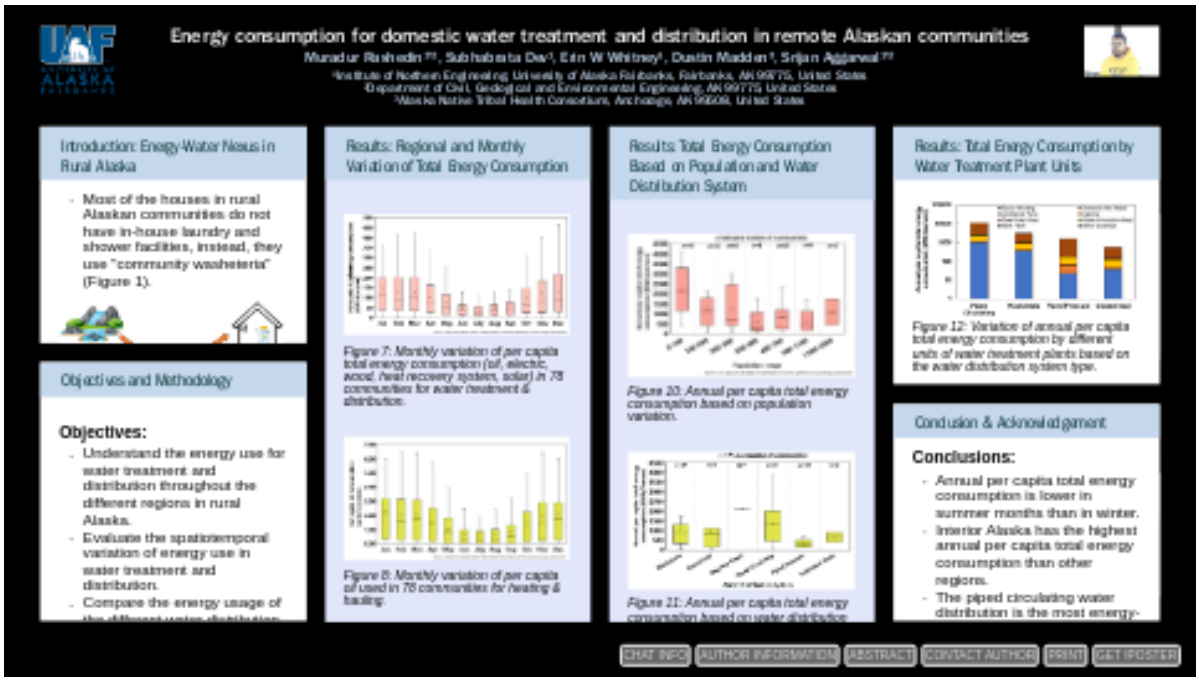
Energy consumption for domestic water treatment and distribution in remote Alaskan communities



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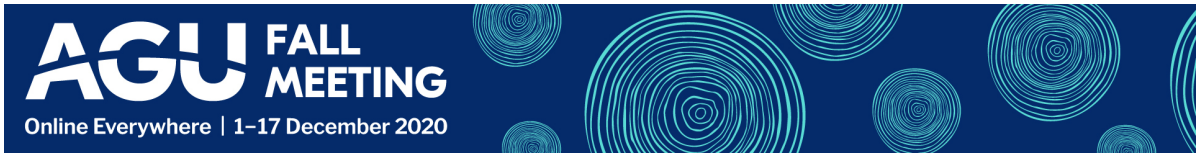


INTRODUCTION: ENERGY-WATER NEXUS IN RURAL ALASKA

- Most of the houses in rural Alaskan communities do not have in-house laundry and shower facilities, instead, they use "community washeteria"(Figure 1).

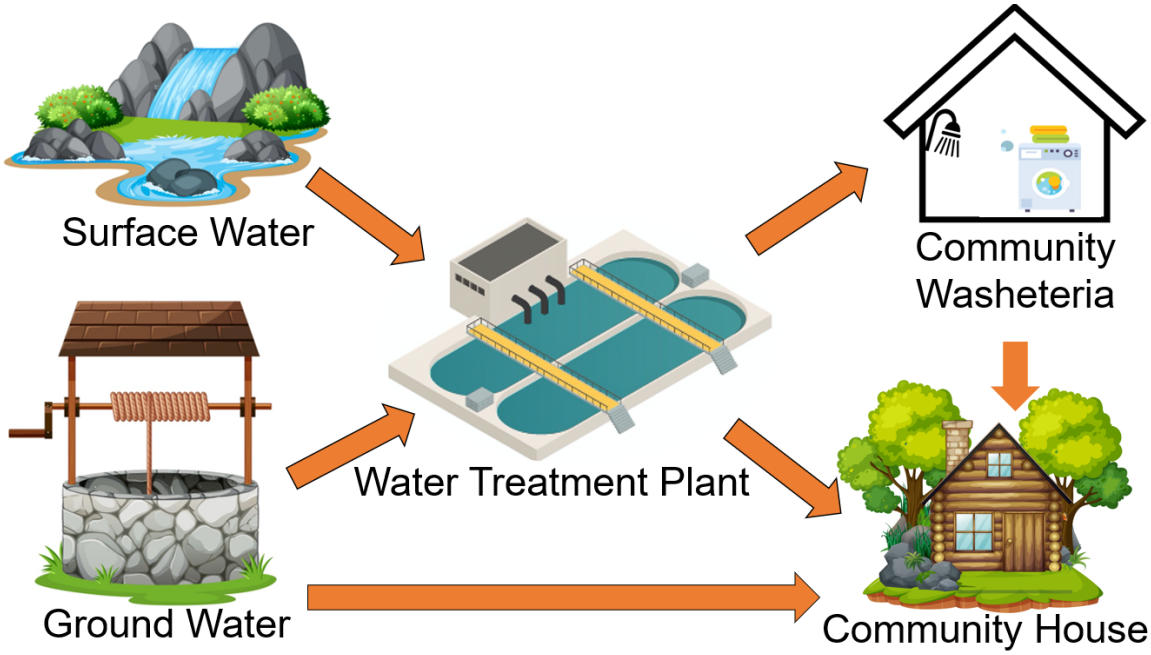


Figure 1: Water treatment scenario in rural Alaskan communities.

- The main energy source in rural Alaska is oil. A significant amount of it is used to operate the water treatment plant units (ventilation, pipe heating, light, and pump) as well as in heating to prevent water freezing and hauling water (Figure 2).

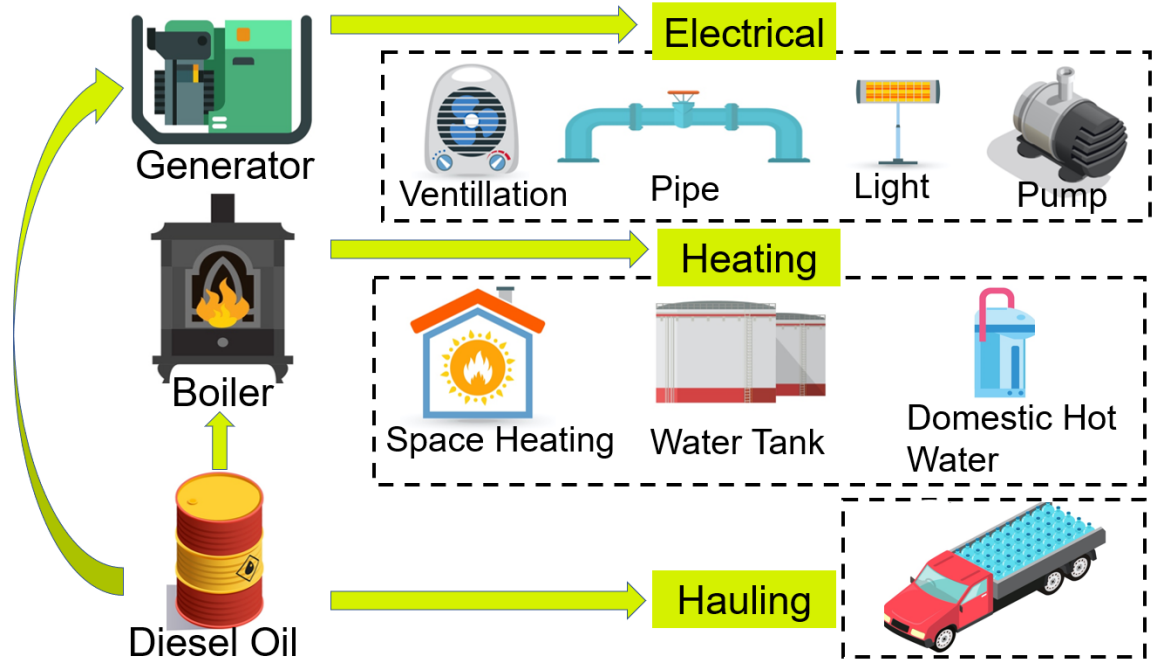


Figure 2: Energy usage for the water treatment plant and distribution system.

- The water distribution system is categorized into three types (Figure 3).

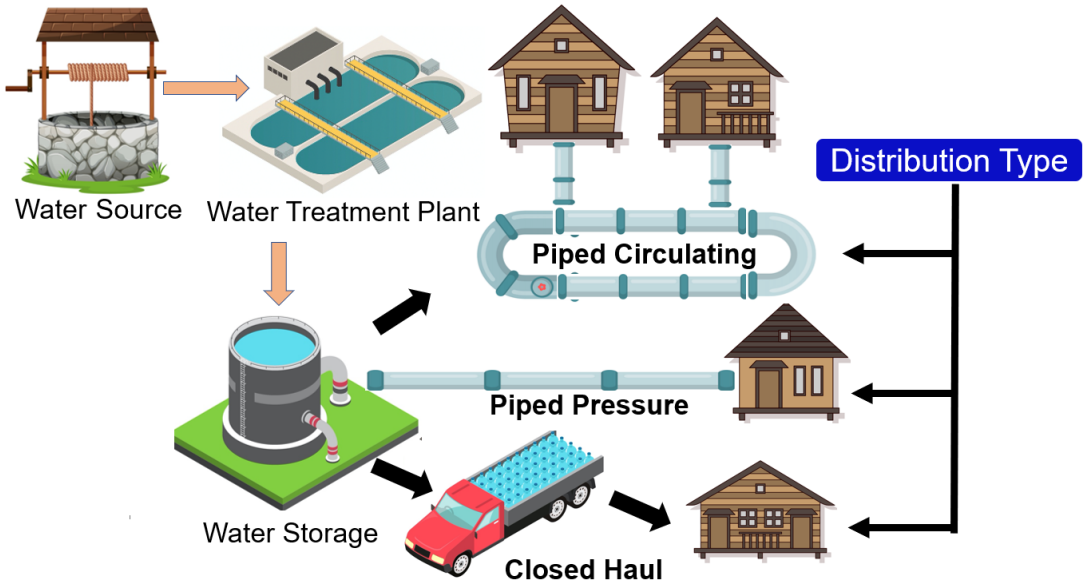


Figure 3: Water distribution system in rural Alaska.

- The present study focuses on understanding the water-energy nexus in rural Alaska using the water and energy data from Alaska Native Tribal Health Consortium (ANTHC).

OBJECTIVES AND METHODOLOGY

Objectives:

- Understand the energy use for water treatment and distribution throughout the different regions in rural Alaska.
- Evaluate the spatiotemporal variation of energy use in water treatment and distribution.
- Compare the energy usage of the different water distribution systems.
- Evaluate energy utilization by different components of water treatment plants.

Study Area:

- A total of 78 communities distributed in 5 regions have been considered in this study (Figure 4).

Region	Communities
South west	35
Northern	18
Interior	17
Gulf Coast	4
South east	4

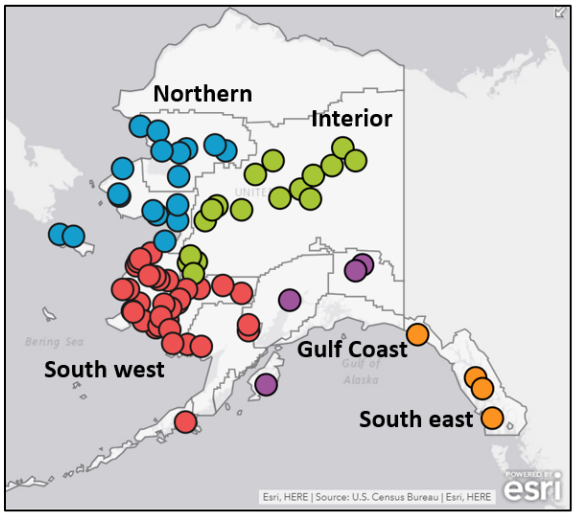
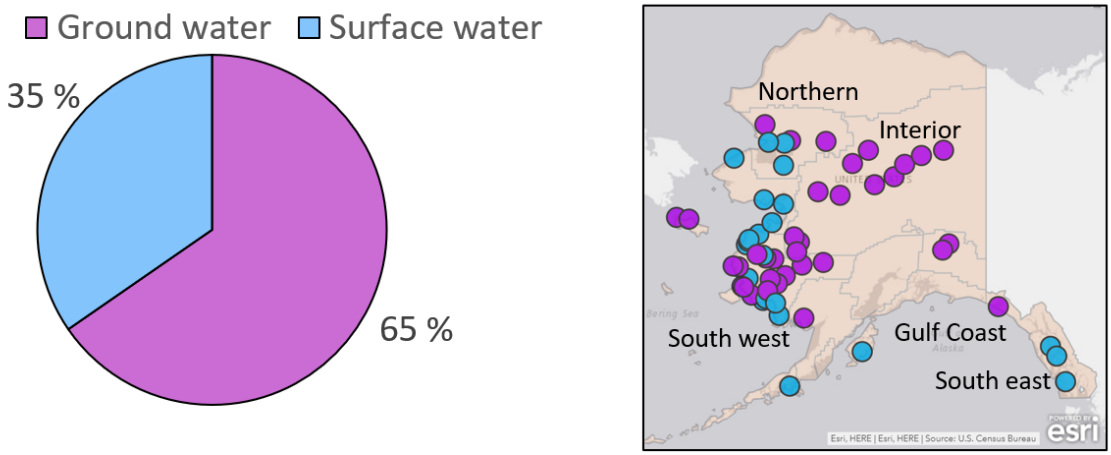


Figure 4: Arc-GIS map showing the distribution of 78 communities in the five different regions of rural Alaska.

- Distribution of water utilization based on the drinking water source (Figure 5).



Source : Water source classified from Alaska Department of Environmental Conservation (ADEC)

Figure 5: Drinking water source in rural Alaskan communities.

Methodology:

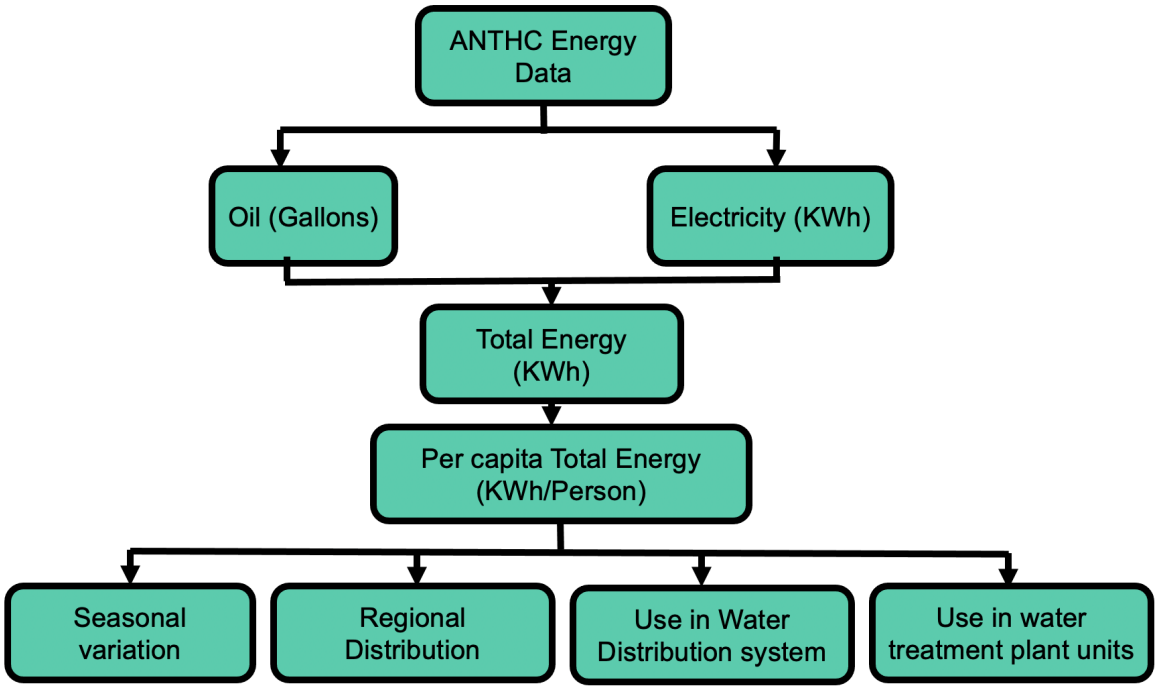


Figure 6: Flow-chart showing the methodology of this study.

RESULTS: REGIONAL AND MONTHLY VARIATION OF TOTAL ENERGY CONSUMPTION

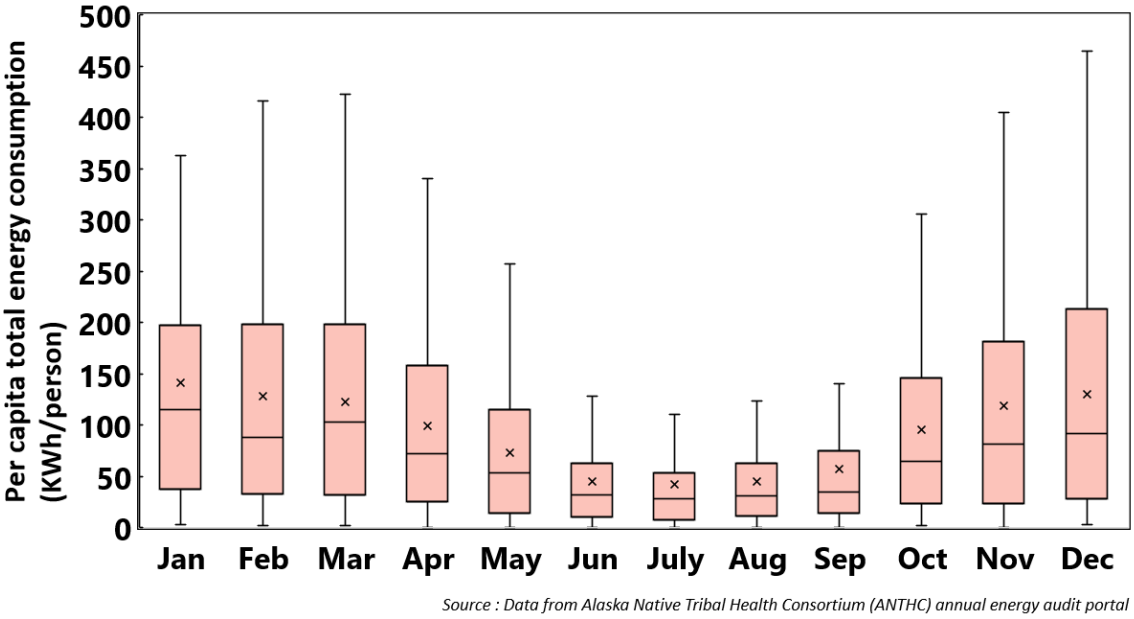


Figure 7: Monthly variation of per capita total energy consumption (oil, electric, wood, heat recovery system, solar) in 78 communities for water treatment & distribution.

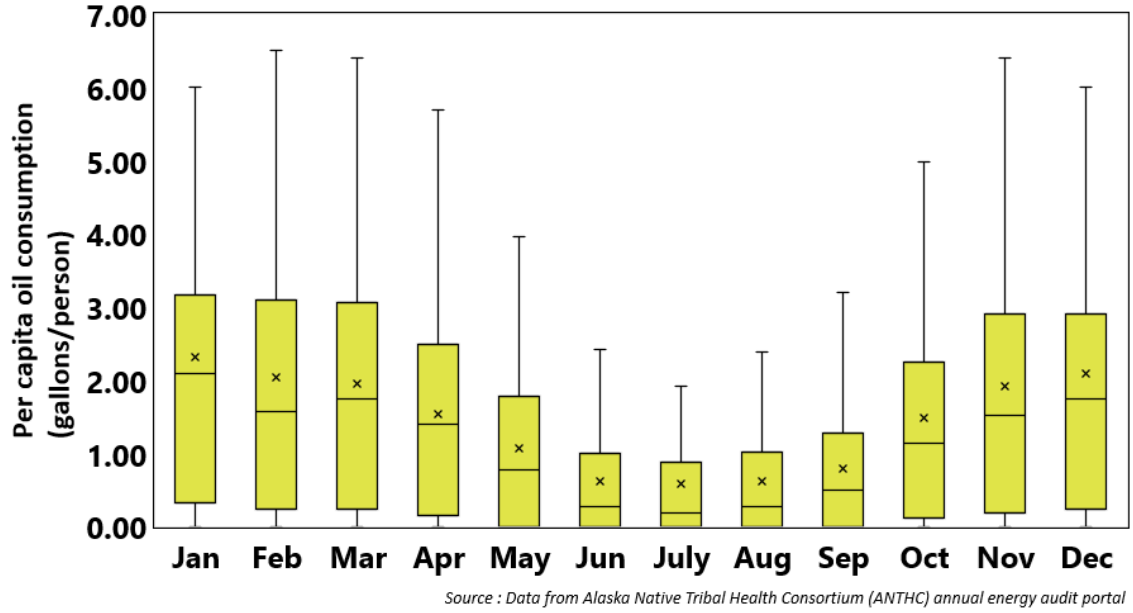
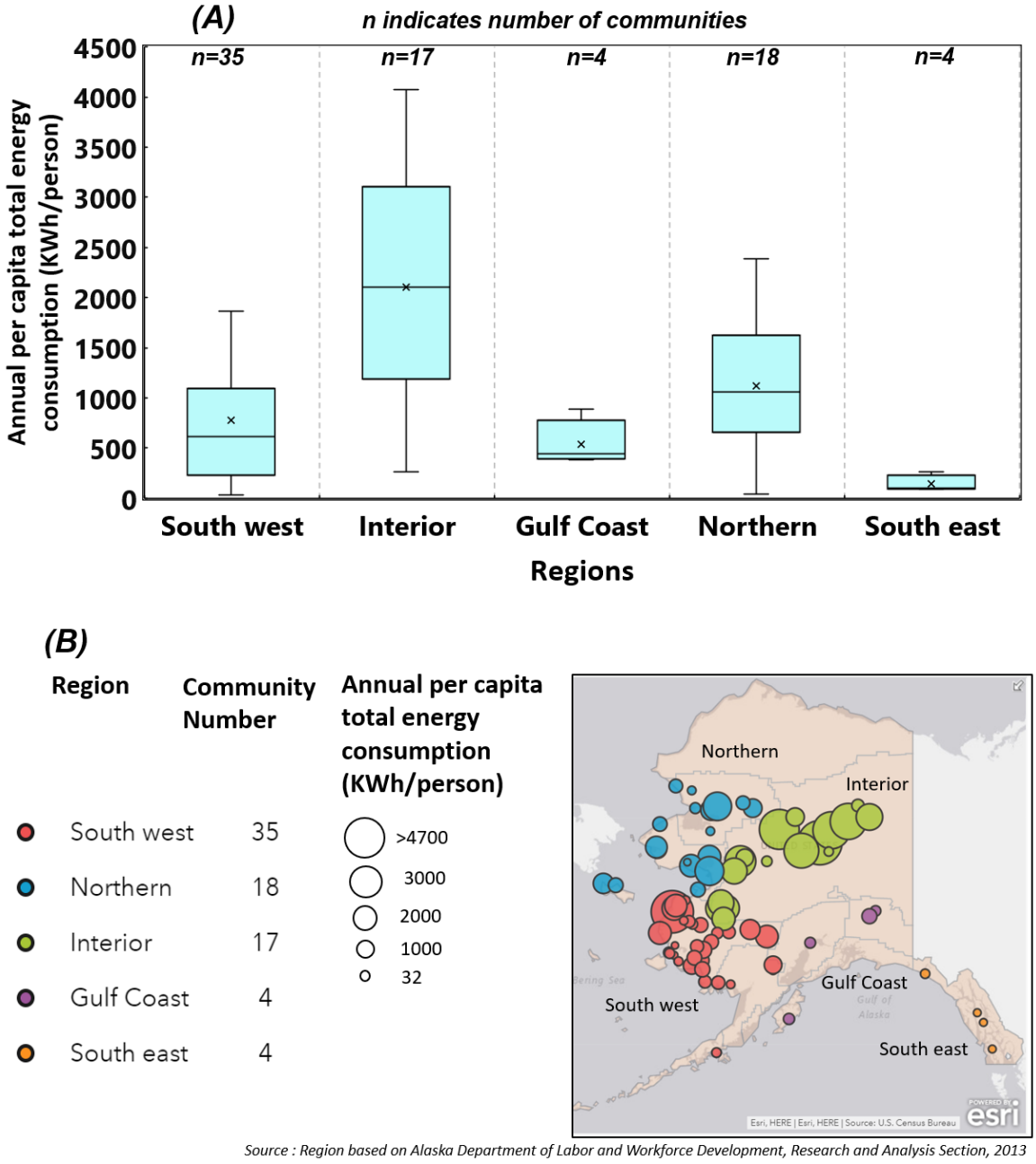


Figure 8: Monthly variation of per capita oil used in 78 communities for heating & hauling.



Source : Region based on Alaska Department of Labor and Workforce Development, Research and Analysis Section, 2013

Figure 9: Regional variation of per capita total energy consumption for water treatment and distribution for 78 communities represented as (A) box-plot, (B) Arc-GIS map.

RESULTS: TOTAL ENERGY CONSUMPTION BASED ON POPULATION AND WATER DISTRIBUTION SYSTEM

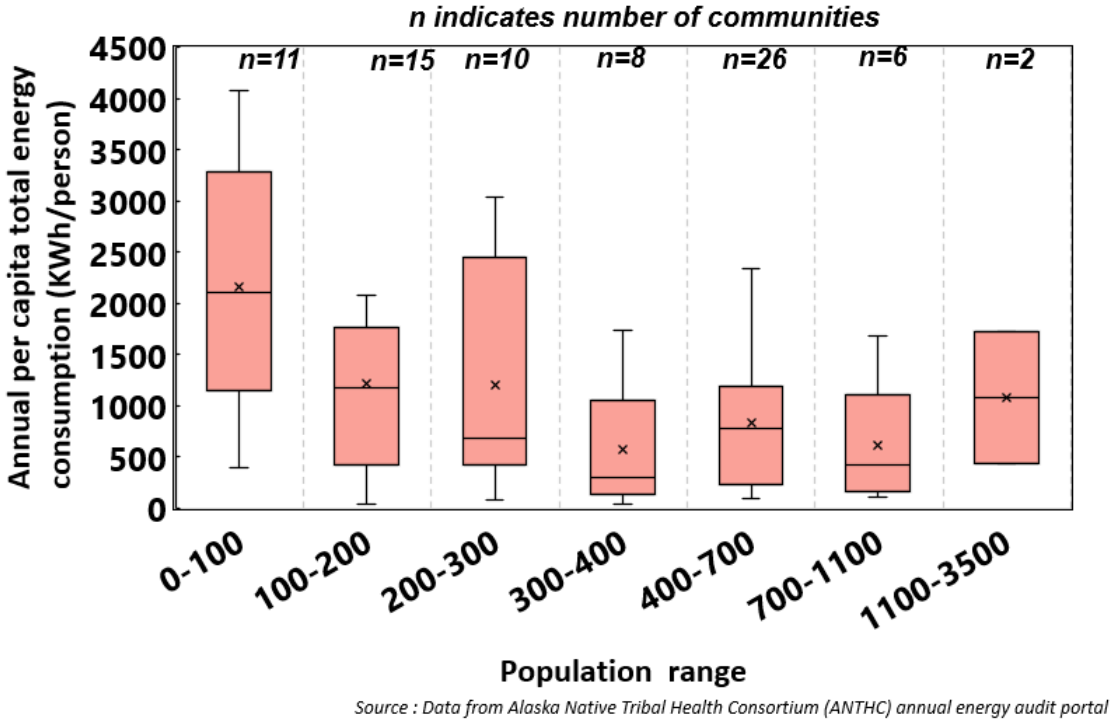


Figure 10: Annual per capita total energy consumption based on population variation.

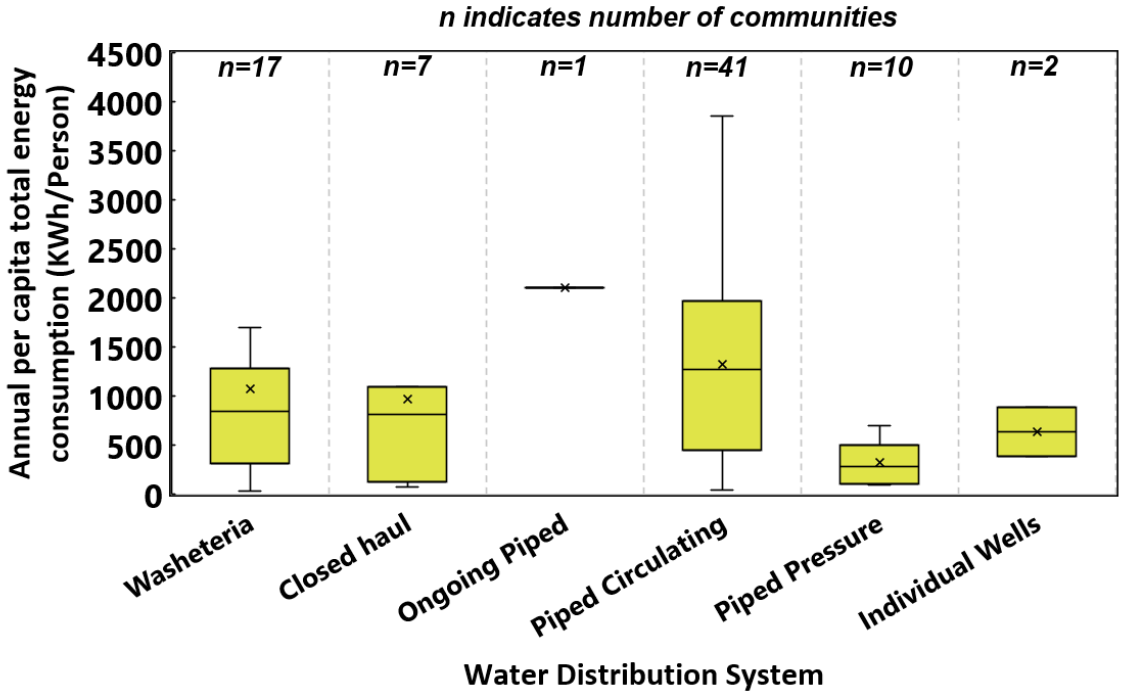


Figure 11: Annual per capita total energy consumption based on water distribution systems.

RESULTS: TOTAL ENERGY CONSUMPTION BY WATER TREATMENT PLANT UNITS

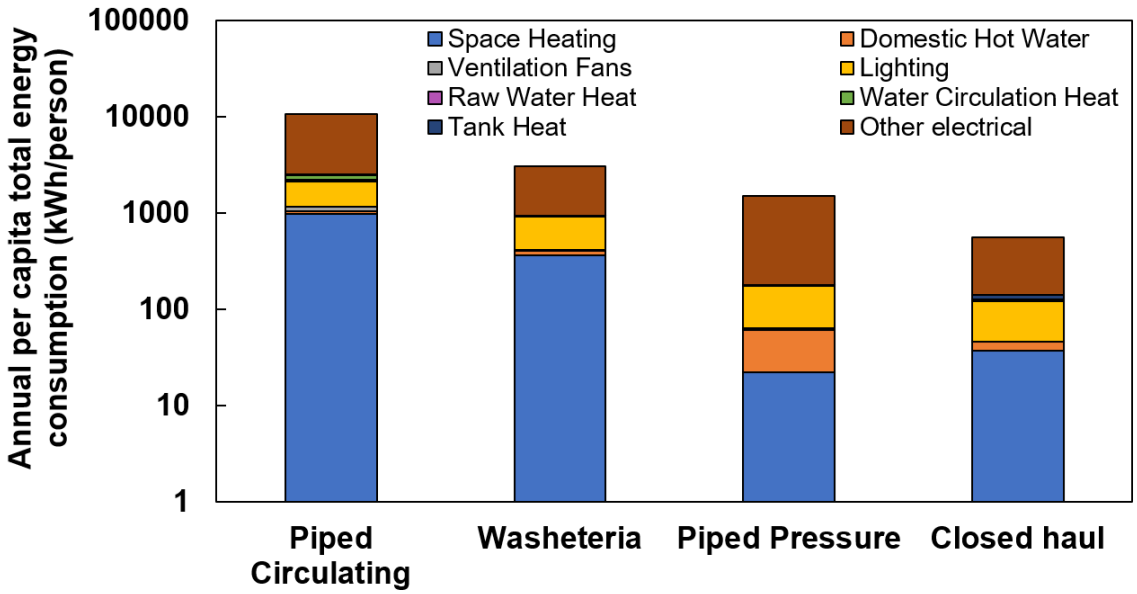


Figure 12: Variation of annual per capita total energy consumption by different units of water treatment plants based on the water distribution system type.

CONCLUSION & ACKNOWLEDGEMENT

Conclusions:

- Annual per capita total energy consumption is lower in summer months than in winter.
- Interior Alaska has the highest annual per capita total energy consumption than other regions.
- The piped circulating water distribution is the most energy-intensive system.
- Space heating, lighting, and other electricals like pumps and plug loads consume most of the energy in a water treatment plant.

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ABSTRACT

Rural Alaska, home to 229 Alaska Native tribes, is one of the coldest and most isolated regions in the U.S. As a result, it uses more energy than any other state and residents pay some of the highest energy costs per kWh. Water utilities rely heavily on electricity and heating oil to provide reliable service through the cold winter months. Stored water must also be continually heated and circulated with electric pumps to prevent system freeze-up. Individual homeowners with water and sewer services must shoulder costs for heat tracing lines, pump operation, and in-home water heaters to receive the crucial health benefits of water systems. The treated water is available at centralized community washeterias or distributed for in-home use through pipes, closed-haul, or self-haul. Using data from energy audits conducted by Alaska Native Tribal Health Consortium (ANTHC), we investigate the patterns of annual electrical energy consumption in 78 rural Alaska villages (average population <500 people) along with seasonal and regional variability, impacts of population, and water treatment/distribution system types. Preliminary analyses indicate that high energy costs and economic conditions in rural communities challenge the sustainability of water systems. A considerable percentage of a community's household income often pays for water and sewer and the largest portion of these costs usually goes to energy. Energy needs vary notably between communities and systems. Not unexpectedly, the per capita electrical energy consumption is highest during winter and lowest during summer months. Regional trends of per capita electrical energy consumption for water systems in the rural villages are as follows: interior>northern>southwest>gulfcoast>southeast. Generally, the per capita energy consumption decreased with an increasing population. The variation of per capita energy consumption based on water distribution shows that piped circulating systems consume the highest amount of energy, followed by washeteria, piped pressure, and closed haul. At the water treatment plant, the space heating and electricals consisting of pumps and plug loads show the highest per capita electrical energy use, followed by lighting, water circulation heat, domestic hot water, ventilation fans, raw water heating, and tank heat.