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Development of a Prototype Energy Modeling Framework for Residential Buildings in Rural Alaska

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Abstract

Communities in rural Alaska face many housing challenges. Existing housing is often overcrowded, outdated, and not well designed for extreme weather conditions experienced in the arctic climate. In addition, heating oil and electricity are notably higher than average of the U.S. Increases in weather extremes and climate change have impacted Native Alaskan housing exacerbating energy inefficiencies and energy burden and impacting indoor air quality. Some retrofits through weatherization programs have been implemented and have helped promote improvements in existing housing in these communities. However, more alternatives are needed to help support housing improvements in these highly energy burdened areas. In order to address these challenges and improve energy efficiency, building energy simulation is a tool that can be used to estimate energy consumption of homes, and to estimate energy savings potential resulting from energy efficiency improvements both for individual and groups of homes. It can also be used to help identify the most effective energy efficiency measures to implement according to community needs. This study aims to develop a residential building prototype model for modeling rural communities in Alaska. Field data collection was conducted to understand building characteristics of rural Alaska existing housing and better represent housing conditions in this region. Developing a building prototype model can be used to evaluate energy consumption and preliminary energy savings potential estimates of these existing homes.

Introduction

Rural Alaska

Rural communities and Native Alaskan communities located throughout the Arctic region face many housing challenges due to extreme weather conditions combined with their remote location, which limits their ability to address housing energy efficiency. Existing housing is generally overcrowded and outdated. According to the Cold Climate Housing Research Center (CCHRC), over 50% of the homes in Alaska are between 25-45 years old. In addition, many of these homes are not energy efficient. Inefficiencies, in addition to electricity and heating fuel prices being 3-5 times more expensive than most of the U.S. (DCCED, 2020), result in significantly higher annual energy costs for households compared to the rest of the U.S. This cost can be more than four times the national average in some regions in Alaska, such as rural areas (CCHRC, 2015). There are additional challenges for remote communities due to their distance from urban areas, their lack of roads connecting rural communities to others (i.e. only accessible by boat or plane). These include dependence on expensive heating fuels, lack of available building materials, and high energy burden (Robinson et al., 2017, U.S DOA, 2017). Energy burden can be defined as the percentage of gross household income spent on energy costs. According to the DOE LEAD Tool, energy burden in rural Alaska is nearly 10%, while the average energy burden in most of the U.S. states is 2 or 3%. Retrofits through weatherization programs offered by the Rural Alaska Community Action Program, Alaska Housing Finance Corporation, or other agency have been implemented in some rural and remote areas in Alaska and have helped to improve housing conditions in these regions. However, despite the improvements in housing provided by these programs, energy burden remains high. Therefore, there is a need to support these communities and understand their energy challenges.

Energy modeling prototype

Building energy simulation (BES) and model development is an important component of efforts to quantify energy consumption of existing buildings, and subsequently, to use to assess energy efficiency retrofit impacts. The application of BES plays a significant role in predicting or measuring the energy consumption behavior of a building, using inputs and parameters defined by the user (Tuysuz et al., 2020). Residential structures may be similar in external appearance, but they can vary greatly in terms of efficiency and energy use (Rhodes et al., 2015). Many studies have evaluated the energy consumption and energy savings potential associated with increasing energy efficiency of the residential buildings in the United States using different simulation tools (e.g. Sadineni et al., 2011, Wilson, 2015, Lopes et al., 2017, McPherson-Hathaway, 2021, Panchabikesan et al., 2021, Ajayi et al., 2022, Wijesuriya et al., 2022).

The number of BES tools available has also increased in recent decades, covering different parameters and applications (Harish, et. al, 2016). The U.S. Department of Energy (DOE) released a platform in 2001 for building energy simulation called EnergyPlus. Years later, BEopt (Building Energy Optimization Software) was developed by the National Renewable Energy Laboratory (NREL) to provide easier and focused modeling for residential homes (Christensen et al., 2006). BEopt currently uses EnergyPlus as its simulation engine, as well as provides an .IDF file as output which supports further customization of the energy model beyond the limitations of adjustments in the BEopt interface alone.

Specifically for Alaska, AkWarm has also been developed to be used as an energy modeling tool, with a focus on supporting Alaska housing. It uses Alaska-specific databases for weather, fuel, material and utility costs (AHFC, 2022). In recent research, the authors performed tests comparing BEopt/EnergyPlus and AkWarm and found that although BEopt/EnergyPlus was not developed specifically for Alaskan climate and housing conditions, it yields energy consumption values similar to AkWarm (Guillante et al., 2023).

Prototype energy models are simulations of real-world systems that aim to predict and analyze energy use of a building in a specific context. These models serve as tools to estimate how much energy a building or system is likely to consume under different conditions. The development of energy models of building prototypes is of great importance because they are the starting point in carrying out analyzes for various applications, such as the energy saving potential of buildings, the design of buildings and the development of building energy policies (Sun et al., 2021). However, it is important to note that prototype buildings do not, represent a specific existing building, rather they are a set of building features that represent a specific building type.

There are several existing prototype residential buildings for the United States that are widely used. The Pacific Northwest National Laboratory (PNNL) simulates energy savings associated with changes in energy codes and standards using two base prototype buildings based on the International Energy Conservation Code (IECC) Residential Code for One- and Two- Story Dwellings. These include single-family and multi-family low rise building types (DOE Building Energy Codes Program, 2021). The prototypes also consider information from the Residential Energy Consumption Survey (RECS) and American Housing Survey (AHS) databases. These prototype designs provide a consistent basis for running building energy simulations across the U.S. residential building stock for different climate zones and varying some housing characteristics (Kneifel, 2012). In addition to the DOE Prototype Building models, there are also several DOE Reference Building models, including one for multifamily (Deru et al., 2011). However, despite the existence of several prototype home energy models, including one specifically for climate zone 8 using Fairbanks/AK as a representative city, there are still significant differences between rural Alaskan homes and those found in the rest of the U.S. or state of Alaska.

Methods

Sample Validation

The prototype energy modeling is developed based on information collected during field visits and via remote tools (Google Earth) on the exterior characteristics of all homes in Unalakleet, Alaska, as well as energy audits performed on a representative sample of 51 homes in this same rural community. The energy audits include data collection on the exterior and interior of the homes. Housing characteristics, such as roof and foundation types, exterior siding, ventilation system, lighting, windows, among others were analyzed. Household appliances were inventoried, with information collected about their respective brands, models and efficiency. Blower door tests were conducted to assess the air exchange rate (ACH) of each home. From this test, when the blower door is depressurizing the living space to a standard pressure of 50 Pascals, it is possible to determine the volume of air changed with outdoor air per hour (ACH50). The results of this test provide information about the home's energy efficiency (via infiltration), as well as can suggest potential areas for improvement and reduction in energy consumption if the ACH is higher.

To validate the sample collected and ensure that it is representative, the data collected on field was compared with data collected on exterior characteristics of a total of 190 homes in the community (all homes). This includes home area, percentage of windows, neighbor distance, foundation, and roof type, among others were analyzed. Field data collection during field visits was used to verify this data as well as to add any missing data not possible to collect remotely.

Physical housing characteristics collected on-site was compared to the overall U.S. building characteristics for the total of homes and single-family homes. Table 1 shows a comparison between the U.S. and a rural Alaskan community (Unalakleet, located on the west coast of Alaska, with a population of 750) regarding heating and water heater sources, as well as air conditioning (AC) use, and Table 2 shows the comparison regarding physical housing characteristics. There are several rural communities in Alaska facing similar challenges regarding energy insecurity. Unalakleet is chosen due its geographic location, typical housing characteristics and due the amount of data already collected.

Table 1 Main heating and water heater sources and AC use in the U.S. and rural Alaska

	EIA RECS 2015[1]		Field data collection
	U.S. Total	U.S. Single-family homes	Rural Alaska - Unalakleet
Main heating source			
Natural gas	**48.82%**	**54.88%**	0.00%
Electricity	34.60%	28.80%	1.75%
Fuel oil/ kerosene	4.91%	4.94%	**94.74%**
Propane	4.23%	4.94%	0.00%
Wood	2.96%	3.58%	3.51%
Main water heater source			
Natural gas	**47.63%**	**51.17%**	0.00%
Electricity	46.19%	42.15%	**53.06%**
Propane	3.55%	3.96%	0.00%
Fuel oil/ kerosene	2.37%	2.22%	**46.94%**
Air-conditioning equipment			
Use AC	**86.97%**	**88.38%**	1.96%
Do not use AC	13.03%	11.62%	**98.04%**

[1] Residential Energy Consumption Survey (EIA, 2015)

The data from the U.S. total, U.S. single-family homes was obtained from the Residential Energy Consumption Survey (RECS, 2015). The data from Unalakleet was obtained through field data collection. This includes documenting the exterior characteristics of all homes in the community, and in addition, conducting energy audits of a representative sample of 51 homes between 2021-2023. These represent approximately 27% of the total of homes in the community.

Table 2 shows the comparison of physical housing characteristics among the U.S. and rural Alaska. The data from the Residential Energy Consumption Survey (RECS, 2015) presented in these tables may not add up to 100% in some of the parameters. This is because some information regarding apartments and mobile homes, such as basement, attic, attached garage and others do not apply for these types of buildings and therefore, the percentages were not included in this paper.

Table 2 Housing physical characteristics in the U.S. and rural Alaska

	EIA RECS 2015[1]		Field data collection
	U.S. Total	U.S. Single-family homes	Rural Alaska - Unalakleet
Year of construction			
Before 1959	**28.26%**	**30.90%**	8.51%
1960 to 1969	10.83%	10.88%	6.38%
1970 to 1979	15.48%	13.97%	**31.91%**
1980 to 1989	13.54%	11.99%	**21.28%**
1990 to 1999	14.21%	14.22%	17.02%
2000 to 2015	17.60%	18.05%	14.89%
Number of stories			
One story	**40.19%**	**58.71%**	**88.24%**
Two stories	24.96%	36.46%	11.76%
Three or more stories	3.30%	4.57%	0.00%
Major outside wall construction			
Aluminum vinyl or steel	**34.01%**	**36.22%**	41.18%
Brick	27.83%	25.46%	0.00%
Wood	15.23%	16.69%	**56.86%**
Stucco	12.94%	13.10%	0.00%
Shingles	2.54%	2.97%	1.96%
Other	7.45%	5.56%	0.00%
Major roofing material			
Shingles	**61.84%**	**79.48%**	6.00%
Metal	8.29%	6.92%	**94.00%**
Other	11.93%	13.47%	0.00%
Basement			
Yes	29.78%	43.51%	5.88%
No	38.66%	56.49%	**94.12%**
Attic			
Yes	**38.32%**	**56.12%**	**62.31%**
No	30.03%	43.88%	34.69%
Attached garage			
Yes	39.68%	**57.97%**	9.68%
No	28.76%	42.03%	**90.32%**
Number of windows			
1 to 5	19.97%	4.33%	16.66%
6 to 9	23.86%	22.00%	**60.00%**
10 to 15	**31.81%**	**39.43%**	23.33%
16 or more	24.37%	33.99%	0.00%
Type of glass in windows			
Single pane	41.20%	34.61%	7.84%
Double-pane	**57.78%**	**64.28%**	**62.75%**
Triple-pane	1.02%	1.11%	29.41%

[1] Residential Energy Consumption Survey (EIA, 2015)

The results of the comparison show in Tables 1 and 2 highlight the differences found in terms of heating sources and housing characteristics between the U.S. and rural Alaska. The most common energy source used for heating in rural Alaska is fuel oil (94.74%) while the rest of the U.S. uses natural gas or electricity. When comparing this data to the state of Alaska, 49.70% of the homes use natural gas as a source of heating, followed by fuel oil (28.5%) (ACS, 2021). Several differences are also noted in terms of housing characteristics, materials employed, and types of construction elements within rural Alaskan homes when compared to the rest of the U.S. In terms of housing characteristics, rural Alaskan homes have fewer windows and, in some cases, have triple-pane windows. Basements are also very rare due to the permafrost conditions present in many parts of rural Alaska.

Table 3 shows a comparison of household size in the U.S., the state of Alaska, and in rural Alaska (i.e. Unalakleet). The data from the U.S. and state of Alaska were obtained from the American Community Survey for 5 years, year of 2021. The occupancy of rural Alaska differs from the national and state patterns. While in the U.S. and Alaska the majority of homes are occupied by 2 people, in Unalakleet the majority of homes are occupied by 3 people. These differences directly affect energy modeling results. Occupancy patterns are crucial for accurately assessing and predicting energy consumption, as the dynamics of larger households may influence the demand for heating, lighting, and other energy-intensive activities.

Table 3 Household size and average home area of the U.S., and rural Alaska

	ACS 5Y 2021[2]		Field data collection
	U.S. [2]	Alaska[2]	Rural Alaska - Unalakleet
Household size			
1-person	28.10%	26.70%	16.67%
2-person	**33.80%**	**33.50%**	25.00%
3-person	15.50%	15.10%	**33.33%**
4-or-more-person	22.60%	24.80%	25.00%
	U.S.[1]	U.S. Single-family homes[1]	Rural Alaska - Unalakleet
Average housing unit area (m^2)	186.5	201.0	**100.0**
Area per household member (m^2)	73.3	77.1	**33.2**

[1] Residential Energy Consumption Survey (EIA, 2015)
[2] American Community Survey – 5 Year (U.S. Census Bureau, 2021)

The average area per U.S. housing unit is 186.5 m^2 and for U.S. single-family homes; considering both detached and attached dwellings, is 201 m^2. While in rural Alaska, the average area per housing unit for single-family homes is 100 m^2, which is approximately half the area of the continental U.S. When comparing the area per household member, the U.S. average is 73.3, for U.S. single family-homes it is 77.1, while for rural Alaska single-family homes, it is 33.2. This is significantly lower than the national average.

The variations in physical building characteristics, occupancy, and heating sources between rural Alaska and the rest of the U.S. directly affects the energy performance of the building and the assumption associated with inputs into energy model development. These differences represent significant challenges in accurately predicting and optimizing energy consumption. Understanding the unique characteristics of buildings, how they are used by homeowners, and the different heating sources and equipment is essential for developing effective energy models tailored to the specific region studied. Therefore, it is essential to develop a residential building prototype model that incorporates all the particularities of rural Alaska communities. In particular, since these differ from many of the averages across the rest of the U.S. Opting for a new prototype model, rather than relying on existing ones, stems from the fact that current prototype models may not adequately address the challenges and characteristics specific to rural Alaska. Through the development of a customized model, it becomes possible to ensure a more accurate representation of existing homes in rural Alaska.

Energy Modeling

For the energy modeling prototype, an initial model was developed initially using BEopt 3.0.1 (NREL, 2023). Further adjustments are carried out by modifying the IDF file generated by BEopt to further refine building characteristics using EnergyPlus. For the sake of this initial model, BEopt was chosen, and a data-driven approach was used in order to input the parameters to the energy modeling software. The values considered were based on the average of values found or most common characteristics observed by the authors in the rural community of Unalakleet, in Alaska (Milan et al., 2022, Gioppo et al., 2023 – under review).

Occupancy was determined based on the assessed homes, which resulted in an average of 3.08 people living in each home. In an effort to demonstrate the differences between rural Alaska and the broader U.S. the occupancy empirical equation referenced by BEopt (2014) is shown in equation (1), which calculates occupancy based on number of bedrooms.

$$N_{occupants} = 0.59 * N_{bedrooms} + 0.87 \qquad (1)$$

To determine the appropriate calculation for homes in rural Alaska, a similar linear empirical model is developed based on the authors' field-collected data. Figure 2 shows the datapoints from data obtained during the energy audits and the parallel equation (2) to calculate occupancy, based on a linear regression model fit to this data. Information on the number of occupants and bedrooms was gathered for 24 of the total assessed homes.

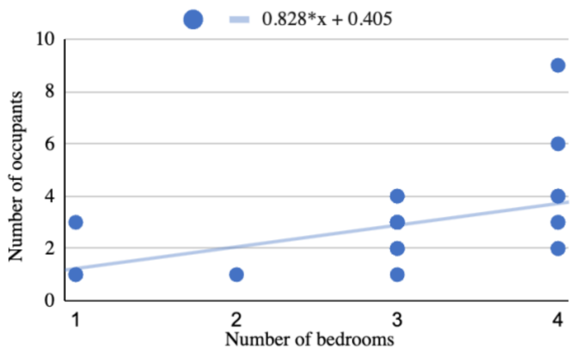

Figure 2 Correlation between occupancy and the number of bedrooms

$$N_{occupants} = 0.828 * N_{bedrooms} + 0.405 \qquad (2)$$

All appliances, fixtures and miscellaneous schedules considered in this model were stochastic. By incorporating stochastic schedules, the model takes into account fluctuations in occupant behaviors and daily routines. Unlike standard schedules, which follow fixed patterns, stochastic schedules introduce an element of variability into the model. Electricity rates incorporated into this study were adjusted to align with current community bills. Unalakleet is served by a single utility company and that employs a flat rate structure, which is the only rate structure available.

In Alaska, some communities also have what is called a Power Cost Equalization Program (PCE). PCE attempts to equalize high electricity costs in rural communities, which are generally not accessible by road and face high electricity production costs (oil fuels) due to high transportation costs and high fuel prices. Through PCE, eligible residential customers have up to the first 500 kWh/month partially subsidized by this program, which mean a lower rate of electricity per kWh. The building's orientation was determined based on data collected on site, where 43.1% of all homes assessed were south oriented. Table 4 include inputs adopted to develop the energy modeling prototype.

Table 4 Selected inputs for energy modeling

Parameter	**Assumptions**
Area (m^2)	100.4 (12.2 x 8.2)
Age of home	37 years
Building orientation	South
Neighbors distance (m)	W-8.2, E-9.7, N-7.8, S-8.3
Windows to wall ratio (%)	S-9.93, N-6.75, W-4.75, E-6.60
Terrain type	Rural
Electricity price ($/kWh)[3]	0.2977
Oil price ($/gal)[4]	6.15

[3] Unalakleet Valle Electric Cooperative, Inc.
[4] Alaska Fuel Price Report: Summer 2022

Results

Sample Validation

Considering the methods outlined, an extensive dataset was collected to provide baseline information on housing characteristics. This section summarizes the results of this data collection, providing an understanding of overall characteristics of homes. In addition, a comparison between energy audit data collection and all of the home is presented. The results from the sample validation methods are shown in Figures 3 to 5 and Table 5. For this validation, data collected from the 51 assessed homes were compared to all home 190 homes in the community of Unalakleet. The distribution of home sizes is presented in Figure 3.

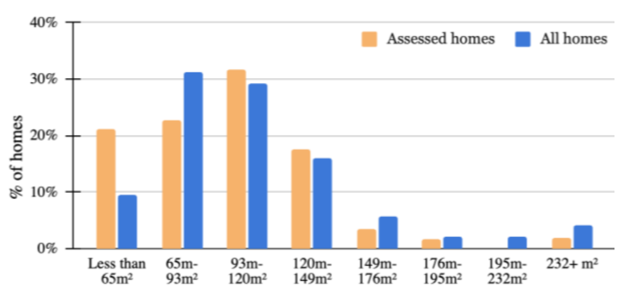

Figure 3 Percentage of homes by size

When comparing the size of the homes, there is a higher percentage of assessed homes with less than 65 m^2 when compared to the entire dataset. However, when considering homes smaller than 92.8 m^2 in size, the percentage of assessed homes and all homes are very similar: 43.8% and 40.7%, respectively. Table 5 shows the results of the average percentage of windows in each direction (North, South, East, and West) and the average neighbor distance in each direction.

Table 5 Average windows percentage and neighbor distance in each direction

	Assessed homes	All Homes
Windows area coverage (%)		
North	6.75	7.45
South	**9.93**	**8.41**
East	4.75	5.02
West	6.60	6.10
Neighbor distance (m)		
North	7.8	8.4
South	8.3	8.6
East	**9.7**	**9.5**
West	8.2	9.1

Results from average windows percentage in each direction are similar when comparing the assessed homes and the data from all homes. The south wall is the one with the highest percentage of windows (9.93%) among all directions, followed by the north side. The average neighbor distance for all directions is also similar for both datasets analyzed. In this case, the east side was the one with the largest distance between adjacent buildings. This information is valuable as an input for energy modeling, since the distance of adjacent buildings can affect factors, such as shading, solar exposure, and wind patterns. A larger distance on the east side, for instance, could lead to increased sunlight exposure in the mornings, impacting heating requirements.

The results of percentage of homes by foundation type are shown in Figure 4. The crawlspace foundation was the most common type observed during the energy assessments conducted and appears to be accurate with when compared with data from all homes. Nearly 80% of homes have crawlspace, followed by slab-on-grade. Some crawlspaces were enclosed with skirting while others were not. These types of foundations are in accordance with the c recommendations, which also includes other foundation designs tailored for permafrost conditions (CCHRC, 2000). The category labeled as "unknown" comprises 11% of the entire dataset. This “unknown” are foundation types that could not be identified through current data collection methods. Further field data collection is needed to fully assess these homes. However, it is not likely to impact the identification of the crawlspace foundation type as being the most common.

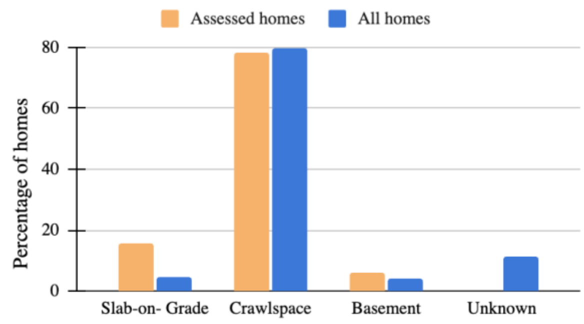

Figure 4 Percentage of homes by foundation type

Figure 5 illustrates percentage of homes by different roof types, such as metal (corrugated and standing seam) and shingles. Approximately 5% of the roof types are unknown, as they could not be determined easily without further field data collection. Some also had snow covering the roof surface that prevented the identification from being completed. The most common roof type observed during the energy assessments was the corrugated metal. However, there is a difference between the two most common types observed (corrugated and standing seam) when comparing the assessed homes and all homes. However, considering the thermal properties of the corrugated and standing seam metal roofs are similar, and that the total percent of homes with a metal roof in both the assessed homes and all homes is similar, this different is not determined to be critical to model development.

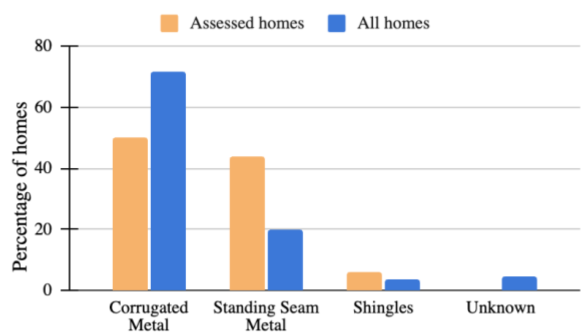

Figure 5 Percentage of homes by roof type

Overall, the assessed homes sample in comparison to all homes in Unalakleet demonstrates a considerable level of consistency among all variables analyzed. This suggests that the assessed homes can effectively represent and serve as a reliable sample for characterizing housing for use in developing an energy modeling prototype for these homes. Therefore, this research assumes that the average interior characteristics determined from the energy assessments of the sample of homes is representative of the rural community as a whole.

Energy Modeling

The developed model inputs the most common characteristics observed during the energy audits (for categorical data), as well as average values measured (for numerical data). Parameters such as, heating system, water heater, and appliances model and efficiency were also based on data collected. For this case, the default option from BEopt, which closely matched the collected data, was chosen to run the model. Ventilation rates were based on the average ACH50 values obtained from the blower door test performed in the homes.

Figure 6 illustrates the configuration of the modeled home considering the neighboring distances presented in Table 5 and the south building orientation, which was the most common observed among all assessed homes (43.14%).

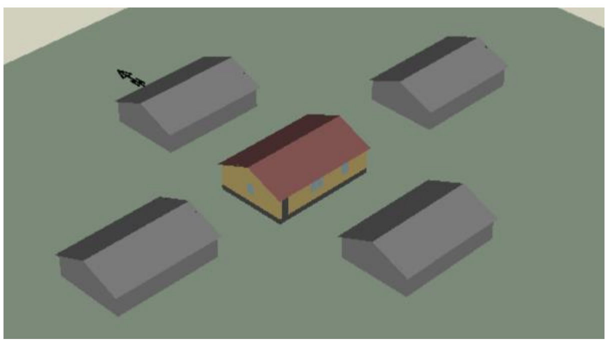

Figure 6 Configuration of the modeled home (center)

Based on the above-mentioned assumptions, the developed model was run using a TMY3 weather file for Unalakleet, AK (2008). The total estimated annual electricity consumption estimated through the energy model for the developed prototypical home in Unalakleet is 5,464 kWh/yr. Figure 7 shows the energy use breakdown, revealing that miscellaneous (such as plug loads, extra refrigerators, and freezers, and large appliances) are responsible for most electricity consumption. Together they represent nearly 84% of the total electricity consumption. When conducting the energy assessments, it was observed that 98.2% of assessed homes had a refrigerator and 90.2% had at least one freezer, and 55.3% had a second freezer. This condition and the fact that there is no cooling system in most homes may explain the greater consumption of electricity coming from household appliances. When considering the electricity consumption in single family buildings in the U.S., air conditioning accounts for almost 20% of the total consumption, followed by space heating (16.8%) and water heater (12%) (RECS, 2015). When comparing this with Alaska, most of homes use oil as a source of heating, while there are no cooling systems present in the majority of homes. Lighting system is one of the major consumers (10.8%) among single family buildings in the U.S., followed by appliances, such as refrigerators (7.2%), TVs (6.8%), and clothes dryer (4.8%) (RECS, 2015).

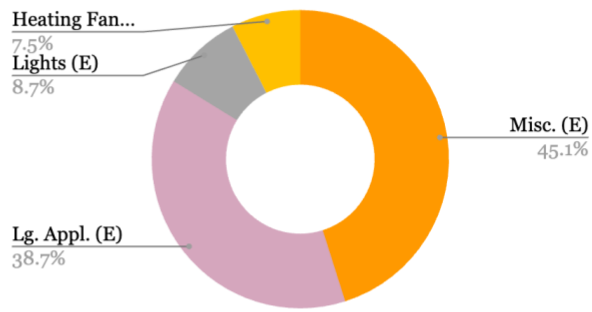

Figure 7 Site electricity use breakdown

The breakdown of oil consumption results is detailed in Figure 8, with an estimated annual oil consumption from energy modeling obtained of 802.8 gal/yr. Oil fuel is the primary source used for heating in rural Alaska, observed in almost 95% of the total assessed homes. As expected, a substantial portion of the oil consumption is used in space conditioning for heating, which represents 80.6% of the overall amount consumed. Water heaters are responsible for utilizing the remaining oil consumption.

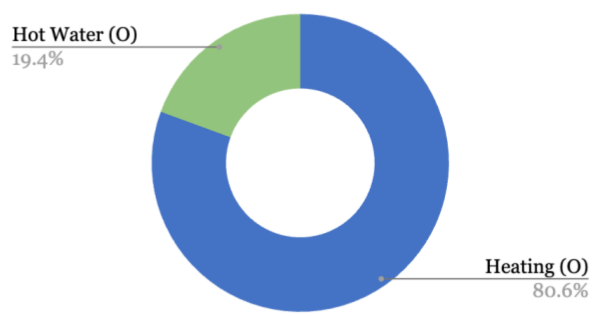

Figure 8 Site oil use breakdown

The modeled home presented an annual site energy use of 130.2 MBtu/yr. Figure 9 illustrates this site total energy use breakdown. The breakdown of total local energy consumption shows that heating represents 69.1% of total energy consumption, the predominant consumer among all energy categories. The second major energy consumer is water heaters, accounting for 16.6% of the total. These results appear to be in accordance with what was observed in homes in terms of energy consumption and cost. Furthermore, the observed results suggest that energy savings could be achieved by improving elements of the home that are directly related to conditioning the space for heating, such as the building envelope, adding adequate insulation, or even having more efficient appliances.

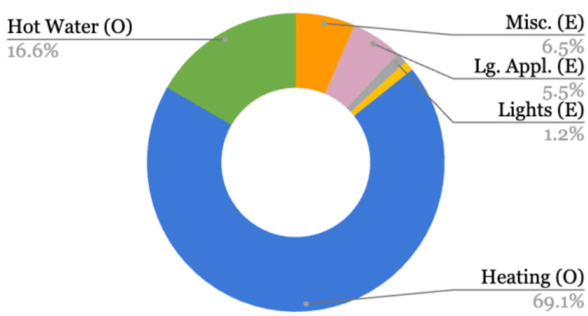

Figure 9 Site energy use

The total annual energy cost observed for the proposed prototype model is $6,823. From this total amount, electricity accounts for 38.23% of the total cost and oil fuel accounts for 61.77%. The annual energy costs observed in this model is slightly higher than the average annual energy cost of energy of $5,902 from the Low-Income Energy Affordability Data (LEAD) Tool (ACS, 2020) for this region. Data for the LEAD Tool comes from the U.S. Census Bureau's American Community Survey 2020 Public Use Microdata Samples and the energy data available is for housing only. This difference can be attributed to the fact that information from the LEAD tool is from 2020 and electricity and oil prices have substantially increased in recent years.

Figure 10 shows the estimated electricity and oil consumption throughout the year. For this prototype model, the heating season was adjusted to result in a more realistic values for energy consumption. For this purpose, it was considered a heating season from August 15 to June 15. This long winter season is defined based on information collected when conducting energy audits and interviews and considering the heating degree days (HDD) of Unalakleet, which are decreasing in June and at their lowest during the months of July and August. Results show that electricity and oil consumption decrease during the summer months, which is expected based on the lower amount of heating needed. In terms of electricity consumption, future models will consider the prolonged daylight in Alaska during summer months. During summer months is when homeowners are mostly out of home, because the local economy is heavily subsistence-based, with many community members hunting, fishing, and harvesting during the summer.

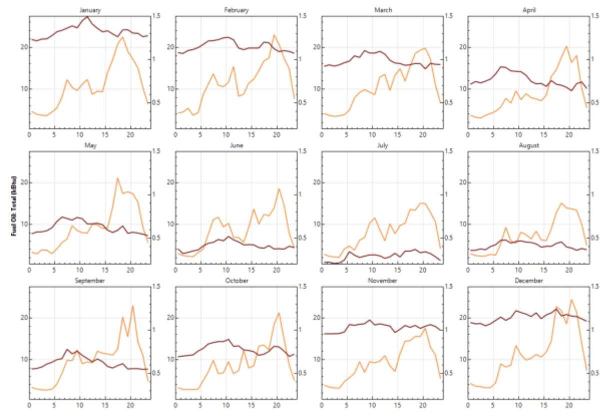

Figure 10 Electricity and oil consumption throughout the year

The prototype energy modeling development can help identify energy-related challenges. The results indicate high oil consumption, suggesting a high demand for heating in these homes. Considering this scenario, several energy efficiency strategies could be adopted and tested to identify potential energy savings. In addition, further data collection is underway in other rural communities in Alaska to identify similarities and differences among communities. This will help to understand the applicability of this prototype to other rural communities.

Conclusion

Rural Alaskan communities face many housing challenges associated with overcrowding, house age, and the lack of design considerations to their extreme weather conditions. Furthermore, heating oil and electricity prices in this location are notably higher than average of the U.S. One alternative to address these challenges is improving energy efficiency of homes. Building energy simulations can be used to estimate energy consumption, and to estimate potential energy savings resulting from energy efficiency improvements both for individual and groups of homes. This study aimed to develop a prototype energy modeling for rural Alaska housing as the existing prototypes may not accurately represent rural Alaskan homes.

Comparing the data collected in 51 homes in the community of Unalakleet to all homes supports the conclusion that the sample analyzed is representative of the broader range of homes in the community. This conclusion arises from the consistency and alignment of the main external characteristics observed, ensuring that the information collected appears representative. The initial findings from the energy modeling prototype align well with the observed patterns in the community of Unalakleet. While the preliminary results offer valuable information, continued efforts, including collecting information on utility bill and energy data, and refining parameters, should be undertaken towards a more refined final model.

This research is part of an ongoing project where further data on housing characteristics and energy systems is being collected in different rural communities in Alaska. Energy models at the building and community levels will be considered and refined in future work, as well as calibration and validation of these models.

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