

Chapter 1

A History of Northern Energy-efficient Housing



Early Houses of Alaska's Native People

Originally, housing was necessary for early man to survive in harsh natural elements. Beginning with the earliest Neanderthals, people designed housing that would protect them as a means of survival. Energy efficiency, comfort and health are quite recent concerns that have spawned developments to provide occupants with better convenience at less cost. As our social sophistication has increased, so has our concept of shelter.

First Contact

At one of the very first contacts between Alaska natives and Europeans, an artist accompanying Captain James Cook on his third voyage was put ashore in Golovin Bay (then Golovnin Bay) on Alaska's Seward Peninsula. A small village had been observed, and the artist was charged with drawing it for documentation of the journey. This sketch is perhaps the first Western rendering of Alaska Native houses and living conditions by a European artist.

During the Russian colonial period, many drawings and sketches of the Aleutian *barabara* were made and are in the historical archives of Alaska and Russia. The early habitations had to use local materials: rocks, sod, animal skins, snow, moss, and the like. These homes were not durable and spring thaw could render them useless. However, some of the design features were elegant.

In Yupik Inupiat skin dwellings, an opening near the top of the domed skin hut was left to provide for air and smoke release. It was called the *qanaq*, which is the same word in that language as the word for "nose." Clearly the purpose of the opening was to ventilate.

Also, homes in Yup'ik and coastal Inupiaq regions were often designed with a very low subterranean entrance, which served two very useful purposes. First, it kept cold air from entering the dwelling when people came or went, since a low entrance is really a trap for cold air. Cold air, which is heavier, stayed low in the entrance and kept warmer air from leaving. Second, it provided a form of household defense, because anyone entering had to be stooping and in a vulnerable position. If they were undesirable, they could be fended off more easily.

Wood houses were used in southeast Alaska, especially for important community dwellings like clan houses. In the interior of Alaska, some log structures were used, but mainly Alaska Natives were too mobile to erect any permanent wood buildings, except in southeast Alaska.

More Contact: Whalers Come to the North

The technique of insulating houses became predominant in the era before Western contact with

Alaska Native people—a time when fuel was gathered by hand.

In his book *My Life with the Eskimo*, Vilhjalmur Stefansson (1913) describes the effect of Western-style housing on the fuel consumption patterns of Pt. Barrow Eskimos. It is an exceedingly insightful and lucid description and gives us all a valuable perspective to consider in our approach to northern housing:

The fuel problem has, of recent years, become a difficult one everywhere in the vicinity of Point Barrow. Up to thirty or so years ago the beach was thickly strewn with driftwood, for the Eskimo used only oil for heating, cooking, and lighting purposes, and whenever a stick of wood was thrown on the beach it

remained there until it decayed, which in the cold North is a matter of centuries. The houses the people lived in then were of such type that not much fuel was needed in order to keep them warm. They were not underground dwellings, but the wooden frames of which they consisted were covered with earth to such a thickness that the houses were practically cold-proof. These houses were entered through a long alleyway by a door that was never closed all winter, and the ventilating hole in the roof was always open, so that a current of air circulated through the house at all times. For this kind of a house two or three seal-oil lamps were abundantly sufficient to keep the temperature uniformly at 60° to 70° Fahrenheit the twenty-four hours through,



Figure 1.1: Artist's rendering of an Alaska Native village in Golovin Bay

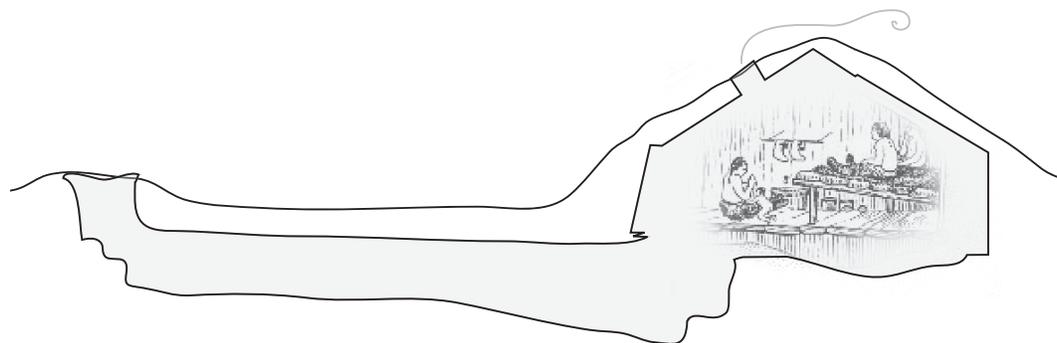


Figure 1.2: A low entrance to a semisubterranean house.

and the winter through. With the white men of the last half-century there came to the Arctic the white men's lofty and commodious frame dwellings. Although these are thoroughly ill adapted to the country they soon became the fashion, and the Eskimo began to build their poor hovels in the best imitation they could make of the pretentious homes of the foreigners. The flimsy walls of these new dwellings admitted cold by conduction so that the seal oil lamps were no longer sufficient for keeping them warm, and even the sheet-iron stoves in which driftwood could be burned had difficulty in keeping them at a comfortable temperature. Driftwood lay in apparently inexhaustible windrows along the seashore, but these were the accumulations of centuries, which the Eskimo, having no use for wood as fuel, had allowed to grow. Now, instead of being used as formerly only in the construction of the house frames and in the making of sleds and implements, the driftwood was used for fuel in an attempt to keep the flimsy new-style houses warm. The result was that the driftwood disappeared so rapidly that in thirty years, by the use of stoves, all of it is gone, from Point Hope to thirty miles east of Point Barrow. With the increasing scarcity of fuel the ventilation of the houses had to be curtailed gradually, so that the modern Eskimo house is practically hermetically sealed against fresh air. If there is a key-hole in the door you will find it stuffed with chewing gum.

Not only is the fuel problem serious from an economic point of view, it is even more serious as a question of sanitation. Although a few of the Eskimo are able to import coal from Seattle, and others can get it through difficult labor from the coal mine at Wainwright Inlet, the majority have not the means to secure fuel of any sort sufficient to keep the new-style houses warm. Instead of the comfortable, well-ventilated, and therefore healthful dwellings of a few years ago, we now have hoarfrost-coated and unventilated frame houses which look well in photographs to those used to frame houses in temperate climates, but which are among

the chief causes of the high death rate among the Eskimo, through their encouragement of pulmonary consumption and other diseases that flourish in filth and foul air.

Russian Influence on Early Alaskan Housing

Another excellent description of indigenous housing is also given in the 1925 annual report by Mr. and Mrs. Samuel P. Troutman, school teachers and missionaries at Gambell on St. Lawrence Island, one of the last northern coastal areas to be settled by Westerners. At the time, Gambell was a small Russian Yupik village of around 240 residents on the northern tip of the island, with only 35 miles of Bering Sea separating it from the Russian mainland. To put this location in perspective, Gambell is almost 200 miles from Nome, on the Alaska mainland.

Troutman's description of housing in 1925 begins:

The typical native house is polygonal in shape averaging about 40 feet in diameter. The wall, which is from five to six feet high, is made of two inch planks and driftwood placed on end and firmly nailed together. The roof is dome shaped, supported by poles, and covered with walrus skins fastened to the wall by means of skin ropes and weighted down with large pieces of wood, iron, bone and large stones. The highest point of the dome is about twelve feet from the ground. On the west side of the house is the entrance which is a rectangular opening about two and a half by three feet placed about two and half feet above the ground. This makes it awkward for one to enter who is not to the manner born.

Inside this larger house and quite independent from it is a smaller house eight feet wide and from ten to twenty feet long with a five foot ceiling, the walls of which are of double construction made of a light frame and walrus skin—the

intervening space being filled with dry grass. The dome shaped top is a single frame overlaid with old walrus skin covered with thick grass mats. Along the entire front part is a curtain of reindeer skins fastened firmly at the top and sides but left free at the bottom. Under this one must crawl on hands and knees to enter. The floor consists of walrus skin covered with layers of grass over which another walrus skin is stretched. Under the lower edge of the curtain and extending the entire length of it is a log about six inches in diameter, which serves as a headrest while sleeping. The air space for each person averages 88 cubic feet.

In this small area the natives live, move and have their being. All the functions of family life are performed here. There is no furniture, not even a stool on which to sit. Everybody sits and sleeps on the floor. Shelves for a few dishes and tools may be found in the corner while the seal oil lamps (usually three), which furnish heat and light, are placed on the floor. There are no windows. The only means of ventilation is through an

opening six inches in diameter cut near the ceiling in the curtain, which forms the front wall.

Since there may be from six to eighteen people in one house, each person has his allotted place to sit and sleep. Everyone sleeps side by side on heavy reindeer skins, with their heads on the wooden head rest mentioned above and is disposed as to keep order and propriety. Their coverings consist of blankets and reindeer skins. The room is kept so warm that the natives wear no clothing inside except a loin cloth worn by adults of both sexes, while children up to ten to twelve go entirely naked.

Cooking is done over the seal oil lamps and the table consists of a long wooden plate from which each helps himself as he feels disposed. Many use spoons although some still find it more convenient to eat with no more aid than their fingers.

The house described by Troutman is similar in shape and construction to those found on the Siberian mainland.



Photographer, Riley D. Moore, 1912. NAA-Smithsonian Institution, Negative SI 85-820 (Reprinted from: *Akuzilleput Igaquilliget. Our Words Put to Paper* 2002, p.415).

Figure 1.3: A St. Lawrence island Yupik family in front of the traditional winter house (*mangteghapik*) in Gambell.



Photographer, Riley D. Moore, 1912. NAA-Smithsonian Institution, Negative SI 85-819 (Reprinted from: *Akuzilleput Igaqulliget. Our Words Put to Paper* 2002, p.416)

Figure 1.4: Men in Gambell, St. Lawrence Island, put a new skin cover on the traditional winter house, *mangteghapik*.

Though construction of subterranean houses on the Alaska mainland was similar, some divergence of design is apparent. The polygonal shape was not popular in the Alaska designs, nor was the double-wall construction. This Siberian domed design allowed for rain and meltwater to flow to the building's exterior, and the house-within-a-house approach facilitated a dry inner sanctuary with additional dry storage around the perimeter.

Out of necessity, material used in construction was entirely sustainable in nature. The fact that only two or three seal oil lamps could heat such houses in extreme cold weather is impressive. Calculations show that the typical seal oil lamp was capable of a BTU output ranging from 500 to 2,500 BTU per hour, making these homes some of the most efficient constructed, again out of necessity.

Even with their understanding of the need for ventilation, occupants of early Eskimo housing were not healthy due to infrequent use of the building's *qanaq* to ventilate the house. Later research has proven the human organism to be a poor judge of when ventilation is needed for reasons of health and comfort.

Early Interior Dwellings

Not all Native dwellings were patterned after Inupiat and Yupik houses. Bands of Athapaskan Indian people traversed Alaska's interior as recently as sixty-five years ago. Their seasonal movements were timed with fishing, hunting, and gathering. Protection from wind, rain, and snow was important to early Alaskans because of our cold climate. Efficient heating and easily acquired fuel allowed them to incorporate lightweight



Figure 1.5: The main Native groups in Alaska

natural materials as insulation and designs that minimized air leakage.

Early prehistory interior Athapaskans used the Western Plains tepee or similar designs. In common with the Crow band in Montana, the tepee consisted of up to twenty long (24 foot) straight poles with bases set in a circle and tops gathered together and lashed with animal gut rope. This pole frame would be covered with numerous overlapping layers of large animal skins such as bear, moose, and caribou. The floor would be built up with layers of dry grass and then covered with moose or caribou hide to provide for a warm, insulated floor that could be swept clean. Outer portions were usually dedicated to sleeping quarters because the slope of the walls made standing upright easy only in the center of the tepee.

A heating and cooking fire was set in the center surrounded by rocks, and by moving one or another pole to which a skin flap was attached at the top, the occupants could control heat and ventilation by natural convection. Tepees were portable dwellings that provided shelter from the elements in a wide geographic area. It is difficult to find remains

of prehistoric tepees because all elements of its construction were biodegradable.

As the Europeans moved north, many local tribes adopted the log cabin but still used Western-style tents in summer fish camps. Figure 1.9 depicts the Athapaskan village of Moosehide on the Yukon River with an early log cabin and tent, circa 1898.

Tlingit and Haida Houses

Traditional Tlingit territory in Alaska includes the Southeast panhandle between Icy Bay in the north to Dixon Entrance in the south. Tlingit people have also occupied the area to the east inside the Canadian border. This group is known as the Inland Tlingit. The Tlingits have occupied this territory for a very long time. The Western scientific date is about 10,000 years, while the Native version is “since time immemorial.”

The original homeland of the Haida people is the Queen Charlotte Islands in British Columbia, Canada. Before contact with Europeans, a group migrated north to the Prince of Wales Island area in Alaska. This group is known as the Kaigani, or Alaska Haidas.

Today, the Kaigani Haida live mainly in two villages, Kasaan and the consolidated village of Hydaburg.

The original homeland of the Tsimshian is between the Nass and Skeena rivers in British Columbia, Canada, although at contact in southeast Alaska's Portland Canal area, there were villages at Hyder and Halibut Bay. Presently in Alaska, the Tsimshian live mainly on Annette Island, in (New) Metlakatla, Alaska in addition to settlements in Canada.

Before and during early contact with the nonaboriginal population, the people built their homes from red cedar, spruce, and hemlock timber and planks. The houses, roofed with heavy cedar bark or spruce shingles, ranged in size from 35 to 40 feet to 50 by 100 feet, with some Haida houses being 100 by 75 feet. All houses had a central fire pit with a centrally located smoke hole. A

plank shield frames the smoke hole in the roof. Generally, each house could hold twenty to fifty individuals of one clan, with a village size between 300 to 500 people.

The people had winter villages along the banks of streams or along saltwater beaches for easy access to fish-producing streams. The winter villages were located to give protection from storms and enemies, drinking water, and a place to land canoes. Houses always faced the water with the backs to the mountains or muskeg/swamps. Most villages had a single row of houses with the front of the house facing the water, but some had two or more rows of houses.

Each local group of Eyak, Tlingit, Haida, and Tsimshian had at least one permanent winter village with various seasonal camps close to food resources. In each Eyak village, there were two potlatch houses, outside of which were



Figure 1.7: An artist's drawing of a barabara at Unalaska (Unalaska) from the "Report of the Cruise of the Revenue Cutter Corwin in the Arctic Ocean in the Year 1885" by Capt. M. A. Healy, USRM, Commander. Washington: Government Printing Office, 1887.

posts topped with an Eagle or a Raven. The dwelling houses were unmarked. The southern Tlingit had tall totem poles in front of their houses. The northern Tlingit houses had fewer and shorter frontal totem poles.

Aleut Housing

To build an Aleut house, called a *barabara*, they would start by digging a rectangle in the ground, no more than fifty feet long and twenty-five feet wide. Then they would build the roof using driftwood and whalebone. Over that they would put sod and moss. Inside the house they portioned off rooms for the separate age groups occupying that house. Usually extended families (cousins, aunts, etc.) shared a house. They would dig trenches inside the separate rooms and line them with fur. That was where everyone worked and played. Inside the main hall there was a trench along one wall that was used as a common bathroom. They would soak skins in it to try to reduce the smell. (Above is

from http://library.thinkquest.org/11313/Early_History/Native_Alaskans/aleuts.html)

These early designs for northern people living in extreme climate zones provide insight into what is possible without written communication and training in modern engineering and architecture. Some indigenous Alaskan people say, “Before the Europeans came we built our houses in the ground and buried our dead above. Now we build our houses above ground and bury our dead below. We haven’t been warm since.”

Our present understanding of buildings has become a true science, building science. The awareness for how buildings perform is based on physics and accurate long term weather records, heating content of fuels, occupant behavior and many other related elements. Knowing how we came to our current understanding is important because it explains many of the problems that have been encountered along the way.

Discoveries Along the Way

Five distinct climate zones are recognized in Alaska. Because of the broad expanse that it covers, the original people used widely varying housing designs. While this was true before the impact of Western civilization, Alaskan climate zones still require greatly different approaches to our modern construction methods.

It is common, and really quite comical, to encounter someone unfamiliar with our state who asks the question “What is the climate like in Alaska?” Using the largest community of Anchorage as the starting point, the following distances indicate the expansive area covered by Alaska.

Distances from Anchorage

- Adak is 1,300 miles southwest
- St. Paul Island is 750 miles west
- Barrow is 725 miles north
- Metlakatla is 800 miles southeast

Insulation

As European influence settled across the territory of Alaska, new designs and materials became available for construction of housing. One of the major changes to construction was using insulation in attics and walls. Early insulation consisted of sphagnum moss used as chinking between logs and then above ceilings in attics. When dried, the moss would become rigid, similar to a fibrous insulation. This dried moss would reduce air movement, in effect adding resistance to heat flow.

Early pioneers brought whip saws with them to make boards and lumber for construction. Sawdust from these whipsaw pits would be collected and dried for use in attics and walls. Numerous early log houses in Fairbanks have been framed over and new siding placed around their exterior. In many of these buildings still standing, the space

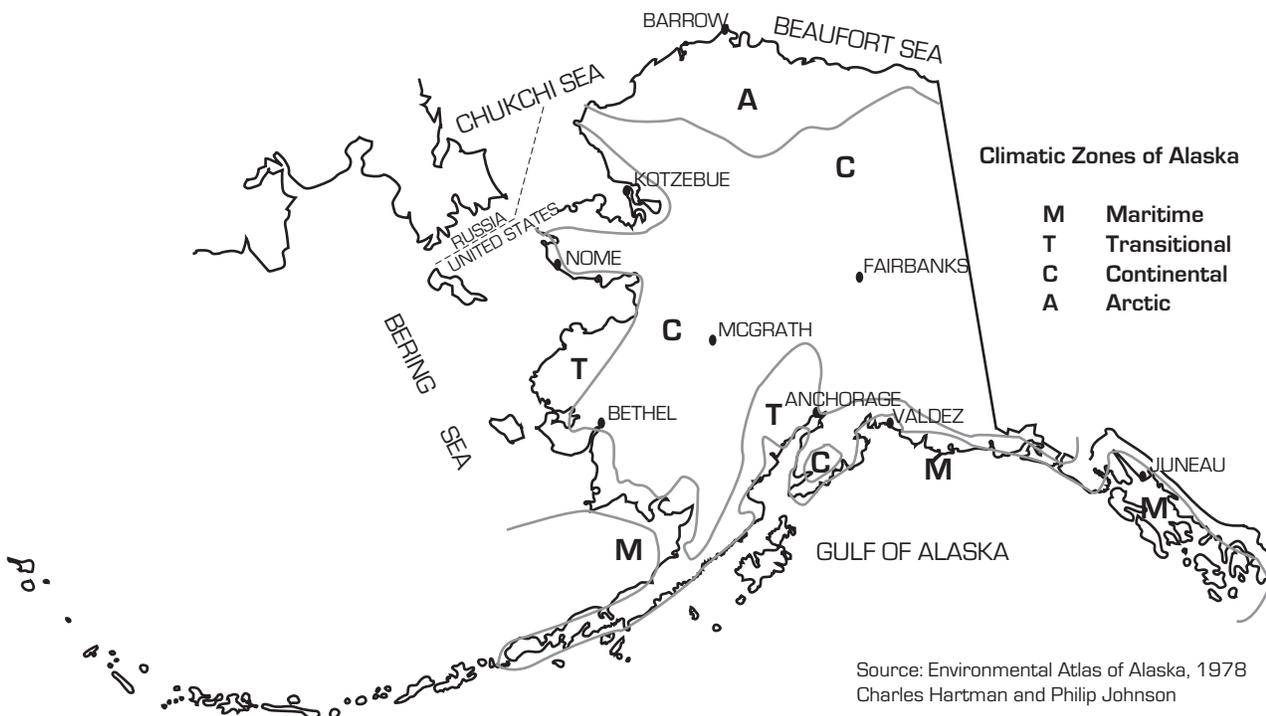


Figure 1.8: Climatic zones in Alaska

between the siding and logs is filled with sawdust from lumber mills. Our experience with the insulation properties of sphagnum moss and sawdust led to the invention of different types of insulations.

Framing Design

Another change occurred with improved design of walls. Early multiple-story buildings were framed as one section that would allow air to easily move upward between floors. This movement of air from the lower wall would take heat with it, increasing fuel use and reducing comfort. Balloon framing required sixteen-foot studs, and the walls required a large crew in order to stand them up. Around 1915, we learned that smaller trees could be used in wall construction with eight-foot stud framing. On top of this wall a platform would be placed

and the second and subsequent floors were then built above the first. Crew size could be reduced and the shorter studs were less expensive than those used in balloon framing. Platform-style construction, while improving the use of wood resources, also brought reduced fuel use by effectively blocking air leakage between floors.

Plywood

Plywood was the first type of engineered wood to be invented. It is made from thin sheets of wood veneer, called plies, which are stacked together with the direction of each ply's grain differing from its neighbors by 90 degrees. The plies are bonded under heat and pressure with strong adhesives, making plywood a type of composite material. Plywood is believed to be an invention of the Egyptians, who first thought of putting

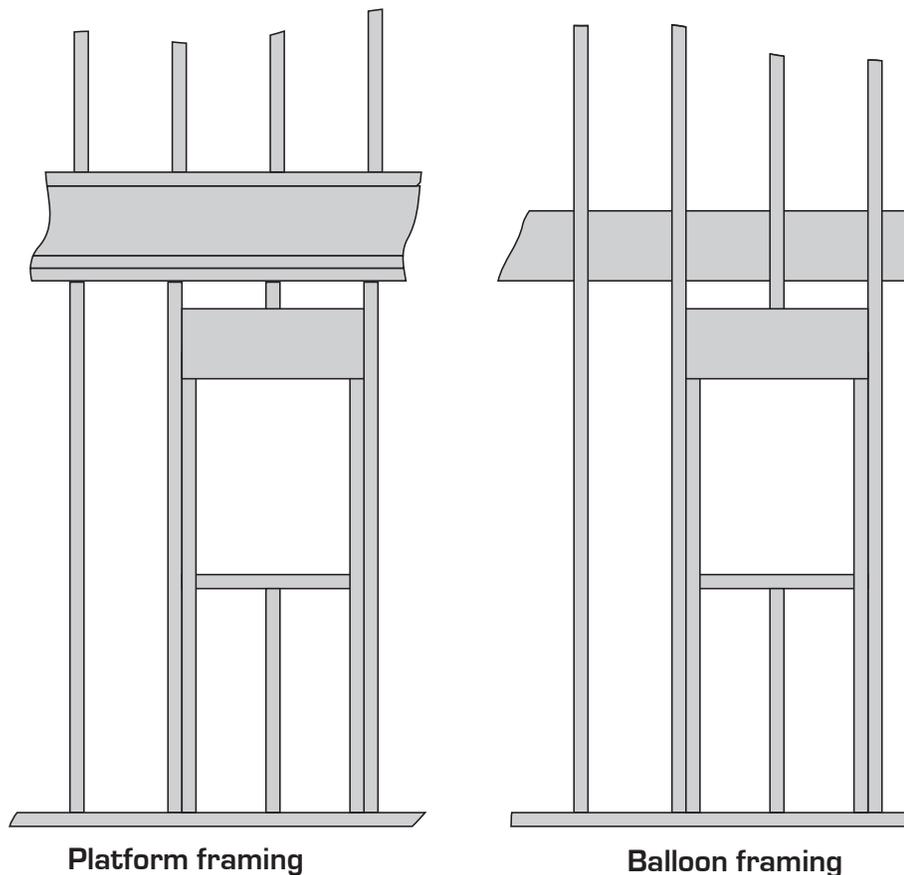


Figure 1.9: Two kinds of wall framing

together several thin layers of wood to make one piece of wood. This was done around 2,800 BC, primarily because they had a severe shortage of good-quality wood. However, the plywood as we know it today was invented by Immanuel Nobel, the father of Alfred Nobel, inventor of dynamite. It was Immanuel Nobel who worked out that several slim layers of wood glued together would form a stronger piece than just one single layer of wood.

There are many varieties of plywood, tailored for all manner of conditions and uses. Plywood production requires a good log, called a peeler, generally straighter and larger in diameter than that required for processing by a sawmill. The log is peeled into sheets of veneer, which are then cut to the desired dimensions, dried, patched, and glued together to form the plywood panel. The panel can then be patched, resized, sanded, or otherwise refinished, depending its intended use. The most common varieties of plywood come in three, five, or seven plies with dimensions of 1.2 m x 2.4 m (4 feet x 8 feet).

Modern plywood, in which the veneer is cut on a rotary lathe from soft-

wood logs, is of relatively recent origin. The first such lathes were set up in the United States in the mid-nineteenth century. With the advent of World War II, wood resources became increasingly more important. A material that would cover a large area and have strength beyond that of naturally found materials was needed for aviation and vehicle construction. Plywood was the answer.

After World War II there was a surplus of plywood manufacturing equipment, and it naturally evolved into being one of the most predominant building materials used today. Plywood allowed an even tighter building by eliminating the many cracks and joints common with earlier plank and shiplap construction. Tighter buildings meant less natural air leakage and even less fuel use. When plywood was combined with insulation in building walls and attics, the fundamental materials of today's housing industry came into being. Plywood has since evolved into numerous types of particleboard and oriented strand board (OSB), making use of smaller wood particles and using advances in adhesives and manufacturing processes.

Post World War II Developments in Alaska

More Frame Houses

World War II also radically changed much of Alaska. The construction of airfields brought air freight and infrastructure to Alaska, and the construction of the Alaska highway made an automobile trip and truck freight from the lower forty-eight states possible.

Although techniques for frame construction were brought with many immigrants during the mining era, after World War II, everything accelerated, and frame houses were the norm. But air sealing, insulation, and various other aspects of housing were not adapted well to the much colder and longer winters of interior Alaska, and so housing quality left much to be desired.

The roots of superinsulation pre-date the energy crisis, extending back to the mid-1960s when two men, Harry Tschumi and Les Blades, promoted the use of heat pumps. Tschumi sold heat pumps and Blades worked for the Arkansas Power and Light Company. Around 1961, they discovered that by increasing insulation levels and improving window thermal performance, heating houses required less energy for heating and thus were better suited for heat pump applications. At that time low energy prices prompted few homeowners to pay the extra construction cost.

The 1970s

The first oil embargo in 1973, which was followed by the assertion of the Organization of Petroleum Exporting Countries (OPEC), of price control by cartel economics. This is a sort of clique of countries that produce oil, and agree to sell it at a fixed price from each to the rest of the world, thus controlling the price of oil. Prices soon doubled from what they were before 1970, and

the world paid attention. Much of the original impetus for superinsulation and housing energy efficiency stems for the price shocks and the application of building science to the new attempts to build more energy-efficient houses.

It wasn't until 1974 that housing analyst Frank Holtzclaw of the U.S. Department of Housing and Urban Development (HUD), brought Tschumi's ideas to fruition. Holtzclaw initiated the Arkansas Project, a series of radically designed superinsulated houses that were not only very energy efficient but also inexpensive. Between 1974 and 1975, thirty-five homes were built and monitored for energy consumption. Annual heating and cooling costs were about \$130, considered low even at 1975 energy prices. The Arkansas houses had 6-inch walls with R-19 fiberglass insulation and a special raised-heel roof truss, now commonly referred to as the Arkansas truss.

The man usually credited with coining the term "superinsulation" is Wayne Shick, an architect with the Small Homes Council at the University of Illinois at Urbana-Champaign. He had worked since the 1940s with several other faculty members on methods of increasing the thermal performance of houses. While lecturing about energy savings from increased levels of insulation, Shick made reference to a maximum practical level and called it "super" insulation. In 1976, Shick's team developed a design called the "Lo-Cal" house. It included double 2 x 4 walls with R-30 insulation and ceilings insulated to R-40, and double-glazed windows with most of the glass on the south side of the house. Computer simulations indicated that a house built with the Lo-Cal design needed one-third as much heating energy as specified by the newly

created HUD standards. Shick's team never built a Lo-Cal house, but many of the details of that design are incorporated into present-day superinsulation techniques.

However, Shick may not have actually coined the term "superinsulation." According to Alaskan lore, the person who first used the term was Bob Roggasch. The Fairbanks designer used the term to refer to a house he built in 1971, which had walls filled with 9-inches of ground-up urethane. Roggasch, his Fairbanks neighbor Ed McGrath, and University of Alaska Cooperative Extension engineer Axel Carlson monitored, analyzed, and evaluated the Roggasch house. The three men became acknowledged authorities on energy conservation.

At the same time, environmental issues and awareness were raised with the passage of the National Environmental Policy Act of 1971. Alaska pioneers such as Dr. Eb Rice, professor at the University of Alaska Fairbanks in the Civil Engineering Department, and Axel Carlson, University of Alaska Extension engineer, were doing basic research on all aspects of heating, permafrost design, and vapor barrier attention that became hallmarks of appropriate design for the north. These scientific people were working in Alaska and would lead us to a solid position in the area of housing adapted to the climate.

The first of these was Dr. E. F. (Eb) Rice. Rice developed the arctic engineering curriculum for Alaska. The oil development at Prudhoe Bay was pumping research money into the science departments, and Rice was leading the way toward solutions to engineering problems, including housing. His book, *Building in the North*, is still a very readable and entertaining look at the problems and solutions to living in the North. The book was the first major Alaska-specific treatment of the principles of heat, moisture, frozen ground,

insulation, and other details pertinent to building in subarctic and arctic climates. The chapters cover all the major principles that make building in the north unique.

Many of the things Rice pointed out in his original work are still crucial today. One of the first he attended to is the threat of fire. He recognized that once fires start, they are more difficult to fight in the far north than elsewhere. Here temperatures are below freezing for a large portion of the year, and firefighting may involve freezing while fighting the fire. Frostbite can occur, and the necessity to rotate fire fighting crews to protect them from freezing and hypothermia is clear. Fire still remains a major threat in Alaska, which has one of the highest fire loss rates in the United States. Many of the concepts that Rice first suggested are now standard practice.

Rice also pointed out a list of things that the builder in the arctic ought to consider. First go heavy on fire warning equipment: smoke detectors, periodic inspections, good housekeeping. Today we would add to the list, carbon monoxide detectors and hand fire extinguishers that are familiar to people and are placed regularly within a building and within easy access. We must ensure that every structure has ample escape routes (egress). Buildings should anticipate snowdrifts, prevailing wind direction, and windows that are operable for egress; these have all trapped people in burning buildings.

Finally there is the clear advantage of having duplicate facilities in small communities that are well separated. If a structure burns, there should be another one nearby that can accommodate the displaced people and provide them with food, warmth, and communications. It can save their lives. It also gives them time for rebuilding or rescue.

Another aspect of northern life that Rice pointed out has become a tenet of our basic building philosophy: Alaska is full of disasters waiting to happen. For this reason all kinds of redundancies should be designed into a house. As security issues become more important in the world it is even more crucial to recognize the necessity for sources of heat and perhaps water that are not dependent on electricity or outside power. Often this means a wood or propane stove backup for heating and cooking. For every reason in all locations this is good planning.

Along with the history of building issues comes the history of foundations and their performance under permafrost conditions. Because of Alaska's climate, our military and mining experience, and general difficulties encountered in dealing with all sorts of permafrost issues, the University of Alaska became a major center of permafrost research throughout the circumpolar north. Rice talks about this in great detail in his book. Rice actually lived on permafrost for all his Alaskan life and loved the challenge it gave him. He has a chapter in *Building in the North* called "Permafrost, Its Care and Feeding." Permafrost is always a threat in most of the areas north of the Alaska Range and west of the Cook Inlet region. It is not an issue in the Aleutians and southeast Alaska, areas of southcentral Alaska below 2,000 feet, and close to the coast.

Rice also mentions the design advantage of minimizing the surface-to-volume ratio in a building. The smaller the area exposed to weather, the less heat and materials needed, so the larger volume the you can enclose with the least material, the better. A sphere is the minimum surface-to-volume ratio, but a cube is much easier to build.

Inaccessible piping needs to be avoided. The old nemesis of placing plumbing in exterior walls where it can easily freeze and therefore fail at the wrong time and cause complicated problems must be avoided.

An entrance must be arranged so that it can be easily adapted to varying wind conditions. Entries that are regularly covered by blowing snow are a problem for the life of the building.

Finally there is simple material resistance to heat and moisture flow. Trapped heat and controlled air leakage can actually lead to overheating, so at times you must ventilate. Materials that are vulnerable to moisture degradation are a continuous problem, and that leads us to the idea of a vapor barrier to control moisture condensation and water damage in buildings.

Axel Carlson was another pioneer in Alaska building techniques. He was the agricultural engineer for the Cooperative Extension Service from 1968 to 1980. He was instrumental in bringing the concept of vapor control to the Alaskan building industry. He made it his life's work, and he was known as "Mr. Vapor Barrier" for the duration of his professional career, and long after. He was one of the first to recognize and make publicly known in several useful publications through the Cooperative Extension Service that most of the problems with moisture were created by indoor air and water vapor leaking through a building shell and causing havoc when it condenses into liquid water. Once this was widely understood it became an easy case to make vapor and moisture control an integral part of good housing designed for the north. Carlson's work enabled us to have a good understanding of how heat and moisture flow work in buildings and showed how the exterior environment affects buildings.

Working independently, Richard Bentley developed and patented in 1976 a design for a double-wall house using an innovative truss system. His patent stresses the need for airtightness and includes a site-built heat-recovery ventilation system (air-to-air heat exchanger). Bentley and his family built a few houses using his design. Although he hasn't gained much publicity, he is definitely one of the originators of the modern superinsulation concept.

The excellent performance of energy efficient houses was demonstrated to the American public through two well-publicized houses in distant parts of the continent: the Saskatchewan Conservation House, built by the Canadian government, and the Leger House, built by Gene Leger in eastern Massachusetts.

Saskatchewan House

The Saskatchewan Conservation House was built in 1977 by a Canadian team headed by David Eyre of the Saskatchewan Research Council. It may have been the first superinsulated house to demonstrate airtight construction as practical, drastically reducing energy consumption. It may still be one of the most energy-efficient houses ever constructed. The 12-inch-thick walls are filled with R-44 insulation, and the ceiling is insulated to over R-60. The house's most distinctive feature is its airtightness. Harold Orr of the Canadian National Research Council supervised the careful installation of a continuous airtight membrane. This resulted in an air-leakage rate far below conventional houses. To ensure adequate fresh air and indoor air quality, a ventilation system with an air-to-air heat exchanger was incorporated into the design.

The most desirable aspect of this house is its energy performance. When the outdoor temperature is -1°F, the total heat demand is about 3,000 watts

(10,640 BTU per hour), less than the average output of a clothes dryer. In the Saskatchewan house with shutters closed, no people in the house, and no heat inside source, the house cools at a rate of less than one degree per hour. According to Harold Orr, the total annual heating cost would be about \$35 in 1978 Canadian energy costs. Originally, an expensive array of solar collectors using evacuated tubes was installed on the roof. However, project managers were quick to realize it would be difficult to justify a \$10,000 solar heating system to displace a \$35 annual fuel cost, so the solar collectors were removed.

The Saskatchewan Conservation House is an example of extreme applications of insulation and building technology. Neither its enormously thick insulation systems nor its general design were immediately accepted by the general housing market. But experience gained in building it affected superinsulation more than any other project. It proved that it is possible to design and build a comfortable house that needs almost no heat, even in a northern climate.

Leger House

About the same time the Saskatchewan home was built, builder Eugene Leger (pronounced 'le jay') invented a superinsulated house design in eastern Massachusetts. Leger's design included double walls and extremely airtight construction, although many of his framing details were quite different from those of the Lo-Cal or the Saskatchewan House. His first house, the Leger House, required so little space heat that heating requirements could be met by using a regular-sized domestic water heater with no need for a furnace or boiler. The annual heating bill was \$40. Unlike the Saskatchewan House, Leger's house looks like millions of conventional American houses and costs only slightly

more than standard construction. Leger and his house were widely publicized. The Leger House proved that energy-efficient construction is practical and economical and impressed the public.

Leger wrote to William Shurcliff, a Harvard physicist and noted author of books on many energy-related subjects. Shurcliff was so impressed by Leger's design that within a few days of getting the letter, he put a press release, saying that these new superinsulate homes had the following features:

1. Truly superb insulation. Not just thick, but clever and thorough. Excellent insulation is provided even at the most difficult places: sills, headers, foundation walls, windows, electric outlet boxes, etc.
2. Envelope of the house is practically airtight. Even on the windiest days the rate of air change is very low.
3. No provision of extra-large thermal mass. (Down with Trombe walls! Down with water-filled drums and thick concrete floors!)
4. No extra-large south windows. Use normal number and size of south windows, say 100 square feet.
5. No conventional furnace. Merely steal a little heat, when and, if needed, from the domestic hot water system. Or use a minuscule amount of electrical heating.
6. No conventional distribution system for such auxiliary heat. Inject the heat at one spot and let it diffuse throughout the house.
7. No weird shape of house, no weird architecture.
8. No big added expense. The costs of the extra insulation and extra care in construction are largely offset by the savings realized from not having huge areas of expensive Thermopane glass, not having huge well-sealed insulating shutters for huge south windows, not having a furnace or a big heat distribution system.
9. The passive solar heating is very modest, almost incidental.
10. Room humidity remains near 50 percent all winter. No need for humidifiers.
11. In summer the house stays cool automatically. There is no tendency for the south side to become too hot—because the south window area is small and eaves shade the windows.

Shurcliff continued investigating on his own and wrote the book, completed that same year, *Superinsulated and Double-Envelope Houses*, published privately by the author and later by Brick House Publishing.

The 1980s

By 1979, a second oil embargo and oil price rise resulted in another wave of influences and increased use of the superinsulated house. However, problems with superinsulation immediately became apparent. These houses were extremely airtight, which led to problems with moisture. All kinds of bad publicity resulted from this early phase of experimentation and development. Building scientists realized the need for moisture control using a good vapor barrier and a technology that came from Canada, the heat recovery ventilator. The heat recovery ventilators first presented to Alaskans were a home-built kit advocated by the University of Saskatchewan.

It turns out that the first air-to-air heat exchangers were designed for hog farrowing barns. A mechanical engineer named Bob Besant at the University of Saskatchewan, explained that hogs produce a lot of heat and moisture and need a lot of ventilation for their facilities where farmers raise the young piglets. Consequently a system was designed that could be built by farmers and do-it-yourself individuals. It was made of plywood and polyethylene sheets that were the heat exchange

surfaces, with two fans designed to exchange heat and eliminate moisture from the inside of a building.

The size and scale of the system was just about ideal for a human habitation, so they were adapted to the first superinsulated houses in the early 1980s and eventually tested at the University of Alaska by professor John Zarling for their efficiency and functional quality. This led to commercial development of similar systems and they were improved all through the 1980s, and necessarily so. Without the element of good ventilation control, superinsulated houses would have never met wide public acceptance.

Canadian R-2000 Program

In Canada, the Canadian Department of Energy, Mines, and Resources set up a subsidized program to train builders to construct energy-efficient homes. Called the R-2000 program, it has been extremely successful and paved the way for much activity in the U.S. Our own Alaska Craftsman Home Program, developed in 1987, was derived from the Canadian R-2000 effort. Some of the information in this manual is derived from R-2000 publications.

In 1979 another Alaskan, Ed McGrath, published a book entitled *The Superinsulated Home Book*, one of the first to use the concept in a title for a book. McGrath's book was seminal, and he eventually worked with Axel Carlson to publish even better-documented technical ideas through the Alaska Cooperative Extension Service.

When Roggach, McGrath, Carlson, and others began experimenting with energy-efficient design, they were trying to improve the technology of housing. The technology they helped develop is now implemented in thousands of American homes, driven by energy prices. But even without that economic whip, these houses make sense. They

are within the economic reach of most homeowners and the scope of most homebuilders. They preserve basic construction, while adding new dimensions in comfort, air quality, and efficiency.

By 1985, major conferences were being held throughout the country on the issue of superinsulated housing and improvements in housing technology. A particularly good conference was held at Rochester, Minnesota, in 1985, where Joe Lstiburek began putting together elements of his airtight drywall approach to housing. This was the concept that if you controlled air leakage through gaskets, a vapor barrier was not really necessary. This became one of the major controversial discussions all through the 1980s. The Alaskan contingent generally held that vapor barriers made out of polyethylene on the warm side of construction, although difficult to install and keep from being damaged during construction, were the desirable alternative to control air leakage and moisture penetration. Airtight drywall also had some vulnerability to racking, more so than was the case with the airtight polyethylene vapor barriers.

At the same conference, the Energy Efficient Building Association came into existence. Also at about the same time, Canada began its development of the Canadian R-2000 Program. This program set a standard specification for new housing design aimed at designing durable, high-efficiency housing for cold climates that met the specification for a new millennium.

Through efforts of the Alaska Department of Community and Regional Affairs and Cooperative Extension Service at the University of Alaska Fairbanks, a plan to improve building construction in Alaska was put into place. A meeting in Anchorage in 1986 between six Alaskan representatives and consultants Oliver Drerup and Ned Nisson,

initiated what was to soon become the Alaska Craftsman Home Program.

Using materials from the Canadian R-2000 program and numerous publications, including *Energy Design Update*, the program was roughly drafted into a builder education program for energy-efficient construction. Beginning with twenty-four volunteers selected from around Alaska to teach two-day workshops in every climate zone, the program fused many current housing technologies and incorporated many aspects of the Canadian R-2000 Program into an Alaskan version of energy-efficient construction training. Rich Seifert and Don Markle worked to develop the first ACHP Building Manual in 1987, and followed it up with a second more detailed and comprehensive manual in August 1988.

The acknowledgements from the 1988 manual are instructive. They include detailed information from the Norwegian Building Research Institute booklets, *Trebus* (which means wooden house), and the Norwegian Building Research series. Also cited are Alchem, a company in Anchorage known for its very durable, high-efficiency panelized construction using urethane foam-filled panels. These panels were ultimately tested by the National Research Council of Canada and found to be durable and still performing to specification twenty years after they were first used in a building in northern Alaska.

The Canadian Society for Civil Engineering allowed us use of material from their Cold Climate Utilities manual and an appendix in the second edition of the manual. Many of the utility concerns for the North are still quite relevant. And the present Bible of energy-efficient design, *Energy Design Update*, is cited in this second edition of the Cold Climate Homebuilding Manual and has since become a staple in keeping up with the technological and professional developments in energy efficient design.

By 1990, the Alaska Craftsman Home Program had become a central focus of the energy-efficient housing industry in Alaska. In 1994 a third edition of the manual called *Northern Comfort* was released. By this time many subtle changes had occurred, moving housing toward a standard practice of a much higher quality: for instance, going from 2 x 4 stud construction to 6-inch studs, and a slow but improving incorporation of energy-efficient design using the Alaska Craftsman specification. This specification was originally appended as a chapter of technical requirements to the second and third edition of the Alaska Craftsman manual.

About this same time the Alaska State Legislature mandated minimal thermal standards for residential buildings financed with state funds. The State of Alaska through the Department of Community and Regional Affairs, developed the Building Energy Efficiency Standards (BEES), which became effective in July 1992. Although this standard only affected residential buildings financed by the Alaska Housing Finance Corporation (AHFC), it set the pace for the industry because it required this energy specification be used if funding for the mortgage was provided by the Alaska Housing Finance Corporation. Currently BEES sets the goal for many Alaska builders who strive to incorporate energy efficiency into their designs, whether using financing by AHFC or any other available source. Due largely to the success of BEES, construction of Alaskan dwellings is some of the best in the world today.

Today

Much has happened in the eighteen years after the legislature first mandated a minimum thermal standard be developed. As this manual is being produced, the BEES standards are in revision and

are reviewed for improvement with some regularity. Along with the building energy efficiency standard came an energy efficiency rating system and a mortgage interest rate reduction program, which gave people incentives to build higher efficiency structures. This system had modest success; but it was especially effective when interest rates were high. In the early part of the new millennium, interest rates steadily dropped, and consequently energy mortgage incentives had less appeal. This has not meant that energy efficiency has become any less important, however. It is now much easier to persuade both the industry and homebuyers to buy into energy efficiency.

The desire for energy efficient, comfortable, and healthy housing has led to what is perhaps the next evolution of housing, which is the Health House, a specification originally developed in Minnesota by the American Lung Association of Minnesota. This is currently being adapted to the Alaska situation and approved by the Alaska Housing Finance Corporation for use in Alaska. It adds to the specification of high efficiency and high technical quality in housing the concept that the home should also be healthy to live in. Much of this new specification can be seen on the web site for the Alaska Lung Association, www.aklung.org.

Global awareness of the importance of petroleum fuel conservation has recently increased due to high prices. Petroleum reserves are diminishing with time, and new sources are being sought. The International Energy Agency predicts that at our current rate of use there is only twenty to twenty-five years of remaining global oil and gas reserves, and political and economic realities are manipulating markets worldwide. To understand the important contribution that energy efficiency can make to our

future one must only read the news or watch television.

In addition to diminishing resources, accelerated use of these resources contributes to global warming, a phenomenon where excess CO₂ in the atmosphere causes a significant and rapid increase in world temperature with subsequent sea level rise and unpredictable atmospheric disturbances. Using “green” materials in construction, materials that may easily be recycled and that use less energy to manufacture, we may slow global warming and extend the petroleum resource. Sustainability has become a key word in describing such issues, and building in a sustainable environment means we must use designs and materials that are easily replaced and are without high energy production costs, as well as construct houses that use much less fossil fuels to operate.

The environment that we live in has a tremendous effect on everything we do. People in each culture that we have looked at made decisions based on their surrounding environment. Inupiat people had to learn how to erect shelter by collecting driftwood and whalebone. The Aleuts built into the ground because they had to in a land with no trees. Haida people constructed huge houses from huge trees. All used materials that were common to their environment and necessary for their survival.

In 2006, modern man is still experimenting with materials, assembly, and operation of shelter in all regions of Alaska. What we do know is that the most appropriate design for Metlakatla may not be the best for use in Kaktovik. As we move down this path of applying science to buildings we are sure to arrive at many more premature conclusions. By looking back in time to when all that was available for Alaskans to build houses with were materials one could collect nearby, we gain an appreciation for the quality of housing today.

One issue remains clear. We must get back to that day when sustainable housing was the norm. Until we do so we are only repeating mistakes of the modern post-war era, a time where consumerism and flashy advertisements overruled practicality and good old common sense. Building science can point the way but it can't save us all by itself. Only by integrating healthy, green, and sustainable concepts can we develop designs appropriate for any climate that are durable and affordable. Such buildings should have their useful lives measured by centuries, not years.