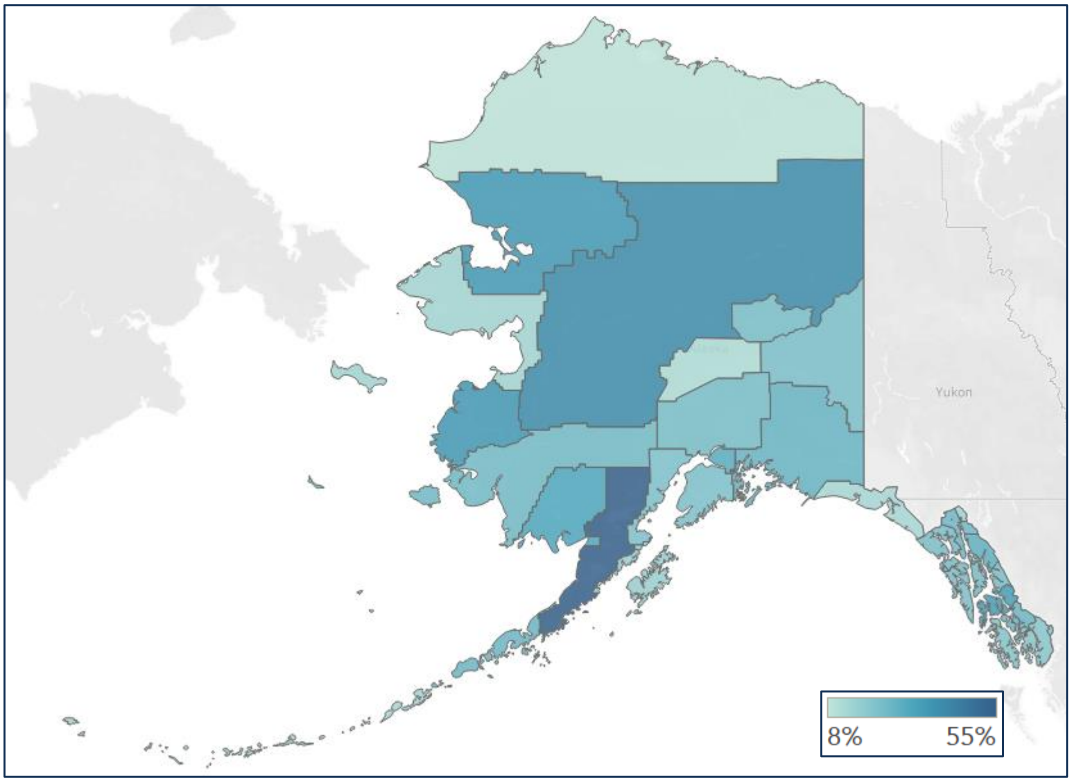
[18] Alaska Office of Management and Budget/Department of Health and Social Services. *FY2022 Governor's Operating Budget*.
[19] Alaska Housing Finance Corporation

Regional Efficiency Participation

As of 2018, an estimated one-quarter of homes in Alaska had undergone an energy audit or received retrofits through HERP or the weatherization program.[20] Energy retrofit spending has been deployed in the state's urban centers and in rural Alaska. However, participation has varied across boroughs, from a high of 55% participation in the Lake and Peninsula Borough, a region in Southwest Alaska with about 500 housing units, to a low of 8% in the North Slope Borough.

Figure 6. Percentage of Residential Units Participating in Energy Audit or Retrofit



Source: Alaska Housing Finance Corporation

Residential Renewable Energy

While no comprehensive accounting of spending to integrate renewable energy technology at the residential level exists, available data and spending estimates show the trajectory is strongly positive. Along the Railbelt alone, installed net metered capacity, which measures the generation capacity of residential and commercial customers whose generation may be sold back onto the grid, increased about eight-fold between 2010 and 2020.[21] Nearly all net metering

[20] Alaska Housing Finance Corporation. *2018 Alaska Housing Assessment*. Excludes housing units certified under Alaska Housing Finance Corporation's Building Energy Efficiency Standard

[21] Alaska Center for Energy and Power, University of Alaska Fairbanks. *2021 Alaska Railbelt Net Metering Update*. 2021.

customers along the Railbelt use solar photovoltaic systems. Significant reductions in solar panel costs over the last decade have aided this adoption, and programs like The Alaska Center's Solarize Anchorage and Solarize Fairbanks Campaigns, which work to coordinate group solar panel purchases, have brought household costs down even further.

Technology to reduce heating costs and fuel consumption are also being adopted in parts of Alaska. Examples of residential heat pump integration include several projects in Southeast Alaska where many residents have access to relatively affordable hydroelectric-generated electricity used to operate the pumps. Heat pump projects by Baranof Island Housing Authority in Sitka and by Tlingit-Haida Regional Housing Authority in Petersburg are two such examples. Heat pumps are also being integrated in other regions of Alaska. Installation of combination heat pump and solar array systems in Ambler (in northwest Alaska) are an example of this integration in response to high energy costs.

Economic Impacts

Reducing cost burdens on households is a primary goal of energy retrofit projects. These and other economic impacts of energy retrofit work in Alaska are described below.

Energy Cost Savings and Community Sustainability

Increasing the energy-efficiency of housing reduces the amount of expensive heating fuel necessary to heat homes in rural Alaska, decreasing households' monthly expenses. Installing new technology like heat pumps or solar panels too can positively impact household budgets. Both measures pave the way towards enhanced community and financial sustainability in the face of state budget impacts to vital subsidies like the PCE program.

Based on Alaska's weatherization and HERP program work between 2008 and 2018, energy efficiency programs translated into a combined $444 million in residential energy savings over the decade.[22] Participants of the HERP program saw a $1,389 reduction in their annual energy costs, while the comparable cost savings for weatherization participants was $1,267.[23] Under both programs, participants in the Bering Straits region in northwest Alaska saw the highest annual average savings at $2,889 and $2,441 saved each year from retrofits under the HERP and weatherization programs, respectively.

Beyond the household cost savings garnered from reducing the energy intensity of homes in Alaska, installation of technologies like residential solar panels and heat pumps can further

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[22] Cold Climate Housing Research Center. *Weatherization Program Impacts Report*. *Home Energy Rebate Program Impacts Report*. 2018.
[23] Ibid.

reduce energy costs by substituting for expensive heating oil and diesel-generated energy, especially in rural communities reliant on water or air transportation. In the Northwest Arctic where work is underway on a residential heat pump and solar panel installation project, residents expect to realize an average of $2,000-$3,000 in annual energy cost savings.

Employment Impacts

Home weatherization, energy efficiency system upgrades, and energy conversions all support short-term employment in Alaska. Workers directly employed through this funding include energy auditors, residential contractors (installing new windows, adding insulation, and making other efficiency upgrades), and others employed in energy conversions like electricians.

While it is beyond the scope of this paper to measure the direct employment effects of spending in Alaska on energy efficiency enhancements, previous research suggests about five to ten direct jobs are supported per million dollars invested in these efforts.[24] Based on average annual spending between 2010 and 2020, investments in residential energy efficiency and conversion directly supported about 500 jobs in Alaska each year, resulting in an estimated $38 million in annual labor income (wages, salaries, and employer-paid benefits).[25]

Residential energy efficiency and system conversions support jobs at a rate of 7 to 15 jobs per million dollars invested. Additional spending by contractors, housing authorities, and others to purchase materials and services in Alaska and employees spending their wages locally supported an additional 360 jobs annually and $22 million in labor income.

Employment impacts have trended down over the last decade due to steep reductions in weatherization spending and the conclusion of HERP in 2018. Consistent, sustained funding is important in creating a skilled Alaskan workforce to implement and maintain energy efficiency upgrades.

Social Cost of Carbon

The "social cost of carbon" is a measure expressing in dollar terms the value of reduced carbon dioxide (CO_2) emissions. This cost is designed to account for the long-term, worldwide damage from CO_2 emissions on agricultural productivity, human health, property damages from increased flood risk and changes in energy system costs, and other factors.[26]

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[24] Cold Climate Housing Research Center. *Weatherization Program and Home Energy Rebate Program Impacts Report*. 2018

[25] Labor income estimates are based on average wage rates for select Alaska industries directly supported by this investment using the Department of Labor and Workforce Development's Quarterly Census of Employment and Wages.

[26] Interagency Working Group on Social Cost of Greenhouse Gases, United States Government. Technical Support Document: Social Cost of Carbon, Methane, and Nitrous Oxide Interim Estimates under Executive Order 13990. February 2021.

Residential energy-related retrofits reduced the state's average CO_2 emissions by more than 460 million pounds each year over the 2008 to 2018 period.[27] Using a standard U.S. federal government social cost of carbon estimate of $51 per metric ton of CO_2 emissions, the long-term value of the offset emissions from the additional renewable energy generation in Alaska is $10.6 million.[28]

Health Benefits

Home weatherization and rehabilitation efforts can have significant health benefits. Air sealing, mechanical ventilation, and reduced usage of woodstoves and portable heaters improve indoor air quality and occupant health by reducing the risk of carbon monoxide leaks, asthma symptoms, and adverse health effects from mold or mildew.[29] AHFC's weatherization program alone resulted in an estimated $320 million in health and safety benefits to residents between 2008 and 2018.[30]

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[27] Cold Climate Housing Research Center. *Weatherization Program Impacts Report*. *Home Energy Rebate Program Impacts Report*. 2018.

[28] The $51 social cost of carbon estimate is based on an emissions year of 2020 and the average 3% discount rate.

[29] Oak Ridge National Laboratory. *Weatherization Works – Summary of Findings from the Retrospective Evaluation of the U.S. Department of Energy's Weatherization Assistance Program.* 2014.

[30] Alaska Housing Finance Corporation. *Weatherization Assistance Program Impacts Report.* 2018.

Case Studies

The following are case studies illustrating past and ongoing efforts to increase energy efficiency and convert home energy systems in Alaska.

Ambler Heat Pump Integration

Residents of the NWAB have long faced some of the state's highest energy costs. Against the backdrop of spiking oil prices in 2007 and 2008, NANA Regional Corporation (NANA), the Northwest Arctic Borough (NWAB), and other organizations came together to chart a course toward a lower cost of living by addressing local energy consumption and production.

An important part of these regional efforts has been initiatives to reduce residential energy prices. Annual home energy costs reached $6,223 in the Northwest Arctic in 2018 compared to $4,186 statewide, the second highest in the state.[1] Over the last four years, the Borough has operated a pilot program testing residential heat pumps in all eleven communities in the region.

The success of this pilot project will soon reverberate through Ambler, a community of 255 located along the Kobuk River, where the Borough is finalizing a village-wide home energy retrofit including installation of integrated air source heat pump/solar photovoltaic (PV) systems and LED lighting upgrades. Installed at 65 homes, the heat pump systems will reduce heating oil consumption in a community reliant on a mix of heating oil and wood for home heating. In this upper-river community, the heat pumps too can be used to cool homes, a function that may become increasingly important as the impact of climate change on temperatures continue. The 1 kW solar arrays installed at each home are connected directly to heat pump units and will help households offset electricity costs associated with running the pumps, especially in summer months.

With a cost of $8,300 per household and an estimated fuel cost savings of $2,000-$3,000 annually, benefits to residents are expected to outweigh costs in about three years. The entire $500,000 project was funded through the Borough's Village Infrastructure Fund (VIF), a funding mechanism created in 2017 to provide for critical infrastructure programs in all communities of the NWAB. Annual contributions to this program come from Teck Alaska Incorporated, operator of the Red Dog mine.

Local electricity prices are a key consideration in implementing heat pump technology. With continued high electricity prices in the region, the risk of the heat pumps pushing households above the 500 kWh per month PCE subsidy limit is real for residents, and the integration of solar generation is key to reducing this risk seasonally.

Home Energy Rebate Program

Oil price spikes in 2007 and 2008 increased the already-high energy cost burden on Alaska households, especially in rural communities. In response, the Alaska State Legislature appropriated additional funding to the Alaska Housing Finance Corporation to increase weatherization assistance funding and establish the new Home Energy Rebate Program (HERP). The main goal of HERP was to incentivize home energy retrofits. Key objectives included reduction of residential energy use and costs, construction industry support, and stimulating private investment in energy retrofits, among others.

Through the program, homes received standardized energy audits by AHFC-certified energy raters. Households then coordinated energy retrofit projects based on audit results, paying all upfront costs for projects they chose to pursue. Once completed, homeowners submitted receipts to AHFC to receive rebates up to $10,000 on work performed.

The program proved successful, with nearly 46,000 audits completed representing 16% of Alaska's occupied housing units. Based on these audits, over 26,000 units were retrofitted between 2008 and 2018, when the program ended. Beyond high penetration, the program was successful in reducing energy consumption and costs; the average participant saw a 34% reduction in energy use and an annual cost savings of $1,389.

Over the decade, State rebates totaled $205.6 million and spurred an additional $142.2 million in homeowner spending beyond the rebate amount. This level of investment directly supported 3,235 jobs annually for energy raters, construction workers, and others. Including multiplier effects, the program supported 6,789 jobs each year.

Including HERP and homeowner spending, retrofit projects had an average payback period of nine years; the program showed a net positive return on investment of 11%. Rebates were therefore effective in overcoming a key hurdle for energy retrofit initiatives, namely that homeowners have lower incentive to complete projects when they must wait longer to see a return.

While considered very successful, the program had low penetration in rural Alaska, where a lack of energy raters and increased inability of homeowners to pay upfront costs proved challenging. Against a backdrop of the State's difficult fiscal position, HERP stopped accepting program applications in 2016. Yet the program's successes offer a model for further investment and show the significant economic impacts that can accrue in Alaska from energy efficiency spending.

Cold Climate Housing Research Center

Alaska's harsh, varied climates call for innovation in building design and use of materials suited to the arctic and subarctic. Yet much of Alaska's housing stock is not suited for this environment. Located in Fairbanks, the Cold Climate Housing Research Center (CCHRC) is dedicated to innovation in building design to improve the quality, energy-efficiency, and cost of building in Alaska and across the world's circumpolar regions.

To fulfill this mission, CCHRC operates the Building Science Research Program (BSRP), testing building components including envelopes, foundations, and heating and mechanical systems for temperature, space and water heating, ventilation, moisture control, and indoor air quality performance. A small sample of the BSRP's work includes:

- Developing guidance on optimal foundation designs for use on permafrost and Structural Insulated Panels, among others;
- Developing and testing new wall systems for use in affordable retrofits and building envelope designs to withstand cold climates; and
- Assessing the feasibility of renewable energy technologies including air source and ground source heat pumps, thermal storage, and biomass heating.

The Center's Sustainable Northern Communities (SNC) program applies CCHRC's research findings to construct demonstration buildings across Alaska, focusing on home energy efficiency, local resource availability, workforce development, and culturally appropriate design. Both building cost reductions and energy efficiency are goals of this work; on average, demonstration buildings have reduced energy use by 80%. Through collaboration with communities, regional organizations, and appropriate government agencies the center has constructed prototype homes in more than a dozen Alaska villages including Anaktuvuk Pass on the North Slope, and engaged in disaster relief efforts, creating durable, affordable housing communities like Galena and Crooked Creek.

The CCHRC's work is accomplished at the 15,000 square foot Research and Testing Facility located in Fairbanks and on site in communities across the state, and through partnerships with Alaska-based and national organizations. In 2020, the U.S. Department of Energy's National Renewable Energy Laboratory (NREL) and CCHRC announced a new partnership, reaffirming the global applications and importance of the Center's innovative work in building design and research.

> "What we learn in Alaska can have a profound effect on the world."
>
> **– Jack Hebert, Founder, CCHRC**

Opportunities for Further Investment

Over the last decade, millions of dollars have been deployed to increase the energy efficiency of homes in Alaska, yet three-quarters of the state's non-energy certified housing stock has not been served by the largest programs. In addition to weatherization to reduce energy intensity, organizations and individuals have begun the work of integrating new technologies into homes: heat pumps and residential solar technology are the most widely adopted. Further investment will be critical in designing new, cost-effective building techniques appropriate for the state's climate, to further reduce energy intensity through weatherization, and to install technologies to reduce reliance on expensive fossil fuel-generated energy.

Energy Efficiency

Increasing energy efficiency is the first step toward reducing residential fossil fuel consumption in Alaska. The State's HERP and weatherization programs have been the most successful mechanisms to increase the efficiency of the state's housing stock. Yet, as of 2018, 75% of non-energy certified homes in Alaska had not received any energy efficiency services through these programs.[31] In rural Alaska alone, an estimated $36 million in funding would be needed each year over the next decade to provide weatherization services to all eligible households.[32] This level of weatherization funding would translate to more than $54 million in benefits from reduced energy costs.[33]

The limitations of current and previous programs can inform any new initiatives to increase energy efficiency funding in Alaska:

- Energy raters and contractors are in short supply in rural Alaska due to a low volume of construction activity. Programs requiring an initial energy rating should be done in coordination with local RHAs or other organizations to ensure that economies of scale are sufficient to engage these professionals.
- Program cost sharing with households can be an important mechanism to ensure buy-in and achieve real energy consumption changes. However, programs requiring households to pay the entire upfront cost of energy upgrades leave families who cannot afford these costs with no functional program access. New programs with cost-sharing

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[31] Alaska Housing Finance Corporation. *2018 Alaska Housing Assessment*. Excludes housing units certified under Alaska Housing Finance Corporation's Building Energy Efficiency Standard
[32] Vermont Energy Investment Corporation. *Alaska Energy Authority Energy Efficiency Program Evaluation and Financing Needs Assessment*. July 2016.
[33] Ibid,

measures should consider the level of upfront commitment required to ensure greater access.

- While organizations like RHAs can achieve material and other cost savings compared to individual households, high building costs remain challenging, especially outside Alaska's road system. Weatherization grantees on Alaska's road or marine highway system must ensure average costs per unit do not exceed $10,000. In areas not on the road system or served by ferry the limit is $20,000[34]. However, even at this higher limit is often insufficient to cover the cost of comprehensive retrofit (including insulation upgrades, window and boiler replacement, and other upgrades). RHAs must often supplement state funding with funding from other sources.
- High building costs pose a real challenge for families whose household income exceeds the area median income. These households do not qualify for weatherization assistance but often cannot afford the costly rehabilitation to increase their home's efficiency.

Renewable Energy Integration

While increasing home energy efficiency is vital to reducing household costs, integrating renewable energy technologies like heat pumps and solar panels into home energy systems can be a cost-effective way to further reduce fossil fuel consumption.

Financing Mechanisms

Residential-sized technologies appropriate for Alaska's climate are now available, and prices for some components like solar panels have seen significant declines over the past decade. Yet the high upfront costs of an energy conversion are still a primary barrier to adoption of this technology. Low-interest loans to finance conversions can help families move beyond this cost hurdle. Capitalization of a state "green bank", a public or quasi-public lender to focus solely on energy transitions, would be the most comprehensive way to make financing available statewide. Legislation introduced at the State level to create such a fund, whether within an existing state agency or public corporation or as a new organization, would be key to this effort. So too would State and federal efforts to capitalize the institutions be required to accelerate this transition.

For some families, uncertainty around when they will move to a new home reduces interest in conversions even when low-interest financing is available. Families do not want to get stuck paying off a loan for a heat pump in their previous house. Financing mechanisms like on-bill financing through a utility company or Property Assessed Clean Energy (PACE) programs where the cost of retrofits can be paid through a voluntary tax assessment may offer the best solutions.

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[34] Alaska Housing Finance Corporation. *Weatherization Operations Manual 2021*. Effective April 1, 2021.

Already utilities in Alaska like Homer Electric Association are embracing on-bill financing to help customers finance energy efficiency or other upgrades, and Commercial PACE programs are in development in several municipalities. Statewide authorizing legislation for a residential PACE program will be required for municipalities to offer this solution.

Several factors would likely limit penetration of these financing mechanisms in rural Alaska, such as:

- Even low-interest loans may be unaffordable for families facing extremely high cost of living in the state's most remote communities.
- Costs to implement on-bill financing mechanisms may be prohibitive for small utilities.
- Many municipalities in Alaska do not levy property tax, which limits the reach of residential or commercial PACE programs.

Heat Pumps

Heat pumps are most financially viable and most effective in communities where less expensive, hydroelectric-generated electricity is available.

In communities with high diesel-generated electricity costs, implementing heat pump technology comes with the risk of households exceeding the monthly PCE-eligible electricity usage. Combining systems, such as the integration of solar units and heat pumps in Ambler, is one way to reduce this risk seasonally. Increasing PCE-eligible kWh back to pre-2000 levels may be another step toward greater implementation of heat pump technology, although policymakers should carefully consider the net impacts of this change on overall fossil fuel consumption, particularly for communities reliant on diesel-generated electricity.

Solar Panels

Alaska has abundant solar resources. Reductions in installation costs, campaigns encouraging solarization, net metering, and federal tax credits have all contributed to increased residential solar panel adoption over the last decade.

Currently, Alaska's net metering regulations do not cover all regions of Alaska, and non-RCA regulated utilities are not required to offer this program. While extending net metering eligibility could make residential solar energy more attractive in all regions, extending the program can have financial consequences for utilities and ratepayers.[35] As electricity consumption declines due to renewable integration, utilities must spread their fixed costs over a smaller number of

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[35] Alaska Center for Energy and Power. *A Solar Design Manual for Alaska 5th Edition*. May 2018.

ratepayers, which can make rate increases necessary. Any new requirements extending net metering must carefully consider the expected impacts to these ratepayers.

Net metering requires residential meters programmed to track the amount of electricity sold back to the grid. In the absence of appropriate, and appropriately programmed, technology, meters will *add* the sold generation to a customer's bill. Funding for meter installation and programming will be an important step to increase residential solar panel use.

Emerging Technologies

New technologies that harness renewable energy to offset fossil fuel-based home energy use are emerging throughout Alaska. For example, in many Alaska communities and households, heating water contributes significantly to home energy use. Hot water heat pumps and thermal storage units have thus far seen limited use in Alaska but show great promise in reducing this form of energy consumption. Further feasibility studies will be important to prove this and other technology's efficacy.

Innovative Building Design

Reexamination of building design and materials also offers an opportunity to holistically approach the future of culturally appropriate, energy efficient housing in Alaska. Transportation costs drive up construction costs in Alaska, particularly in communities with no road access. High building costs not only limit the scope of retrofits but are a barrier to constructing high-efficiency homes with integrated renewable technology. New building designs, methods, and materials could reduce these cost barriers or reduce the need for costly home weatherization or rehabilitation in the future. Vacuum or structured insulated panels and rammed earth home designs are just two examples of building materials and design that show promise in reducing building costs while enhancing energy efficiency over traditional materials.

Continued applied research through organizations like the CCHRC provide the best opportunity to realize the potential of these innovative building designs and materials. At the same time, collaboratively designing new building materials and designs with community members in rural Alaska will continue to increase the impact and efficacy of applied research and development.

Community Relocation

No comprehensive Federal or State policy currently addresses village relocation, and no comprehensive funding for such efforts is available. Housing infrastructure funding sources are generally not designed to provide assistance at the scale needed to address village relocation, and no relocation framework or process has been published.

Comprehensive policy and funding sources to address housing needs related to community relocation will be increasingly important as the impacts of climate change unfold. Development of any comprehensive policy or framework to address village relocation should include Alaska Native representation at the development stage to ensure outcomes are culturally appropriate and community directed. Construction of energy-efficient, quality housing from the start of relocation will be key to community sustainability and reducing future needs for housing rehabilitation.

Federal Tax Credits

Federal tax credits can be an important incentive to increasing energy efficiency and renewable energy adoption. The Residential Energy Credit allows filers to take a credit of 30% of costs incurred installing solar, small wind, and geothermal heat pump technology. The Nonbusiness Energy Property Credit provides a 10% credit on costs incurred for energy efficiency improvements, including costs to upgrade exterior doors, windows, and building envelopes. The reach of these credits is necessarily limited to filers with a tax liability, and their use is therefore limited in Alaska.

Closing Comments

Housing infrastructure is at the intersection of climate change and the health, safety, and economic well-being of Alaskans. Housing security is already being impacted by the effects of a warming climate, especially in lower income rural areas. These same areas have high energy demands and often rely on carbon-intensive energy sources.

Weatherization and rehabilitation of Alaska housing is the first step toward addressing these impacts. Over the last decade, Alaskan organizations have made progress in this area. But state government fiscal constraints have resulted in drastically reduced spending on weatherization and energy efficiency.

At the same time, advances in renewable technology have enabled residential energy conversions throughout Alaska. With increased energy efficiency and emerging technology, Alaska is poised to transition its housing stock from being consumers to *producers* of energy. These efforts will take significant capital, new financing models, community collaboration, and close examination of program design and policies, but have great potential to reduce the significant cost burden on families and to reduce the carbon-intensive nature of residential energy use in the state.

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