# Out of the wild: An energy retrofit prospective from the remote communities of Alaska

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## Abstract
Alaska is one of the US states with highest per capita energy use, which can be mainly attributed to its harsh climatic conditions. The long cold winters in Alaska mean that the heating demand in homes is very high, highlighting the importance of energy efficiency in the State's economy. For more than 30 years, state-funded efforts through its weatherization program (WAP) have allowed several residential buildings with poor standards to be retrofitted to higher thermal standards. The analysis presented in this paper provides information about the WAP program as well as historical successes and failures. Recommendations on how the program can be improved are provided, which include a building systems approach based on thermal dynamics and the development of effective education for program field technicians and clients.

## Introduction
This is a brief study of what has been learned from 30 years of applying energy efficiency to existing residential buildings in Alaska. The building stock in Alaska, especially in its remote areas, is often of low thermal standards and in need of renovation. The severe climate of the state coupled with the lack of resources makes it difficult to carry out maintenance and repair work in buildings. Without this work, the situation often gets worsened by the cold climate, which causes further degrading to the buildings, with additional moisture problems, heat flow and bad indoor air quality.

The paper examines the actions taken by the state funded residential weatherization program (WAP) to address such issues. The objective of this paper is to offer the audience practical knowledge gained from applying the science of energy efficiency. Based on the historical successes and failures, recommendations are offered for improvement of the program (WAP).

The structure of this paper is as follows. Information on the State of Alaska is first given, followed by a description of the Alaska Weatherization Assistance Program (WAP). The current status, successes and failures are then discussed and a list of recommendations, followed by conclusions, is then drawn.

## Background information on State of Alaska
Alaska is the largest state in the United States in land area at 586,412 square miles (1,518,800 $km^2$). It is 1/5 the landmass of the continental US, and has 640 sq. miles of land for every mile of paved road (1,038 sq kilometers per kilometer road). Despite its size, it is $47^{th}$ in total road miles compared to other US states: 75 % of the state is accessible only by boat or airplane and it has the most airplanes per capita.

The United States is the world's second largest consumer of energy, and Alaska as a state has the second highest per capita energy use in the nation at 946 Mmbtu per person.[1] This is almost three times higher than the national average of 327 Mmbtu, and is in part due to our climate, with long cold winters throughout most of the state requiring more energy for heating homes.

Alaska is the westernmost extension of the North American Continent. Its east-west span covers a distance of 2,000 miles (3,200 km), and from north to south a distance of 1,100 miles (1,700 km). The State's coastline, 33,000 miles in length (53,000 km), is 50 percent longer than that of the conterminous United States.

In a recent study, a combination of objective analysis and local expert knowledge identified 13 regions of homogeneous climatic variability, or climate divisions, for Alaska on the basis of observed station temperature[2] The average heating degree days vary from about 7,000 in the *southeast panhandle*, to 10,000 degree days in Anchorage in *south central*, 14,000 in Fairbanks located in the *Interior* up to 20,000 in Barrow located in the *Arctic* region. The state average degree-days are 11,358[3]. (Measurements are in degrees Fahrenheit interior temperature is 65 °F (18 °C). To convert, °C HDD = (5/9) × (°F HDD).)

Fuel oil is used for heating by a third of the population in Alaska[4], mostly in the road-less and remote areas. Fuel oil is expensive because it has to be barged or flown in: it is not uncommon to see prices up to US$8 per gallon (1.60 euro/liter). Electricity in the remote areas is also expensive since it is mostly generated by diesel fuel. The average cost to the rural consumer is ¢20 per kWh[5]. This cost reflects an AK government subsidy, where the unsubsidized cost is ¢37 per kWh.

A large amount of the dwellings in remote Alaska are substandard and not built to building codes. Because of the severe climate and lack of resources there is a lack of maintenance and repair. The severe climate is also degrading to the buildings by causing greater pressure differences creating driving forces for moisture and heat flow. Houses are often overcrowded with bad indoor air quality.

The majority of the residents in rural Alaska are Alaska Natives who live in villages with populations ranging between 25 and 5,000 (Barnhardt, 2001). Alaska Native people who live in rural areas maintain a distinct and unique lifestyle. Even though in most rural communities today one will see trucks, cars, snow machines, refrigerators, televisions, computers, telephones, and modern school buildings, these will be next to log cabins, dog teams, fish wheels, food caches, meat drying racks, and outhouses. Each village has at least one store, but many Native residents continue to practice a subsistence lifestyle and depend heavily on moose, caribou, seal, walrus, whale, fish and berries for their supply of food.

## Alaska Weatherization Assistance Program (WAP) in detail

The Alaska Weatherization Assistance Program (WAP) addresses existing residential structures. Services are provided at no cost to income-qualified applicants by designated Weatherization agencies and housing authorities. Since its inception in the late 1970's, it has served almost 40,000 residential structures. It is based on the application of weatherization measures that have a cost effective payback (essentially a simple savings to investment ratio of one based on net present value.). Along with the energy measures, other rehabilitation issues are addressed such as health and safety, building durability and accessibility. There are budget restraints so there is a need to prioritize what actual retrofit measures get applied. Current average investment per dwelling is US$11,000 (€8,458.51) for dwellings on road systems and US$30,000 (€23,068.68). As of March 5, 2012 the WAP has produced an average home energy efficiency savings of 28 % for single-family homes.[6]

#### MILESTONES

The early stages of the program saw the adoption of increases to the thermal efficiency and tightening of the thermal shell. The improvement selection was based on a prescriptive path.

Energy improvements included:

- Adding additional insulation to shell components.
- Replacing windows and doors with low u-value units.
- Installation of air and vapor barriers as well as air tightening.
- Replacing heating systems.

#### High efficiency heating systems

In 1987, Rural Community Action Program (CAP) established Rural Energy Enterprises (REE) as a profit-making entity within the agency's Energy Department. It secured the market franchise in Alaska for the efficient Japanese-made space heater Toyostove that ran on fuel oil and was direct vent. This was a huge advance for rural housing. Up to this point, a pot burner type stove was the main source of heat that was extremely inefficient (84 % efficient for Toyostove vs. less than 60 % efficient for an existing pot burner), difficult to control temperatures and backdrafting was not uncommon.

#### Building Airtightness

One of the most remarkable pieces of technology to arrive in the late 1980's was the calculated blower door test. The test is conducted using a calibrated fan installed in an exterior door along with a pressure gauge. With a measured pressure difference of 50 Pascals across the building envelope, a second pressure reading is read from the fan and converted to a CFM reading. This reading is referred to as CFM50 and gives a comparative reference to the airtightness of building shell. The blower door revolutionized energy rehabilitation and weatherization by providing a way to test building air tightness and target leakage paths. There was also a large advance in the understanding of how buildings perform under various operating conditions.

#### Pressure diagnostics

In the early 1990's the digital pressure gauge replaced the analog magnehelic gauge, increasing accuracy to measure pressure with an accuracy of ±1 %. The pressure gauge typically has two channels, each having an input port and reference port. The measurement is the difference of pressure between the two ports. This gave the ability to measure small pressure differences in a building and accelerated greater understanding of building science. Now it can be determined if air distribution and ventilation systems are balanced and performing safely.

#### Sealed combustion heating systems

As the program became more effective in air tightening of building shells, it became apparent that there could be adverse effects. These included poor indoor air quality and possible backdrafting of atmospheric combustion appliances. WAP began to shift focus more towards sealed combustion appliances. At the completion of a project, there was the assurance that all combustion appliances were operating safely. A combustion safety test is now performed on all dwellings.

#### Building standards for energy retrofits

During the last decade a new set of energy retrofit standards for existing buildings have been developed for WAP in Alaska. These standards are specific for WAP and are for existing residential structures that are being retrofitted by the program. The basics of the standards include minimum required assessment and testing protocols, approved upgrades and material specifications. Also included are minimum airtightness and ventilation levels, as well as required health and safety issues to be addressed.[7]

#### Energy modeling

Almost 100 % of all dwellings worked on in the WAP program now have a computer modeled energy analysis performed before and after to determine cost effectiveness of improvement measures and a determination of overall energy efficiency of the retrofitted dwelling. In the beginning, a rather primitive priority chart was used to calculate the energy usage before and after improvements. Since 1995, a computer-simulated energy-modeling tool has been adopted. This tool, called AkWarm®[8], was developed in Alaska and utilizes local climate data, energy resource costs and estimated retrofit costs. The quality of the output from AkWarm® relies entirely on the quality and accuracy of the detailed building evaluation performed by the assessor and the data the assessor inputs into the software application. Past studies indicate accuracy levels within plus or minus 10 % of actual energy use.[9]

#### Health and safety measures required and implemented

It is difficult to make efficiency improvements and ignore health and safety issues. Even though there is not a direct payback, the side effects of altering the performance of the building shell as well as the opportunity to address existing health and safety threats became an integral part of the WAP program. When applying energy improvement measures to existing buildings the laws of physics, especially thermodynamics are at play. A simple cost effective measure such as air tightening of the building shell can cause effect such as poor indoor quality or backdrafting of combustion appliances. These issues must be addressed, but require additional investment of resources and time. An example would be the installation of a HRV (heat recovery ventilator) for improving indoor air quality or a sealed combustion heating appliance upgrade to replace an atmospheric combustion appliance.

## Current status, successes and failures of the WAP

### EFFECTIVENESS OF APPLIED ENERGY MEASURES

At the WAP inception, the criterion for an energy improvement option was to have a cost to savings investment ratio of 1 (SIR-1). In other words, the energy retrofit measure would pay for itself with energy resource savings in its useful lifespan. This is a simple payback scheme with no consideration for rising fuel cost or increase in the monetary cost of applying the measure. These savings are modeled by AkWarm®.

### EXTREME CLIMATE CONDITIONS

Alaska is a land of extreme weather conditions. Often, inappropriate building types and materials have been adopted. This could be due to lack of understanding, economics or availability. Because of the extremes, building failure is common. Inappropriately applied materials or techniques can reveal failures rapidly.

### QUALITY OF WORKMANSHIP AND PROPER INSTALLATION

The Alaska weatherization program relies heavily on applied technologies and the actual implementation of upgrade measures. The application of measures depends on proper installation of appropriately selected materials. Because of this, accurate analysis of the building by assessors and quality workmanship by installers are essential to the success of the program. Extensive on the job training and in progress project monitoring can improve the overall outcome. Because most work is being applied to non-conforming, non-code buildings, innovation and creative approaches are essential. Work scopes must be clear and concise and open communication between management and the field technicians are keys for success.

### CONTROLLED MECHANICAL VENTILATION

Since the inception of weatherization programs, it has been known that air tightening of the building shell can be a cost effective energy improvement. As before mentioned, there are often side effects of greatly decreasing natural air exchange in a structure. Since a building is dynamic, less air exchange can cause elevated moisture in air resulting in mold and mildew, and also trap pollutants such as smoke, carbon monoxide gases and radon.

Therefore it is now mandatory to install a mechanical ventilation system in each dwelling. Because of budget restraints, exhaust only ventilation systems are most often selected. These systems consist of an exhaust fan (designed for continuous run) vented to the exterior of the building, and an intelligent switching device (i.e. humidistat or timer device). Whenever there is a gas range present, a range-hood is installed and also vented to the exterior. The problem with an exhaust only system is clean makeup air cannot be easily assured. The more effective system is a balanced heat recovery ventilator (HRV). The problems with HRV systems are they are more expensive to retrofit and require occupant knowledge of proper use and maintenance.

### CLIENT EDUCATION

The single largest variable of a successful weatherization program is occupant behavior. Being able to effectively communicate building science and conservation practices is a great challenge. Various training methods have been attempted in Alaska with varying levels of success. Methods include educating the individual households during the assessment in the dwelling, a class that the recipients of the program are required to attend, or an education packet that is given to occupants containing energy information. Less formal education happens during the project when the installation crew is at the dwelling. Currently there is a project in AK to include curriculum in the local schools.[10] National studies show the most success with client education involves behavior change and one on one discussion with residents can produce up to 16 % energy savings.[11]

## Recommendations for energy retrofit program success

- Implement a systems approach that considers the dynamics of building science and the practical application of energy upgrades.
- Identify the most cost effective, energy upgrade measures based on best practice and computer modelling. Select by building type, climate and condition and train installation technicians to those measures.
- Continue to have technicians utilize building test equipment in the field, especially the blower door. Practical knowledge and understanding of building science is essential at all levels for the proper installation of energy measures.
- Project management software is essential for the organization and tracking of projects. Field data should be easy to collect and retieve,
- Upgrade measures need to come with clear instructions, develop specifications and critical details that help the process of meeting or succeeding the standards.
- Energy savings to investment should reflect projected rising energy costs as well as carbon credit for the reduced demand.
- Develop a field monitoring test kit model; simple to apply, that collects real data to calculate cost effectiveness of measures and projects.
- Occupants continue to be a significant variable in the success of the energy efficiency programs. Develop a consistent client energy education model that considers culture and demographics and encourages behaviour changes. The energy education model should include a curriculum for primary and secondary schools, as well as occupant energy education that is adjustable to the particular building and conditions. Consider developing a digital-media tool that is interactive and adjustable to each situation.

## Conclusion

Government funded energy retrofit programs have varying degrees of success. This paper has examined the Alaska Weatherization Assistance Program, which has been in place for more than 30 years in the State of Alaska. Through this programme, cost effective weatherization measures have been applied in almost 40,000 residential buildings. What has made the WAP in Alaska successful are the dedicated people who believe in energy efficiency and work closely with the program. There are many decades of practical experience among the workforce, and the program has not been overly burdened by regulation. Energy efficiency consistently proves to be a cost effective investment towards a more sustainable future. The challenges are great, but the rewards are equally great.

## Endnotes


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