Frontier Energy

Appropriate Technology in Alaska, 1979–1984

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Appropriate Technology in Alaska, 1979–1984

State of Alaska
Bill Sheffield, Governor

Department of Community & Regional Affairs .... Emil Notti, Commissioner

Division of Community Development .... Karen Perdue, Director

Energy Conservation Program .... Steve Baden, Chief

Appropriate Technology Programs .... Norman Bair, Manager

Editorial, Design, Production Assistance by
The Alaska Group

December, 1984

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Acknowledgements

The State of Alaska, Department of Community and Regional Affairs, and the editors of this report wish to thank the many AT grant recipients who made the effort to report on their projects so that others might learn from them in this report. That effort came in the form of laboriously lengthy hand-written letters, to printed, bound final reports. And by telephone, once-weekly mail service, and messenger. Both the Department and editors wished these direct communications could each be printed in their entirety. Unfortunately, limitations of space and disparate writing styles made this impossible.

The editors also wish to acknowledge the two principal writers for the project, Cary Virtue, of Anchorage, and Alan Geist, of Fairbanks, for their good nature and on-time production on short deadlines. Ralph Nichols, of Anchorage, also contributed. A special salute is due Miki Ballard and Joyce Talley for well-managed typographical production above and beyond. Naomi Manabe and Johnny Ellis were valuable in managing proofreading, quality control and other minute details of a publication of this size. And finally, state project manager Norman Bair gave unflagging support and guidance to the project.

Preface

The U.S. Department of Energy's Appropriate Technology Small Grants program was a three-year program that gave individuals, companies and governments the opportunity to devise and apply various appropriate technologies, principally for energy-related projects.

"Appropriate Technology" is a term coined by Ernest Friedrich Schumacher, of Germany: student of Oxford University; economist with the British National Coal board from 1950–1970; United Nations economic advisor to Third World countries; and outspoken defender of the poor. After observing that the introduction of modern technologies did not always bring benefits to the poor of underdeveloped countries, he described a new kind of economic development, based on a technology "more productive than the (local) technology but immensely cheaper than the . . . technology of modern industry." Hence, a technology "appropriate" to the local condition.

According to Schumacher, this intermediate, ("appropriate") technology should have four characteristics; it should:

- create employment in rural areas to reduce out-migration to the cities, with their high unemployment rates;
- rely more on local labor than expensive machinery and resources
- be simple enough for local people to make and repair, themselves
- be used mainly to produce goods or services for local use

Alaska is among 50 states and U.S. possessions that participated in the grants program from 1979–1981.

Ironically, with one of the nation's highest per capita incomes, Alaska may be far from the poor nations' plight that Schumacher envisioned improving when he energized the movement.

Nonetheless, Alaska certainly has unique circumstances of local geography, climate, and custom. Some 365 million acres of land area. Four geographic time zones. Nearly 34,000 miles of coastline, 50% more than all other states combined. Annual temperature variations of 140 degrees in some areas. A population density so low that a New Yorker would be hard pressed to imagine it. Four economically maturing Native cultures. The nation's largest producing oilfield. And remoteness, spawning high costs for transportation, fuel and every other necessity.

With transportation and energy costs affecting urban, Bush and rural Alaska alike, it was predictable that support would evolve for Alaska to participate in the federal grant program. (Alaska was the only state providing additional funds, allowing almost twice as many grants to be awarded.)

During the years the program was funded, the federal government and State of Alaska jointly awarded 205 grants with nearly 100 AT grant projects at a total grant cost of $1.3 million, ranging from simple greenhouse structures to complex wind generators and waste recovery systems.

The projects were executed by a diverse group of Alaskans. They live along the western coast, where winds and cold seas carve the landscape; in Southeast, where 100 inches of rain is common; in the Interior, where sunlight is minimal during four months of the year. Everywhere, energy costs are high. In many areas, roads, telephones, sewer and water, and power utility lines have not reached remote homesites and settlements; until the mid-1970s, television was something watched only in larger cities, themselves with a two-week delay from the rest of the United States.

The grantees are homesteaders, teachers, fishermen, students, entrepreneurs, carpenters, cabinetmakers, engineers, housewives, professionals—and public utilities, libraries and government agencies. Some found new applications for old technologies. Others converted conventional materials and appliances to energy-producing or conservation systems. Still others recycled wasted products to create new energy sources or worked to spread knowledge and appreciation for the potential of any individual to be an independent energy producer. Some are innovators, devising systems that may well have wider applications in the future.

For some grantees, the AT program was a means for survival; for others, the program was a catalyst to develop less costly, more efficient ways to heat homes, produce food, or improve safety.

The OPEC oil embargoes of the early 1970s left a lasting impression on a number of the Alaskans who participated in these projects. Others recalled simpler times when windmills dotted the Great Plains, providing a reliable energy source long before rural electrification took hold; or the common use of hydraulic rams to tap abundant water resources; or the power of the captured sun to manufacture plant life; or the capability of a simple waterwheel to heat a home and create light where none was before. Several were optimistic that their chosen design would improve their business, by reducing their costs or improving their performance in the field. Other enthusiasts produced instructional, training or information materials to show others the way.

The program was a pioneering one, from those who had seldom lifted a hammer to the man who devised a new use for crab wastes in the heart of the king crab fishery. There were projects that had high promise, and fulfilled that promise, such as the wind system for a remote cabinetmaker or the hydro project that operates a fish hatchery. There were projects with great promise that never achieved their goal, such as the (somewhat humorous) tale of a family's bout with black flies breeding in the solar collector and infesting the home.

There were several wind generator projects that exceeded even their highest expectations. There was tragedy in the grantees whose unexpected personal problems halted projects altogether; but there was victory for some. All of the projects were practical, planned to allow the grantee to save money and simplify the challenge of creating energy supply.

And it's apparent that the concept and its applications have not died with the termination of government support three years ago. Commercial enterprises have sprung up nationwide, like the entrepreneurial companies that specialize in wind generators and small hydro projects. Replication of the government-funded projects may be found everywhere, from greenhouse construction, to cooperative power use in small communities. At the same time, systems that were devised with the fortuitous help of the government continue to perform well long after the last of the paperwork has been supplied to the sponsoring government agencies.

The stories of a major portion of these projects and the people who tried to make them work is the subject of this final report on Alaska's partnership with the U.S. Department of Energy Appropriate Technology Small Grants program. Although federal and state funding of this program ended with the 1981 funding year, final reporting and close-out of the program continued in 1984.

This report is organized by project type (eg. solar greenhouses, wood-fired boilers, small hydroelectric, etc.). In some cases, projects had more than one application; these are clearly symbolized in the beginning of each.

Some of the project reports were highly technical and edited for general readership; this overall report was compiled so that newcomers to the concept would not be overwhelmed with technical detail and jargon. Thus, for example, temperature references became Fahrenheit rather than Celsius; more common "brand" names were used instead of their technical, chemical trade names; and common building materials (such as "two-by-fours") were written the way most people hear them.

This book is also designed for browsing, and for learning of others' experience in specific areas. For many of the grantees and federal/state coordinators of the project, it was produced in the hope that others will take the same road and accept a challenge of improving on circumstances that surround a chosen lifestyle—be that lifestyle that of a remote subsistence homesteader or commander of a military organization that must improve its power-generating efficiency.

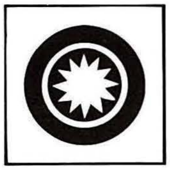
All the materials produced from these projects will be archived in the Alaska Department of Community and Regional Affairs' Division of Community Development library, for those seeking a more detailed description of the project described. These materials include individuals' original applications for the grants; their progress reports along the way; photos of their labors; descriptions of costs; newspaper and newsletter articles about various projects; video tapes filmed by the media or by independent producers; final reports as they were submitted by most of the grantees; and several research reports.

But perhaps the best sources for individual projects are the grant recipients, themselves. Many are quite accustomed to questions from someone who has heard of their endeavors.

The following pages tell their stories.

Key to Symbols

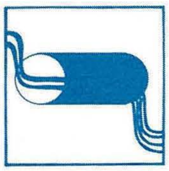
Primary Energy Sources



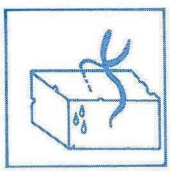
Sun

Wind

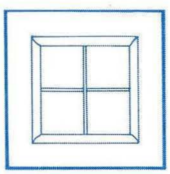
Water



Heat Exchanger



Refrigeration



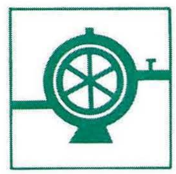
Window or Window Insulation

Distillation

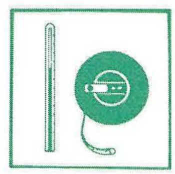
Earth-sheltered Dwelling

Detached Greenhouse

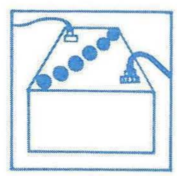
Attached Greenhouse



Water Wheel

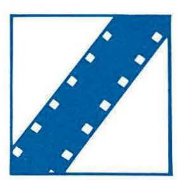


Monitoring



Battery, Storage or Operation

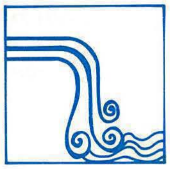
Documentation



Media

Wood Fuel

Insulation

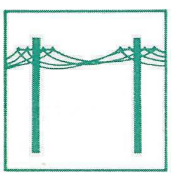


Hydro

Vocational and Technical Training

Combustion

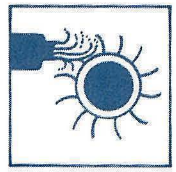
Mass



Electricity

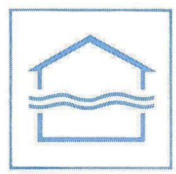
Biomass

Water Pump



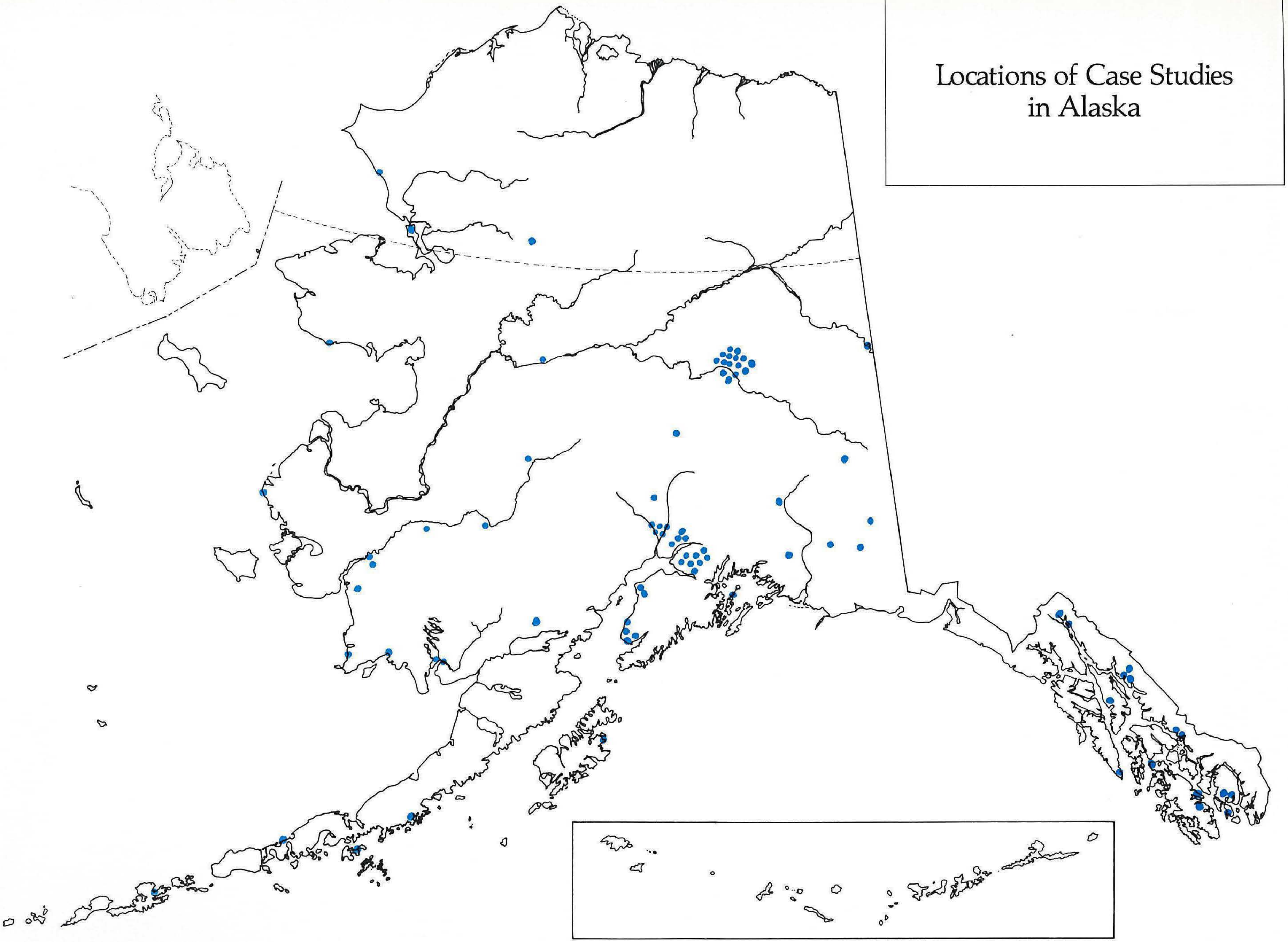
Pelton Wheel

Recycle

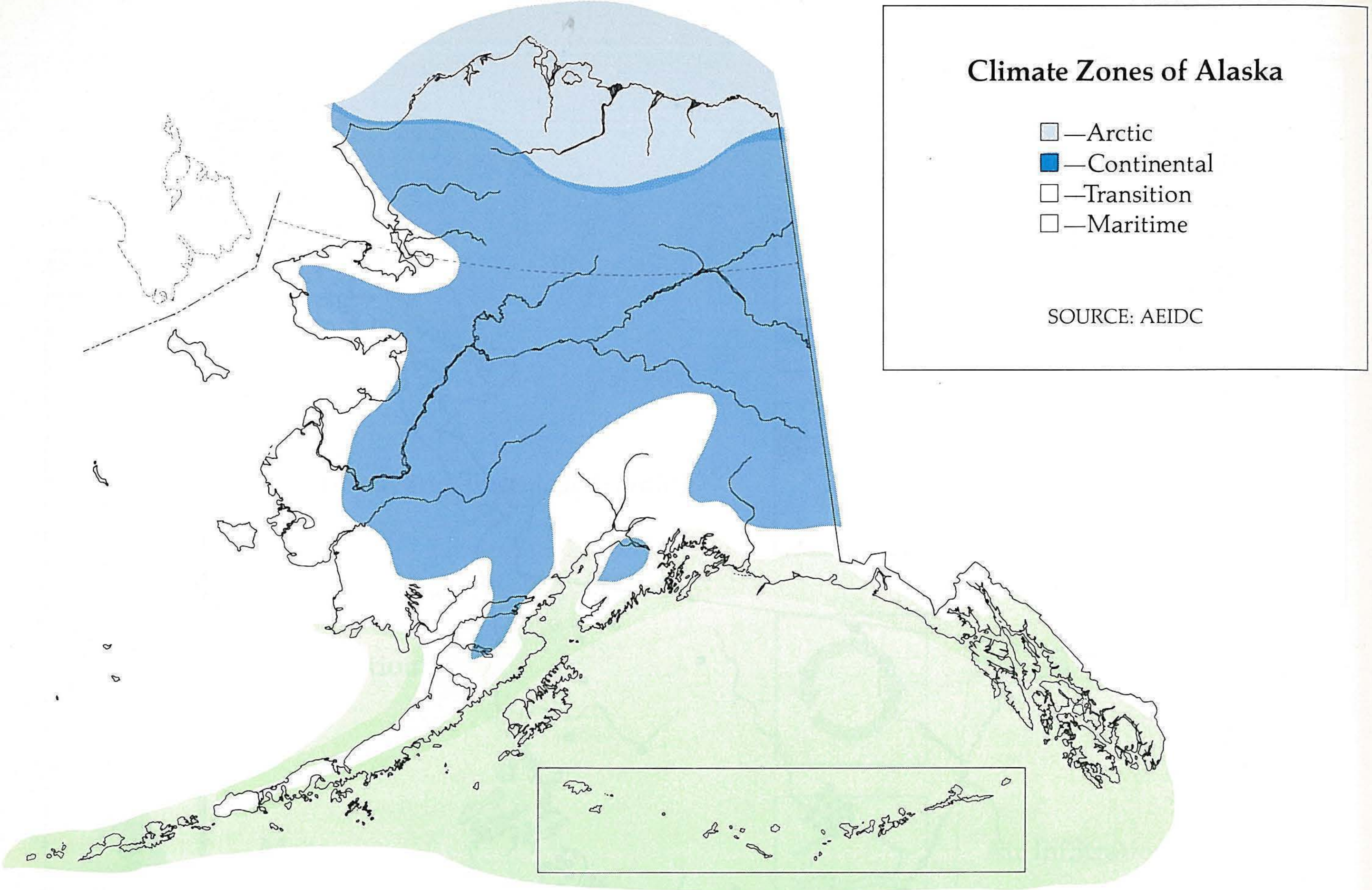


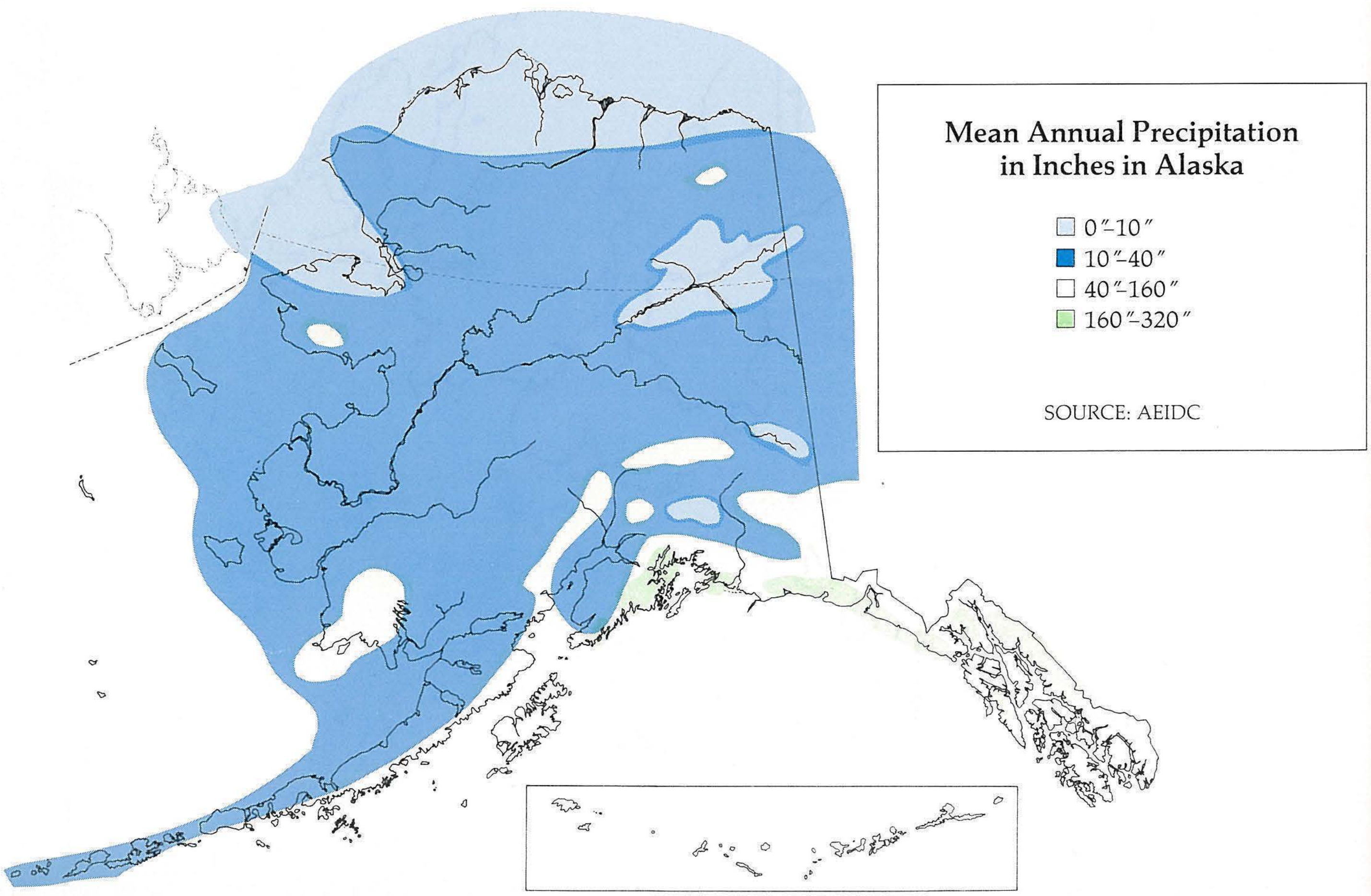
Air Infiltration

Home Enhancement



Locations of Case Studies in Alaska


Climate Zones of Alaska
—Arctic
—Continental
—Transition
—Maritime
SOURCE: AEIDC


Mean Annual Precipitation in Inches in Alaska
0″–10″
10″–40″
40″–160″
160″–320″
SOURCE: AEIDC

THE PROJECTS

Dome house with a difference

Kyle Green has designed a geodesic dome house with a twist. Part of it will be sheltered by the earth to boost its heating efficiency.

In fact, Green designed his home to reduce heat loss as much as possible. Further, the house was planned to reduce windwash, the exterior surface area to floor area ratio, and window and entryway heat loss. He hopes stored solar heat will keep the geodesic dome warm and cozy in winter.

The home is being built on a south-facing hillside in Wasilla, which is about 40 miles north of Anchorage. A completed module of the home serves as an office while the main house is under construction.

House Design

The main floor is a concrete slab at grade with a 17-foot-diameter water tank located in the center, below grade. (Access to the tank is through a wood hatch in the floor.) The water in the storage tank will be heated by the fireplace and by active solar collectors behind the house above the roof line. The egg-shaped house will be earth-bermed along the north side.

The smaller office module similar in design to the main house, will be connected to the main house. The basic dome shape is accomplished by crisscrossing rebar in an elliptical grid. Wire lathing is attached to the formed rebar and cement is applied in a thickness of two to three inches. Three inches of urethane is then applied to the outside of the cement and a protective coating is put on the urethane to prevent ultraviolet degradation. One small triple-paned window looks to the south from inside the office. The office module will be heated from the main heating system.

Construction

The office module was completed in the second half of 1979, along with the main house slab and rebar structure. Initial plans to use blown-on ferrocement were abandoned due to limitations of supply and cost. Instead, the cement was troweled onto the wire lath. The excavation for the main house removed gravel down to sand. Plans to have an earth-formed water tank in the gravel were modified, since this was not feasible in sand. Instead, corrugated culvert sections were used as concrete forms for a seventeen-foot diameter tank that is five feet deep.

Solaroll-brand mat tubing was placed below the concrete slab for distributing heat to the house from the storage tank.

Some progress on the main house rebar structure and storage tank has been made, but additional funds are needed to complete the project.

Problems

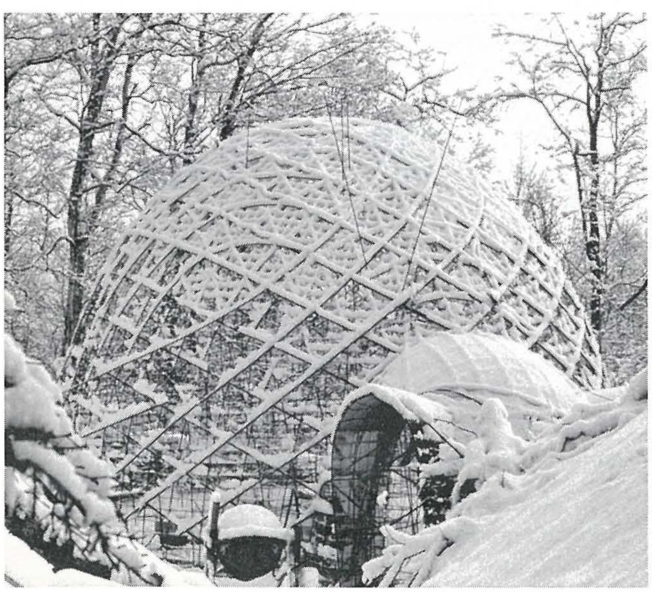
It appears that total construction costs for such a structure would exceed conventional construction costs. The office module has a number of holes in the insulation where birds have tried to make a nest. Interim bank financing was not available for the funding requirements.

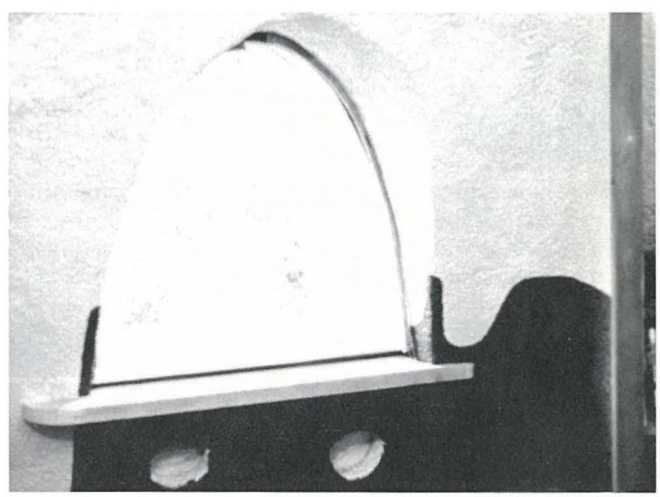
Funding

U.S. Department of Energy $47,900

Grant Recipient

R. Kyle Green
SRA Box 6268
Palmer, Alaska 99645





Kyle Green's Wasilla home (left) being built using a steel rebar superstructure. This arched window (above) is located in the completed portion of the house that is used as an office.

Unique construction method: Inflatable house

The economic hub of Interior Alaska—with Prudhoe Bay oil fields to the north, mineral deposits to the west, and regional corporations nearby—Fairbanks has remained vital since its Gold Rush days early in the century. Fairbanks is hardy—few have not shivered through Robert Service's tales of what strange things the cold can do to inhabitants of the frozen North.

Advanced, Inc. of Fairbanks received a grant in 1980 to design a dome house that could dig in against the grip of the cold winters Service described so eloquently decades ago.

The company proposed a unique rubber construction approach to this earthsheltered house on the hillside. (The project assumed 11,344 heating degree days with a minus 60 degrees winter design temperature).

Design Criteria

The house was designed to be highly energy efficient. Fuel use was to be limited to 225 gallons of oil per year, and conventional materials were used (no sophisticated energy saving systems). The project also was designed to have minimum impact on surroundings and to use a southern exposure.

House Design and Construction

The house shape is an elliptical dome with earth-sheltering in all directions but the south. The unique design of the house was combined with an unique method of construction. An elliptical concrete slab was poured at the excavated grade level over urethane insulation sprayed directly on the ground two to four inches thick.

Solaroll-brand flat tubing was snaked over the urethane before the concrete was poured. This provides for the radiant hot water heating of the house.

A vinyl plastic balloon was fabricated and fastened to the concrete slab. The balloon was inflated with a large fan to take the shape of the final structure. A double-door entry system allowed workers to enter and exit the balloon without altering the structure. This allowed for the majority of the activities equivalent to frame-up to be performed out of the weather.

Window and door openings were marked on the inside of the balloon. An initial coat of urethane insulation was sprayed on the inside of the balloon. Eight-inch wire rods with peel and stick bases were fastened to the urethane in a one-foot square grid pattern. The final five inches of urethane were sprayed on, securing the wire rods in place. A vapor barrier also was sprayed on the urethane.

Rebar (three-eighth-inch diameter) was curved and fastened to each of the wire rods to form a uniform grid pattern. Additional rebar was shaped and fastened around the window and door openings. An eight bag gunite concrete mix was sprayed to a thickness of six inches at the base, tapering to 2½ inches on the roof. With all the concrete on the inside of the urethane, the house has a large thermal storage mass. This helps to minimize the problems of freeze-up that can occur with a heating or power failure.

After the concrete had cured, the reusable balloon was peeled off the outside of the shell. The interior was

A concrete slab (above left) was poured as a foundation for the dome house. The completed structure is above right.

finished with normal stud walls to provide a 2,200-square-foot, three-bedroom house. A glassed-in plant room on the north wall brings daylight into the house from a skylight.

Performance

The house has been lived in since February, 1981. Although it uses less oil than most for its size, the 850 to 1,200-gallon annual use is more than the predicted 225 gallons per year. The floor layout and high ceilings provide open spaciousness which is very nice during the long, cold winters of Fairbanks.

Problems

The radiant heating system does not always keep the house at a comfortable temperature on colder days. Some possible reasons are inadequate tubing under the slab for the required heat transfer; or inadequate pressure to keep the slab from flattening the tubing when the concrete was poured, or inadequate size of the heat exchanger on the hot water heater, or inadequate hot water heater temperature on cold days.

The garage and front entryways are recessed about four feet from the edge of the slab. This means that portions of the slab are allowed to freeze and there is no thermal break from the outside to the inside in the slab. The slab has heaved slightly at the front door, causing interior walls to crack and misalign entry doors.

Either shrinkage of the shell or a slight movement inward from the earthsheltered side may have caused sheetrock bulging in the inner plant room. The skylight has a chronic leakage problem that is increased with condensation buildup in the plant room.

Mildew grows on the inside sills of some south windows from condensation buildup. An air-to-air heat exchanger was in the plans but never installed. This could have controlled the interior humidity.

The garage door was installed at a slope to match the slope of the exterior walls. Gravity keeps the door from sealing tight against the door stop and air infiltration is evident.

Tips

It is important that a prospective contractor have a good record of project management before a unique project like this is undertaken. For the first-time homeowner/builder, a homeowner/contractor pretraining course could help decrease problems that arise between the homeowner and contractor.

Funding

U.S. Department of Energy	$20,804
State of Alaska	20,804

Grant Recipient

Advanced, Inc.
Box 2424
Fairbanks, AK 99707

Underground greenhouse a major success

Everett Drashner is raising fresh vegetables and flowers year-round despite frigid temperatures and little wind or sunlight in Alaska's heartland.

His secret? An earth-sheltered commercial greenhouse powered by wind generators and solar panels.

"I'm diversified," said Drashner, a retired construction worker and owner of Wind-N-Sun-Enterprises. "I raise cucumbers, tomatoes, peppers, squash, all kinds of herbs, some flowers, greens of all kinds, lettuce, beets and dill. The whole project is working better than our fondest expectations."

Drashner's enterprise is on the Denali Highway some miles east of its junction with the Parks Highway. It's near Old Cantwell, about 210 miles north of Anchorage and 160 miles south of Fairbanks.

"In this area you can't grow very much outside in summer because we're 2,000 feet up and it can freeze 11 months out of the year," Drashner said. "That's why the emphasis is on greenhouses. And there's no doubt that it can be done in the Interior. That it's feasible. We've already had success."

System Design

The building—44 feet long by 40 feet wide—juts out from the south side of a sandbank overlooking Drashner Lake. Only the greenhouse roof and south wall protrude above ground. The structure also is divided in half into a growing area and a work area, each of which is 20-foot-wide-by-44-foot-long.

In designing the building, Drashner took a number of factors into consideration, including:

Conservation of electrical energy. A 10 kilowatt wind-powered generator produces electricity for direct use and storage in batteries. The power is used for lights, fans, pumps and heating water in a 1,000 gallon tank; batteries supply power when the wind is not blowing.

Conservation of heat. The entire greenhouse was designed as a large heat sink. Smaller heat sinks within the building include a 1,000-gallon hot water tank; a sauna; a three-tiered sand floor in the greenhouse heated by pipes in the sand carrying hot water; two plant watering tanks with a total capacity of 350 gallons; a septic tank; an emergency battery-charging engine; and, an emergency coal-fired furnace.

Use of new materials. Some of the products and materials used were new to Alaska, and few had been tested in Cantwell's rigorous climate.

Knowledge gained through 25 years of underground building experience in the area. Before the greenhouse was started, the Drashners had been living in an earth-sheltered house with two tunnels leading to outbuildings. They also had developed an earth-sheltered barn. When it was completed, the greenhouse also was connected to the house by a tunnel.

Little sunlight. During the shortest days of the year, between December 21 and 22, there are only three hours and 42 minutes between sunrise and sunset at Cantwell's latitude of 63 degrees north and 148 degrees west.

Construction

Excavation was done in May, 1981, followed by erection of concrete block walls during June.

The ground under the floor was covered with six-millimeter Visqueen, a layer of sand, and three-inch foamglas. Two thousand feet of three-quarter-inch polybutylene pipe was laid over the foamglas so hot water could be pumped throughout the building. The pipes also heat three terraced sand beds in the greenhouse.

All the walls were heavily insulated on the outside with three-inch foamglas. Sheets of Tuffak-Twinwall, a brand of double wall polycarbonated glazing material, was installed on the south wall, ceiling and on the top section of the end walls in the greenhouse. Nine inches of fiberglass also were added to insulate the ceiling.

Interior surfaces were paneled with Wafer-Weld, and painted white. An aluminum reflective material also was installed on some of the walls to enhance light reflection for photosynthesis during low-light days.

A 1,000-gallon water tank was lowered onto its cradle before the roof was finished and covered with a foot of sand. A cement floor was poured in the work area before freeze-up. And 10 tons of lignite coal was stored in the building.

Performance and Problems

Overall, Drashner has been very pleased with his commercial enterprise. He's been able to harvest two crops of vegetables between March and December, and raise flowers such as begonias (which require little light) between December and March.

Drashner also has considered putting rabbits in the greenhouse, although he says animals can cause frost build-up on the south wall glazing.

One problem, however, has surfaced. The greenhouse conserves heat so well that Drashner has to find new ways to prevent the building from overheating on hot summer days. Although operating at capacity, the solar fans were not sufficient. He said opening vents, doors and windows did not help much.

"As long as the wind is blowing, we can cool it down," Drashner said. "It's when there's no movement of air that we have overheating. But we hope to have it shipshape by the spring of 1985. Basically, the thing is done, but we have to finish the refinements, which takes some experimenting."

Modifications and Tips

Based on the greenhouse's performance, Drashner believes several modifications would be beneficial. These include plans to:

Modify the solar collectors. Redesign the system so that extra heat can be used to warm the outside ground adjacent to the greenhouse for planting during spring and summer. By thermosyphoning, warm water can be circulated through the earth in pipes without using electricity. The system will be virtually maintenance free since it will automatically start operating when the sun returns in February.

Modify the emergency coal furnace. Originally, Drashner planned to build a large elaborate coal furnace surrounded by sand. But he discovered that the furnace was not needed because his pot-bellied stove was able to keep the 16,000-cubic-foot greenhouse at a cozy 50 degrees—even when it was minus 40 outside. He plans to improve the stove by adding a coil water jacket which will be connected to the 1,000-gallon water tank. He also will wrap half-inch copper tubing around the stove's mid-section. The cold water will thermosyphon from the bottom of the water tank through the coil to the top of the hot water tank when the stove is hot. It will act as a back-up to the wind generators.

Improve temperature control and increase humidity. Install larger photovoltaic panels which will increase the speed of ventilating fans and turbines. In addition, Drashner is fashioning an evaporative cooler and equipping it with an adequate DC motor.

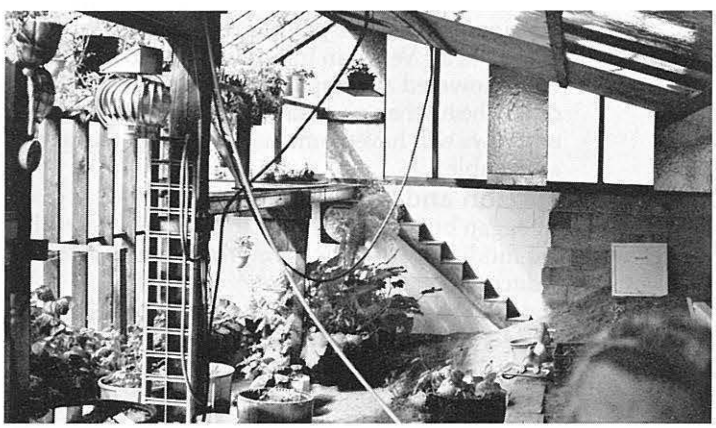
Boost power. Install two more four-kilowatt wind generators to supplement the 10-kilowatt generator. The additional power will be used to heat the 1,000 gallon water tank.

Funding

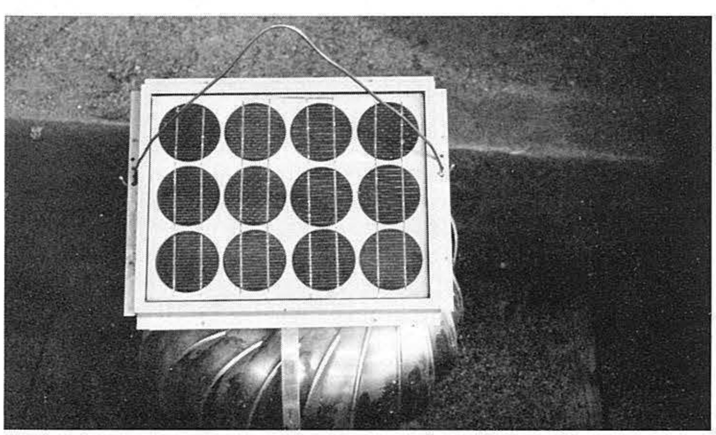
State of Alaska	$ 24,760
U.S. Department of Energy	24,760

Grant Recipient

Wind-N-Sun Enterprises, Inc.
Everett Drashner
Mile 131 Denali Highway
Cantwell, Alaska 99729



The greenhouse roof (above) before backfilling. A view of the interior of the Drashners' greenhouse (middle). A solar-powered rotary turbine was used in the design (bottom).



'I want to live as soft upon the earth as I can'

(Editor's note: At press time, this project was still under construction.)

Jerry Brown, seeking to live as self-sufficiently as possible, is building a solar-energy-heated, earth-sheltered home in Southcentral Alaska.

"I've had a specific five-year plan during which I wanted to see how self-sufficiently I could live," says Brown, a former junior high school music teacher. "I wanted to see how much an individual could divorce himself from the economic system. I was wondering how much I could cut down on what I spent and on what I made."

Brown's solar-heated home is four miles north of Palmer on Soapstone Road, about 45 miles north of Anchorage in the Matanuska Valley.

The home, which he hopes to complete by the fall of 1984, is on top of a wooded, five-acre gravel hill about 300 feet above the valley floor. It has good southern exposure.

Brown hopes that the knowledge he gains from his project will be of some assistance in developing low cost housing for people living in rural Alaska.

"I'm interested in developing those things that will actually help and are low tech," he said.

More importantly, Brown wants to make as little impact on the environment as possible. "I want to live as soft upon the earth as I can," he said.

Design

The two-bedroom concrete block home, which has a sleeping loft, is 32 feet wide and 40 feet long. It also has a bath and a four-foot by six-foot fireplace in the center.

The front of the house, which protrudes from the ground and faces south, is made of vertical thermopane glazing. A south-facing clerestory with three by four feet of glazing will be installed below the roof.

Underground, the concrete block is insulated on the outside with two inches of polystyrene. The south side (40 feet) is all windows. There is a clerestory with sleeping lofts behind it. The bathroom and bedrooms are across the back. Otherwise, it is all open to make it easier to heat.

This project sought to answer four main questions:

- Will the thermal dynamic advantages remain the same (and will it cost less to build an underground house) if the six-foot excavation around the structure is not backfilled, and a superinsulated roof is extended over the excavation to a concrete abutment? This construction method eliminated cost of backfilling; allowed building with any material, since it doesn't have to stand the weight of backfilling; and enabled the excavated area (600 square feet) to be used as a dry storage and root cellar.
- Can a concrete block and firebrick stove burn trash and garbage by adding large amounts of outside air to the chamber? Can these temperatures be stored efficiently in water tanks located in the fireplace and in the concrete block walls of the structure? Can a house be heated sufficiently with this stove by firing it up once or twice a day? Does trash burn better loose or compacted? Can hot air from the solar collector windows be stored in the water tanks? These questions are still under study.
- Will this type of simplified hot air collector contribute the greatest amount of available solar heat to the home? It consists of a standard double-glazed thermal window with a single sheet of glass mounted two inches inside the window, open at the top and bottom. "Space blanket" curtains are hung between the glazing, foil side out. They can be closed to prevent light and heat coming into the structure but heat can still be collected, transferred to the highest point of the building and blown down across the fireplace water tanks.
- Can reflection of light into a structure increase heat? Can interior heat be magnified and controlled by reflecting light with venetian blinds on walls? To determine whether this is the case crushed white gravel or quartz will be spread under the windows outside the structure; all interior walls will be painted dark brown to absorb heat; Venetian blinds will be mounted over them (lowered and angled various degrees to reflect heat when necessary); and ground floor windows will have homemade awnings that are adjustable.

Construction and Modifications

Brown began building his home in May, 1981, developing and modifying designs to improve its efficiency and to reduce costs.

The concrete blocks were poured solid to provide more mass for heat storage. Rebar was placed every 16 inches vertically and every three courses horizontally. Brown doubled the amount of steel he planned to install, for greater protection against earthquakes.

A steel "I" beam was used in place of a glue-lam wooden beam because of its low cost and availability. The beam, spanning lengthwise across the middle of the building, will be covered with two layers of half-inch sheetrock for fire protection.

The fireplace also was redesigned. The chimney was extended into the firebox to prevent smoke from billowing up the hot-air flue. The firebox will be made of sheetmetal and lined with firebrick. A drawer bin will be added below the grate to catch falling ashes. Brown enlarged the outside air duct to four inches to enhance air flow. And, the air holes in the lower fireplace were enlarged to 18-inches-by-18-inches to boost circulation.

In the roof, Brown plans to use two-by-twelve-foot roof joists and to insulate with 12 inches of fiberglass and two inches of styrofoam.

Brown also plans to save money by installing the windows upright with a 90 degree angle instead of trying to place them at a 77-degree tilt. Trying to slant the windows at the more acute angle would have cost more for an additional heat-collection gain of only three percent by Brown's calculations. Moreover, a two-inch space will separate the exterior thermal glass from the interior side of the glazing to improve air circulation. Floor vents beneath the windows have been enlarged to enhance air flow.

A second wall behind the clerestory windows also was removed and the loft extended to the windows to cut costs and improve heating efficiency. Vents were placed in the side walls of the loft to allow hot air to escape. Because there was not enough space where heat could gather after the inner clerestory wall was eliminated, the loft above the bathroom was removed. Heat that collects there will be blown across the water tanks.

Finally, a six-foot square arctic entryway was redesigned to provide more room inside the home.

Tips

Brown has several suggestions from his experience, including:

- Check on whether federal taxes apply to the grant; these taxes can be an unexpected, unwelcome "cost."
- Don't rely on donated labor from friends. People's lives change, they move and they are busy with their own projects. Plan on paid labor for anything you can't do yourself. It is cheaper and faster in the long run. But when contracting for labor, check references.
- Consider refusing the grant if you are offered only a portion of what you requested, unless you have independent resources to see the project to fruition.
- Discuss your plans with friends and people in the building industry. They may have information that will save you time and money. Building supply houses will supply roof load factors, beam sizes and just about anything else you need.
- When buying supplies, check all the lumber yards and supply houses for prices. Don't buy all your materials from one place. Prices vary a lot. Take advantage of sales, but only after comparing the sale price with regular prices.

Funding

State of Alaska	$ 7,032
U.S.Department of Energy	3,014

Grant Recipient

Jerry Brown
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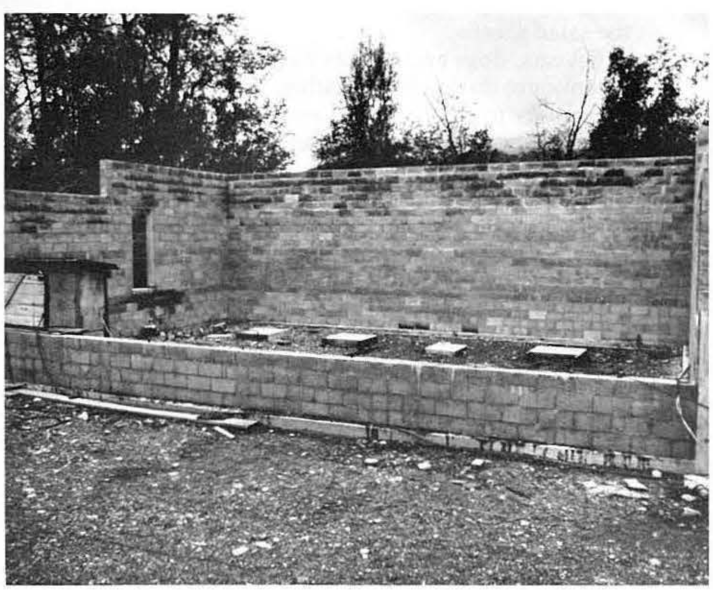
Palmer, Alaska 99645



These are the walls of an earthsheltered house Jerry Brown is building near Palmer (left).

Fuel bills down, vegetable crop up

Try planting an outdoor garden in Petersburg. It's a drenching experience.

Each year more than a 100 inches of rain pelts this small Southeast Alaskan community, which is on Mitkof Island between Juneau and Ketchikan.

But gardener Alice Grant has discovered a unique solution to this perplexity. She and her husband, Herbert, built a 190-square-foot, solar-heated greenhouse onto their home in 1983.

"I struggled along trying to garden outside," says Grant. "But it was so discouraging that putting things in a greenhouse appealed to me."

Thanks to the greenhouse, she now enjoys harvesting strawberries, beans, peas, onions, tomatoes and other vegetables virtually year-round without having to worry about getting wet outdoors. It's also a convenient place to raise rabbits and chickens and to dry firewood.

And the Grants have been able to slash their heating oil bills in half by recycling warm air from the greenhouse into their home.

"It's been a big boost to the house," says Grant, who also works as a gardener raising saplings for the U.S. Forest Service. "It's already performing well."

System Design

The Grants decided to build their greenhouse where it could get the most sun—on the southern side of their rectangular, 60-foot-long by 24-foot-wide house.

The greenhouse, 24 feet long by eight feet wide, encloses the front door and two bedroom windows.

"Whenever the sun does shine we open the windows and front door and the heat from the greenhouse will come right into the house," says Alice. "We use half the amount of oil we used before."

The greenhouse roof, built of plywood and insulated to R-30, was formed by extending the aluminum roof on the Grants' house by eight feet. The roof was built along the lines of the existing roof to make it easy for the snow to slide to the ground. The east wall was built of plywood and two-by-fours and insulated to prevent heat loss.

Sliding glass patio doors were used for the south and west walls instead of the slanting glass panes, that are usually pictured on solar greenhouses. Research showed that at Petersburg's latitude the vertical wall would be more efficient if it were able to capture the maximum amount of solar energy when the sun is at a low angle—during the spring, fall and winter. Daylight varies from about six hours in December to about 21 hours in June.

Cost comparisons showed that ready-made patio doors were cheaper than buying the glass and frames. The sliding doors, which came with screens and locks, were easier to install. And they also can be opened and closed for ventilation.

Originally, the Grants intended to build a concrete foundation, but local building codes would have required pilings to support the concrete, at a cost exceeding the entire project.

So they built the foundation on two feet of shotrock fill, consisting of gravel, rock and earth. Sill plates of pressure-treated lumber six inches wide and 12 inches high support the walls.

The floor of the greenhouse was laid with polyethylene over the shotrock; covered with four-inch rigid polystyrene insulation and half-inch plywood; and filled with rocks up to the door-sill. A top layer of garden earth smooths out the walkway. All seams, openings and cracks were caulked and insulated to prevent heat loss.

Performance

Beginning on February 1, 1983, bedding plants were sown, including tomatoes, lettuce, cucumbers, Brussels sprouts, broccoli, squash, and flowers. Daytime temperatures inside the greenhouse were averaging 50 to 60 degrees; nighttime temperatures were averaging 35 to 40 degrees. Outdoor temperatures averaged 35 to 40 degrees, and many nights were below freezing. The hours of daylight began getting long, gaining five minutes per day.

The crops grew nicely and were transplanted outside in late April and early May. The tomatoes, kept in the greenhouse for the full season, flourished. Lettuce, green onions and radishes, which were grown in flats, kept the Grants furnished with fresh salads daily from April until October.

"We don't get a big bountiful harvest, but we get enough to munch on and keep us supplied with salads," says Alice.

Flowers grown in hanging baskets provided fresh blossoms for Thanksgiving. There were even fuchsias blooming on Christmas day in spite of three weeks of 10 to 20-degree weather.

The greenhouse also has been used as a place to brood baby chicks, which the Grants used to do in their living room. Pet ducks acted as slug control until the birds outgrew the greenhouse space and began munching on the salad greens.

Pet cats, dogs and rabbits have been sheltered in the greenhouse during bad weather. The greenhouse also is a great place to dry firewood and store pet food.

Heat recycled from the greenhouse is saving the Grants money. Before building the greenhouse, they were spending about $1,232 (1984 prices) on 1,200 gallons of oil per year, and about $210 for six cords of wood.

But now the Grants use only about 600 gallons of oil annually, because of the solar greenhouse and a more efficient woodstove that only uses four cords of wood. That's a savings of $613 on oil and $70 on wood.

Another surprising feature about the greenhouse is that it never overheats. During summer, its aluminum roof shades the plants from the hot sun. The highest recorded temperature was 86 degrees. On the same day that conventional plastic greenhouses needed to be cooled by electrical fans and vents, the Grants' solar greenhouse required no electricity.

Problems and Modifications

There have been some minor problems with the roof leaking and insulation getting soaked, but these were easily fixed.

Originally, the Grants planned to place black, painted water drums in the greenhouse to provide thermal mass by absorbing heat and releasing it as the temperature dropped. However, the drums leaked and took up so much space that they decided to use just six 30-gallon drums. In addition, they also placed 100 one-gallon, plastic milk containers (each filled with water tinted black) around the potted plants for thermal mass.

Tips

The sliding doors allow various degrees of ventilation as well as four different exits from the greenhouse into the garden. The sliding feature eliminates the problems of swinging doors.

Planting in buckets makes plants portable. They can be turned toward the sun, tall ones moved behind shorter ones, and diseased plants removed. It is much neater than permanently installed beds.

Hooks on the ceiling are convenient for hanging baskets of flowers or tying up tall plants.

Water and fertilizer are mixed in a garbage can, and heated by the sun before being applied to the plants. Different mixtures of fertilizer are put in different cans and labeled.

Pegboards on the house wall are handy for hanging tools, etc.

Recycled wire book racks for paperback books can be fitted with small pots to use vertical space. The racks rotate to give all the plants exposure to the sun.

Some sort of thermal curtain or shutters might be made for nighttime use. This greenhouse has none to date, but they would prevent more heat loss at night.

Funding

U.S. Department of Energy $4,294

Grant Recipient

Alice Grant
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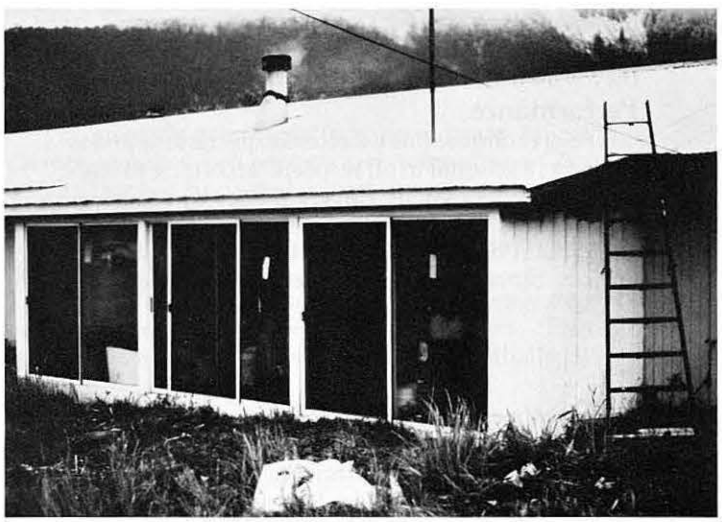
Petersburg, Alaska 99833



Sliding glass doors (left) enclose the front of Alice Grant's greenhouse.

Greenhouse more than an indoor garden

Tucked away in Pedro Bay on the northeast end of Iliamna Lake, some 150 air miles southwest of Anchorage, is Norman Aaberg's solar greenhouse.

The greenhouse was added onto Aaberg's home, one of a handful of dwellings in this Bush community of about 50 people.

"The greenhouse was to serve as a source of heat year-round, for starting and growing vegetables, and for wood (fuel) storage during the winter months," he said. "The project has proven a real asset."

Design and Construction

Construction of the greenhouse (eight by 24 by seven feet high in size) began in mid-1981 when Aaberg started expanding his home.

Originally, Aaberg planned to excavate a one-foot space under the house for an air space. Heated air from a solar panel on the back wall of the greenhouse would flow up through the collectors into the house. Cold air on the floor at the opposite side of the house would drop through vents in the floor and return to the greenhouse. There is no electric utility in Pedro Bay, so the system was designed to work naturally with no electricity. But he abandoned this plan because the ground was too rocky and he could not excavate enough space for an air-tight system under the house.

He also used two-by-six planks to save money and time in building the floor instead of pouring concrete. So far, the wooden floor has worked fine.

The west wall of the house, which abuts the east wall of the greenhouse, was covered with half-inch CDX plywood. This didn't work out very well because the hot air and moisture weathered the wood too quickly.

The lower half of the longer west wall and the short south wall are insulated with glazing along the upper half. The greenhouse is built on the west side of the house as a windbreak to provide protection against prevailing winds from that direction.

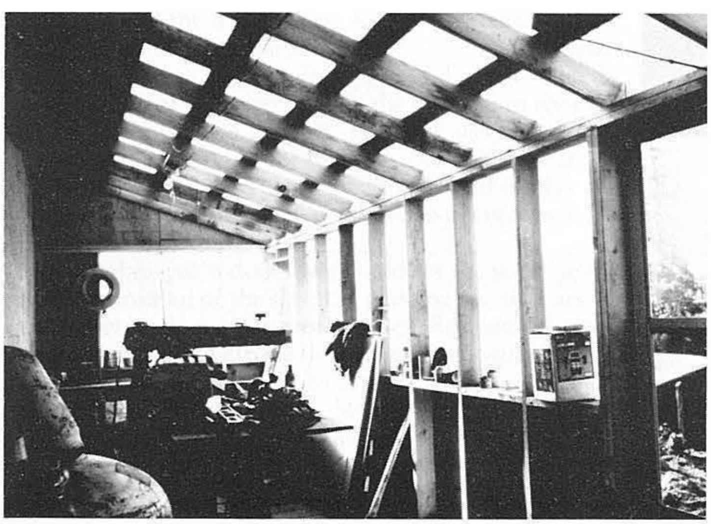
Foam insulation was applied on portions of walls covered with T1-11. Lucite sheets were used for the roof, although the roof was tinned where it joined the main house.

Trim was added and the exterior was painted and weatherized. Several 52-gallon oil drums painted black and filled with water were installed as heat-collecting thermal mass inside the greenhouse. Wall vents allow warm air to circulate from the greenhouse into Aaberg's living quarters.

The planned solar panels were not installed because they were not needed, Aaberg said.

Performance

The greenhouse has exceeded expectations and is proving functional in all respects, according to its builder. And it's saving Aaberg money by reducing his heating bills. His 2,200-square-foot home is well insulated, but it does not have any other energy-saving devices. Since building the greenhouse, though, he's only



This Pedro Bay greenhouse (left) is also used as a shop.

had to burn 4½ cords of wood and 380 gallons of heating fuel.

In short, the greenhouse conserves heat in winter. And it has supplied all the heat needed for the living quarters during late spring, summer and early fall.

The greenhouse also was a good place to dry out firewood and it provided Aaberg with additional work space in winter.

Tips

Actual use of the greenhouse prompted Aaberg to make a few suggestions for improvements.

- The roof should be strong and steep enough to shed snow. Instead of Lucite, consider using plywood and other material for the roof. Also, use rubber "wiggleboard" instead of wood for end-sealing corrugated Lucite.
- Do not connect the clothes dryer vent to the greenhouse. During the winter, moisture created by the dryer froze to the Lucite ceiling.
- Install proper ventilation to ensure that the greenhouse doesn't overheat in the winter.

Funding

State of Alaska	$2,000
U.S. Department of Energy	2,000

Grant Recipient

Norman Aaberg
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Pedro Bay, Alaska 99647

Greenhouse first step to energy self-sufficiency

Mark Garrett wants his home in Anchorage, Alaska, to be as energy efficient as possible so he added a solar greenhouse.

And he's enjoying it.

"I'm currently growing lettuce, peas, beans, spinach, carrots, radishes, bell peppers and onions," says Garrett, adding that he's harvested several crops already.

The greenhouse helps keep his home warm year-round, and its garden beauty is a pleasant contrast to Anchorage's long winters.

"My goal is to create a small home completely dependent on its own design for energy," says Garrett. "This initial (greenhouse) step is the beginning of that project."

Design

The south-facing solar greenhouse is 10 feet wide by 36 feet long, featuring 280 square feet of double-paned Filon brand glazing. It uses insulated shutters and 1,500 gallons of water as a thermal mass.

The foundation, an extension of Garrett's home, is made of concrete blocks stacked five coarse high. The centers of the concrete blocks were filled with tightly packed polyurethane beads. The floor was insulated with two inches of Insulfoam brand polystyrene.

The north wall of the greenhouse abuts the house so that excess heat from the greenhouse can be ventilated into Garrett's home, helping to reduce his home heating bills.

Both the east and west walls are opaque and built on two-inch by eight-inch framing. The walls are padded with six inches of fiberglass and covered with thermoply for an insulation value of R-25. Sheets of T1-11 siding were placed on the exterior. The roof, insulated to R-30, is made of wood.

The ceiling and all the opaque walls were covered with either white or foil surfaces to balance the light inside the greenhouse. At night, the insulating shutters are folded down to cover the glazed south wall. The two-foot-wide by four-foot-long shutters, which provide an R-10 insulation value, are hinged at the base of the wall.

Temperatures are electronically monitored. When the temperature rises to 75 degrees, a thermostatically controlled blower comes on, pulling hot air from the top of the greenhouse ceiling into the sealed thermal storage area. The water absorbs some of the heat, and the cooler air is circulated back into the greenhouse through an opening at floor level.

Heat stored in the water is gradually released into the greenhouse at night. When the temperature drops to 65 degrees, a blower is activated and fans warm air from the thermal storage into the greenhouse.

Inside the greenhouse, Garrett built an 18-foot-long by three-foot-wide plant bed to a depth of two feet. Holes were built into the bed's concrete retaining walls to allow excess water to drain into a sump.

Tips

Garrett found that several procedures worked well for his needs and recommends that others might:

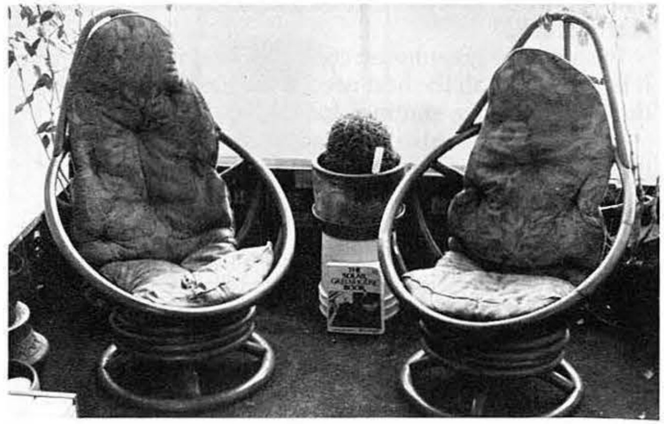
- Install flourescent lights in the greenhouse between November and February to overcome poor winter sunlight.
- Use five-gallon plastic jugs filled with water for thermal mass. The 1/16-inch thickness is sufficient to allow for heat exchange.
- Use Filon 502 brand greenhouse glazing; it transmits light well even though it is not transparent. The greenhouse plants turn only slightly toward the south glazing because of the defusing effect of the fiberglass and reflections of the north wall.

Funding

U.S. Department of Energy	$1,613
State of Alaska	1,613

Grant Recipient

Mark J. Garrett
3636 Knik St.
Anchorage, Alaska 99503



Inside Mark Garrett's greenhouse, both vegetables and people thrive (above left and right). The race gets underway (above) to complete construction before winter; (at left), the greenhouse in progress.

Greenhouse overcomes severe climate

Location

This project was designed to demonstrate the feasibility of constructing and operating a relatively low-cost attached solar greenhouse in a rural Alaskan community. Dillingham, the site of this project, is a community of about 1,700 people on Bristol Bay, a region of very high transportation and energy costs, with a relatively severe climate and short growing season. Rising fuel, transportation, and food costs hit residents of rural Alaska harder than they do people in urban areas.

Among the most cost effective measures for reducing costs appear to be energy conservation; use of local building materials; use of sun, wind, and water energy; and increased production of local foods. An attached solar greenhouse appears to contribute to energy efficiency and self-sufficiency in three major ways. First, it serves as an extra "skin" to reduce heat loss from a portion of the house. Second, it produces extra heat to supplement the home's heating system; and third, it allows production of food that would otherwise not be possible to grow in the climate of Southwestern Alaska. An additional benefit, in view of the small size of many homes in this region, is the extra space which an attached greenhouse provides.

Design and Construction

Steven Behnke's greenhouse was attached to the south wall of the basement of his new small, well-insulated (R 32 walls, R 50 ceiling), two story house. A "pit" design, in which the greenhouse was partially sunk into the ground, was used so that the surrounding earth could provide extra mass and insulation, and so that the structure would fit beneath the south-facing windows of the first floor of the house.

Although the original proposal called for glazing to be installed at an angle of about 30 degrees from the vertical, the final design used a 45 degree angle. This enabled a simpler roof design, and provided more exposure to the sky. The diffuse light characteristic of the cloudy Dillingham summer climate made this greater exposure desirable for plant production.

The greenhouse was designed to cover the entire front wall of the basement, which is 26 feet long, and to extend out eight feet from the basement wall. The first floor of the house is cantilevered two feet over the basement, and so forms part of the greenhouse roof.

The original proposal called for the use of concrete for the walls of the greenhouse. A framed wall of treated wood was substituted due to the high cost of concrete in this area. The walls were built of treated two-by-fours on 24-inch centers and half-inch all-weather plywood. Spacers (two-by-twos) were installed horizontally on the interior of the two end-walls to accommodate extra insulation and provide a nailing surface for an interior finish of half-inch plywood. The walls were insulated with five inches of polystyrene, and the foundation perimeter was insulated with two inches of polystyrene to a depth of two feet below floor level.

A double layer of reinforced fiberglass glazing .040 millimeter in thickness was installed instead of the originally planned inner layer of Teflon film. The 49½-inch-wide rolls of glazing were installed on two-by-four rafters on 24-inch centers. Treated one-by-two-inch wood battens were used as spacers between the layers. They also hold down the top layer. Silicone sealant was applied along all joints. This system was simple to install and has worked well.

The greenhouse is normally entered through a door from the basement of the house. This door permits circulation of warm air from the greenhouse into the basement. A small, homebuilt door insulated with polystyrene allows access to the outside so that materials can be brought into the greenhouse more conveniently, but in the colder months this door can be sealed off to reduce heat loss. Originally, an airlock entry to the greenhouse from outside was planned, but the depth of the excavation made this impractical.

The floor of the greenhouse consists of two feet of gravel; the center portion of the floor is covered with paving bricks.

Performance

The greenhouse captures considerable heat from the sun. In spring, 1982 (February-April) as the days lengthened and the sun rose higher, the greenhouse made a major contribution to heating the basement, which is normally heated with a woodstove. During these months there are normally a high proportion of cloudless days compared to late summer and fall, which are normally cloudy and wet. From late April through June, woodstove fires were needed only after several days of rainy weather.

The greenhouse tended to overheat on hot summer days and had to be vented manually to the outside. Automatic vents and fans to circulate heated air into the basement would improve efficiency.

The house was heated by the greenhouse through the summer and into late October on all sunny days. By November 1, the door between the greenhouse and the basement was kept closed because little heat was being gained.

The water storage tanks added to the greenhouse relatively late in the summer of 1981 appeared to decrease daily temperature changes.

From November to February the greenhouse is used to store and dry firewood, and to dry laundry. These uses provide major benefits, since Dillingham has a wet climate, and it is often difficult to obtain dry wood. Clothes dryers in Dillingham cost from $8 to $40 per month to operate. Drier wood improves the efficiency of heating.

In March and April the greenhouse is used as a warm play area for children, and planting is started at this time. Soils are prepared for planting tomatoes and cucumbers. Flowers, broccoli, cauliflower, lettuce, and other plants are started in the greenhouse to be transplanted into the garden later. From May through October the greenhouse produces tomatoes and cucumbers.

Because the house is heated with wood (supplemented by oil) it is difficult to assess the exact contribution of the greenhouse in heating. Fuel oil bills averaged $50 per month in winter and about $5–$10 in spring, summer, and fall based on a noticeable contribution to heating the house (records from September, 1982 to May, 1983).

Public Information

The project contributed to local and regional knowledge about energy alternatives in several ways. During construction and after completion the project was visited by more than 30 local residents. This provided opportunities to discuss concepts and construction methods with a wide range of people. The project was described on a program about local energy issues on the Dillingham radio station, KDLG, in January, 1982. This program briefly touched on the benefits and methods of construction. The greenhouse was also discussed and shown on Alaska public television throughout the state. A program produced by Alaska Review, of Independent Public Television, Inc., entitled *Energy Alternatives for Alaskans,* featured both the greenhouse and the house to which it is attached. It showed construction techniques and described the benefits of such structures in rural Alaska, where fuel and construction costs are high. A tape of the program is available from the State Film Library.

Funding

U.S. Department of Energy	$1,176
State of Alaska	1,176

Grant Recipient

Steven Behnke
2130 Second Street
Douglas, Alaska 99824

This greenhouse (left) is attached to Steven Behnke's salt box house, located in Dillingham.

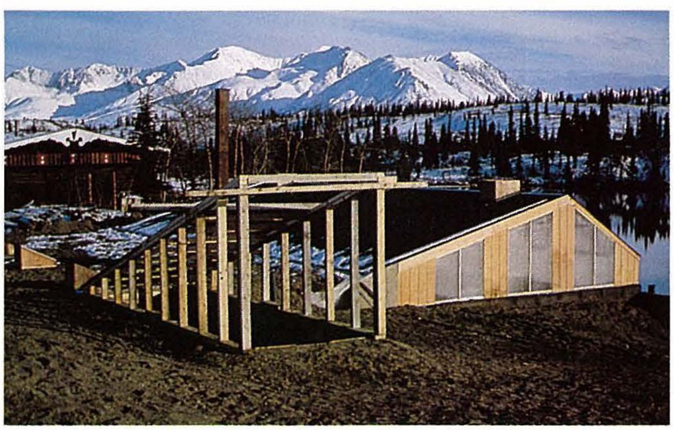


Plate 1 *Morning light (above) hits grantee Wind-N-Sun's greenhouse near Cantwell. A view of the west side of the greenhouse (middle left). Advanced Inc. of Fairbanks developed a unique dome design that fits well with the winter scenery (bottom left).*

Plate 2 Western exposure of Norman Aaberg's homesite at Pedro Bay is perfect for an attached greenhouse (below). (At right) Paul Robinson of Fairbanks chose a detached greenhouse to supplement his outside vegetable garden. A strawberry patch hangs on the wall of the greenhouse in McGrath built by MTNT, Ltd. (bottom).

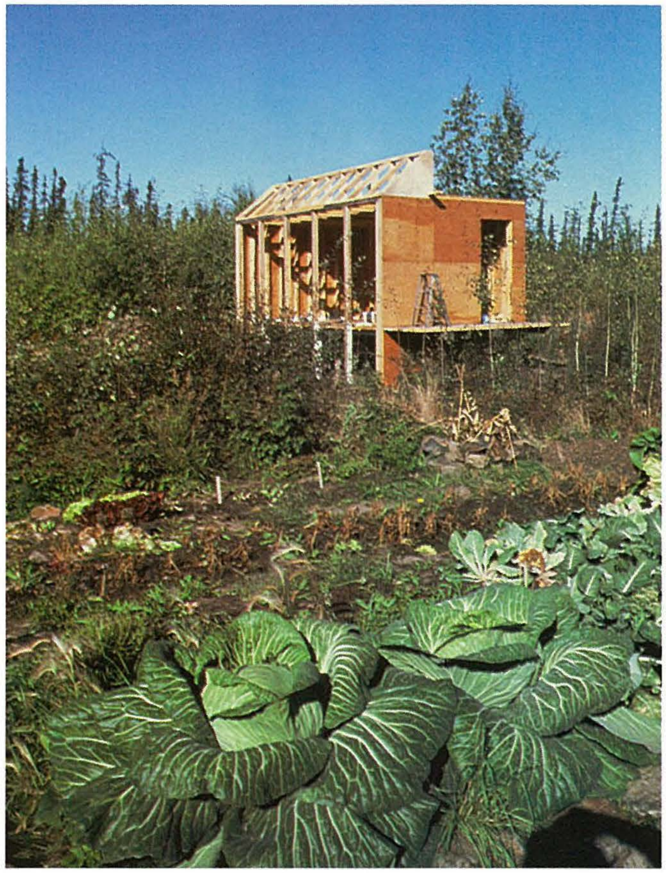


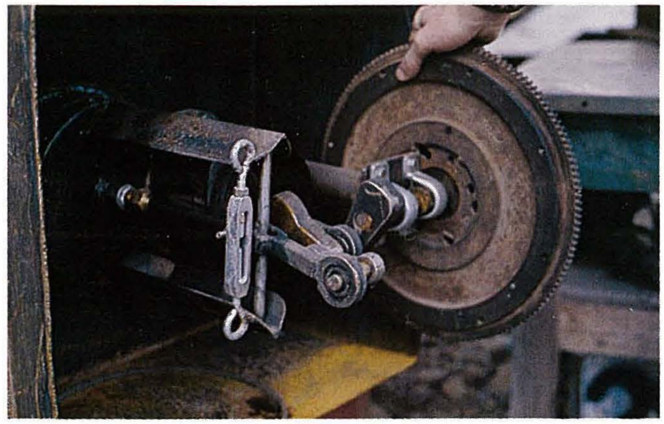
Plate 3
A scenic view of Unalaska (top) from Charles Vowell's methane digester. A workman inspects a bread box solar collector sponsored by the Municipality of Anchorage (left). Grantee Dois Dallas added a solar collector to heat water for this Fairbanks home (above).

Plate 4 A view of the Portage Creek fish counting camp operated by the Alaska Department of Fish and Game near Bristol Bay (top right). John Greene's cabin in Eagle (middle right) makes good use of a wood fired boiler. Steve Smiley's wind energy system is raised near Homer (below).

Plate 5 *An overshot wheel built by Robert Nelson generates power at Thayer Lake (left). A collapsible pipeline transports water to wheel (top). Chester Johnson of Valdez performs the weekly greasing of his hydro turbine (above).*

Plate 6 *A view of the hydraulic ram assembled by Don Chaney in Petersburg. Louis Butera (at right) of Eagle River stands beside his micro-hydro project. A larger scale hydroelectric project was undertaken by Richard Matthews of Port Armstrong (bottom).*

Plate 7 *The Mitkof Lumber sawmill in Petersburg studied the feasibility of wood gasification (above). Perry Hilleary of Trapper Creek demonstrates one of the unique features of his Bush refrigerator (middle left). A gray water heat recovery system was designed and installed by Richard Runser of Wasilla (bottom left).*



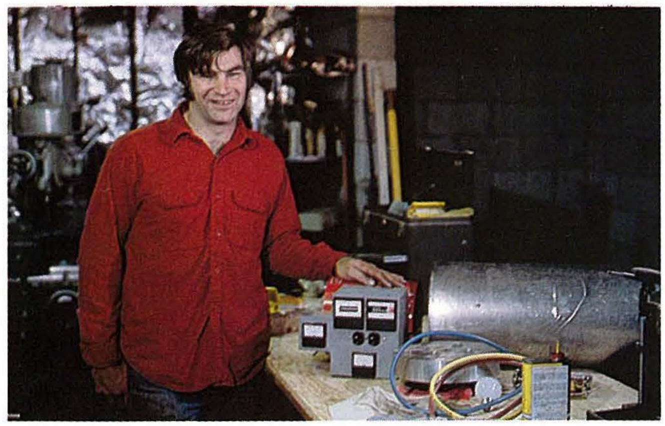


Plate 8 *David Newcombe mounted a Stirling engine on his home boiler tank in Wasilla (top right). A rankine cycle engine was used by Arthur Manning in his hydrothermal freon electric plant (middle right). The Kenny Lake Community League mounted a solar collector on their library to help reduce energy costs (bottom).*

Solarium an asset during Alaska winter

Larry Cline is taking the experience he learned from building a solarium and applying it to other homes he's constructing in Anchorage, Alaska.

"I'm starting to build fourplexes and I'm including hallways on the south side with lots of windows," says Cline, who owns Alaska Carpenter and Construction Company. "And I'm getting my method of doing this from what I've learned here (on his solarium)."

Cline says a solarium enhances the beauty of a home, helps reduce fuel bills, and provides a warm retreat during Anchorage's cold winters. "A solarium aesthetically enhances the design of a house," he says. "It's a warm place to be even when the sun's behind the clouds. You have so much darkness up here in the winter, but the solarium seems to change all that." He's even grown several crops of tomatoes, lots of flowers and he's thinking about adding catfish to his solar water containers.

Design

The solarium was built on the 10-foot-wide by 26-foot-long second floor deck of Cline's home. Part of the solarium, a 10-foot-wide-by-14-foot-long room, also was built on the ground floor.

The solarium, which is on the south-facing side of the home, increased the interior space of his home to 2,637 square feet. It will gather the sun's warmth, store it and circulate it through the rest of the home.

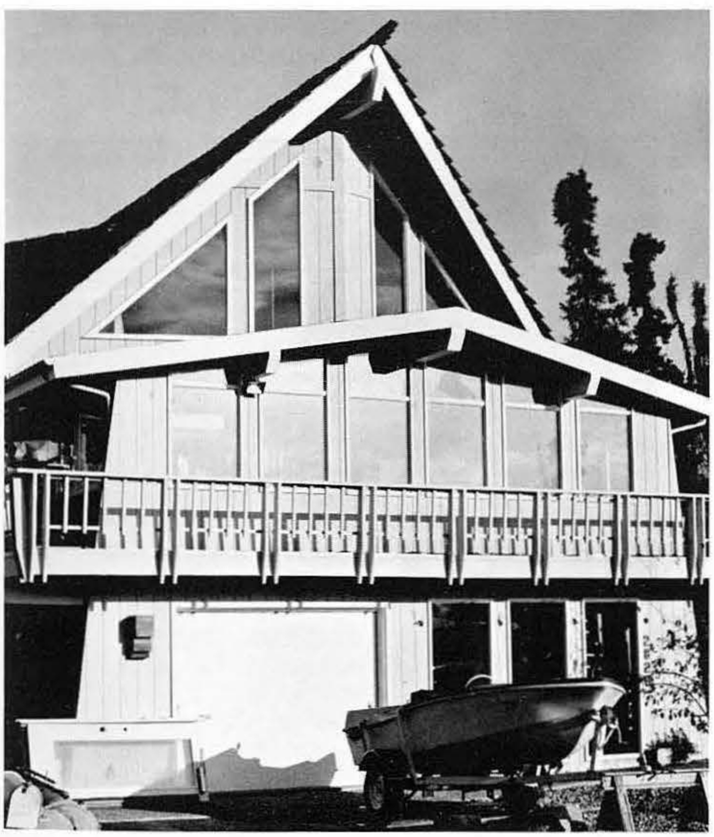
The walls, covered on the outside with T1-11 plywood, are made of two by six inch framing with fiberglass insulation, polyurethane and drywall for an insulation value of R-27. A double two by 10 inch beam acts as a brace with the house.

The roof, which has an R-50 insulation, is made of two by eight inch rafters with six inches of styrofoam and a layer of polyurethane. It was sealed with tar.

Cline also installed triple-pane windows. The outside and inside panes of the one-and-three-eighth inch thick windows are standard three-sixteenths-inch thick glass. Between these two outer layers and separated from them by two air spaces is a third center "pane." This center pane is not glass but a special "Heat-Mirror" made of a visqueen-like material which is coated on one side with a thin copper-tin oxide film. This film allows sunlight to enter a building, but effectively blocks over 50 percent of any heat rays from leaving.

Most solar energy heating systems require that the windows be insulated with shutters or thermal curtains during periods of darkness or no solar gain. These windows don't require that extra insulation, says Cline.

Much of the captured heat will be stored in the floor



Larry Cline built a solarium (left) on the second floor deck of his south-facing home.

thermal mass composed of a rockbed atop two-inch layers of Insulfoam brand insulation capped by a layer of concrete blocks placed sideways, so that the block cores form a series of channels for air ducts and a cement slab. Registers along the outside perimeter of the floor allow heat to rise into the solarium.

Heat sensors located throughout the solarium monitor the internal temperature and control a fan. When the temperature of the solarium reaches a predetermined point, the fan is activated, drawing the warm air into the house. The fan speed increases as the temperature of the solarium increases.

Once inside the house, the home's furnace ducting will be used to transport the warm air throughout the structure. One of the existing cold air return registers for the home heating system is located near the ceiling peak in the highest area of the house, ensuring that air is circulated evenly throughout the structure.

Tips

Cline offers several suggestions in solarium-building:

- Make sure all seams around the window and walls are caulked well. Also, it is important to caulk both sides of each window pane.
- Do not install triple pane windows unless the center is coated with copper tin oxide.
- Install flourescent lights to supplement poor winter sunlight.
- Before building a solarium, take time to figure out how the air will circulate and incorporate the air movement in the design.

Funding

U.S. Department of Energy	$3,155
State of Alaska	8,363

Grant Recipient

Larry Cline
2820 Kingfisher Dr.
Anchorage, Alaska 99502

Rustic comfort: Solar-heated log cabin

Jack Segle drives a truck most of the time. But in his spare time he's building himself a solar-heated log cabin near Palmer, in Southcentral Alaska.

"I was intrigued by solar energy," says Segle, adding that this is the first time he's built a solar heated home. "I hope to provide a working example of the cost effectiveness, the simplicity and the immediate availability of passive solar space heating."

So far, he's grown several crops of vegetables in the attached greenhouse, and used it as a work space during winter.

Segle says he still has to install a planned sod roof, a duct to help circulate heat from the ceiling to the floor of the house, and an earth berm around the walls.

"It isn't complete yet," Segle says. "But it appears to be working just fine."

Design

Segle's two-story log cabin is 16 feet wide by 24 feet long. A bedroom and storage space are on the top floor, above the first-floor living room and bath.

Most of the heat is provided by a solar greenhouse, which was added onto the south wall. The greenhouse, funded by the state grant, has 120 square feet of double-paned glazing; the panes are spaced four inches apart.

The home also has 56 square feet of double-paned windows, all on the south side.

In addition, Segle installed a fireplace equipped with a fan to supplement his heat during winter, when Pioneer Peak prevents direct sunlight from shining on his home for about 45 to 60 days.

Heat is transferred from the greenhouse into the home by convection, using air as a heat transfer medium. Natural thermosiphoning, combined with the building's design, creates a continuous air loop within the home.

Air moves from the greenhouse up to the second story bedroom and storage space. Eventually, Segle plans to install a galvanized air duct to channel hot air from the second story to a crawl space area beneath the first floor.

Segle's planned heat storage consists of 94.8 cubic feet of concrete in the north wall of the greenhouse, 50 cubic feet of concrete in the greenhouse floor, and 226 cubic feet of rocks contained in wire pens beneath the first floor living area.

Furthermore, he plans to build an earth berm against the north, east and west walls of his home.

Funding

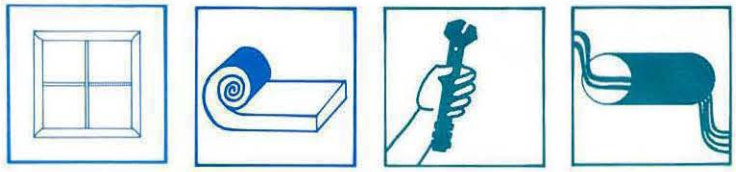
U.S. Department of Energy	$1,250
State of Alaska	1,250

Grant Recipient

Jack Segle
SR Box 7476
Palmer, Alaska 99645

The front of Jack Segle's cabin (above left) features a solarium. This view of the back of the house reveals the various methods of construction which were used (above right).

Building an air tight environment



Imagine an electrically heated home that will stay cozy and warm for two days without power when outside temperatures are 20 below.

Sound impossible?

Not to a group of Wasilla High School students who spent two school years (1981–83) designing and building an energy-efficient three-bedroom home in Wasilla, a growing rural community in the Matanuska Valley just north of Anchorage.

The Mat-Su Valley is among the fastest growing regions in Alaska. Population increased from 18,000 in 1980 to more than 30,000 in 1983; assessed valuation increased from $836 million to $1.3 billion in the same period. Demand for land, housing, basic services, and consumer products has been fueled by a measurable "migration" from the Anchorage area to the rural, less populated valley and its environs, especially in the Wasilla area.

For the students, home construction skills could prove invaluable as their community grows.

"We got to do everything," said Ken Smith, one of the students who helped build the home. For his part, "I got involved in the plumbing and the electrical work the most," he said.

This was the sixth house built by the high school's construction trades program. Each year about 65 students enroll in one of three courses: architecture and drafting interior design or carpentry. Each class contributes to building the home.

Students who want to be in the carpentry class must prequalify a year in advance in the woodshop class. Instructor Richard DeBusman and assistant Gary Richardson work full time with the hands-on carpentry course, involving students with each facet of the home's actual construction.

Students in the drafting class prepare an architectural design using criteria provided by the Vocational Advisory Board of local citizens. Other students design the home's interior.

The advisory board selects the design and makes suggestions. But it's up to the students to complete the home.

Eventually, the students sold the energy-efficient, one-story house for about $119,000. Money from the proceeds went back into the program to purchase materials for new homes and perpetuate the program.

The all-electric heated home also is saving energy. In February of 1984 it only used 2,180 kilowatts, for $178.83; and in July it averaged 576 kilowatts, or a $58.23 electric bill.

"I like the house real well," said purchaser Arnold Warnke, who works on the North Slope in the Arctic as a plant operator for Sohio Alaska Petroleum Company. "But I think it would have been better to put in either gas, propane or hot-water baseboard heat. The electric heat is real nice, it's just real expensive to operate. I think gas would be ideal for this type of home."

Design

The 1,600-square-foot, super-insulated home has a master bedroom with a walk-in closet and bath, a living room, kitchen, dining room, two other bedrooms, a garage, a four-foot crawl space, and electric heating. It doesn't have a wood stove because the home is so air tight that a stove would not be able to get enough draft, Warnke said.

The home has two, two-by-four walls spaced nine inches apart to provide 18 inches of fiberglass insulation for an R-60 rating. A 10-millimeter polyethylene vapor barrier was applied to the inside of the inner two-by-four wall.

Additional two-by-three furring strips were nailed over the vapor barrier. The extra furring allows for all the wiring to remain inside the vapor barrier without making any holes through it except those for exterior electrical outlets.

The ceiling was insulated with 21 inches of blown-in fiberglass. Arkansas-type trusses were used to extend the outside wall two feet above the inside ceiling to provide the space over the outside walls for insulation.

Extra care was taken in the crawlspace to insulate the rim joist spaces. Seven inches of fiberglass were placed between the joists above the plate and then a cut piece of .5-inch urethane board insulation was caulked into place. An aluminum surface vapor barrier was placed over the urethane board.

Special wood shutters, insulated to more than R-10, have been built to slide in-and-out of wall pockets. The shutters slide out to cover the interior face of the double-paned windows to help keep heat from escaping. When the shutters are closed they block light from entering the room.

An air-to-air heat exchanger, known as Metsovent, is another house feature. It is capable of recapturing up to 60 percent of the home's heat as inside air is replaced with fresh air from the outside; it is part of the kitchen range hood.

Vents for carrying warm air from the two bathrooms are ducted through the heat exchanger. The incoming air is warmed by natural heat convection on its way to the living area.

"As the warm air leaves the house, it's warming the incoming air," Warnke said. "The superinsulated house is so tight that you need some type of ventilation or even radon gas will build up."

There also is a unique arctic entryway. It is an enclosed insulated space with two doors, good for storage of boots, rain gear and winter garb.

Performance

Overall, Warnke has been satisfied with his superinsulated home. He said it was built well, and it doesn't lose much heat.

Warnke, however, has had some problems with the shutters warping. Apparently, the shutters expand and contract, making it difficult to open and shut them. They are being replaced by the manufacturer.

Warnke, also, said he would have preferred heating the home with more inexpensive natural gas heat than with costly electric heat. Natural gas, however, was not available when the home was being built.

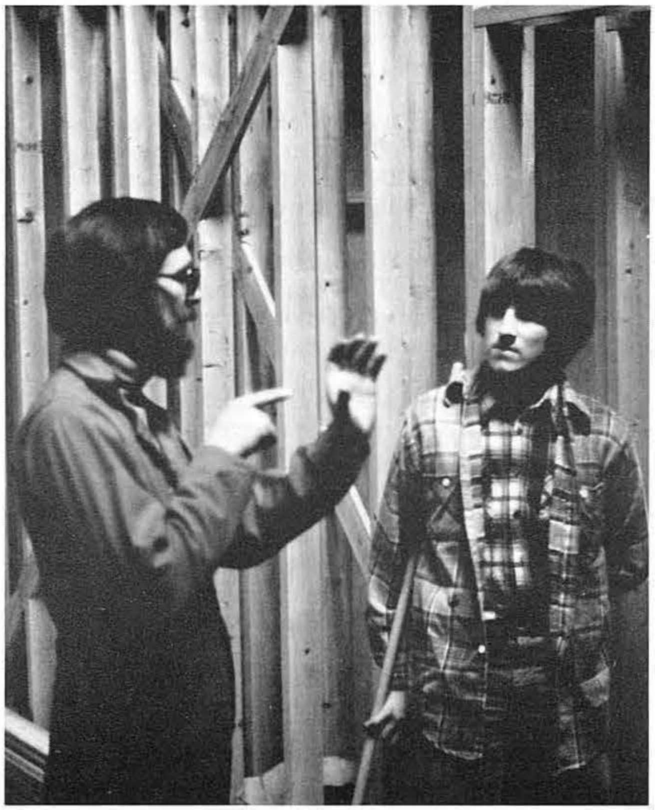
When it becomes available, Warnke says he may convert to gas heating.

Funding

U.S. Department of Energy	$ 4,886
State of Alaska	11,402

Grant Recipient

Matanuska Borough School District
Construction Trades Class
P.O. Box AB
Palmer, Alaska 99645



Richard DeBusman makes a point (left) about construction; (above) the south side of the house.

Home's 'shell' holds heat

Making sure that a home loses as little heat as possible is an important concern for Alaskans living in the Interior, where winter temperatures can plummet below minus 40 degrees.

Terry L. Duszynski, a construction consultant from Fairbanks, has superinsulated his home and added a sunspace.

Moreover, the appropriate technology grants he received also provided funds to make two half-hour video tapes about the project. The two-part series, entitled "The Great Alaska Warm-up," has aired on public television in Alaska.

"We have the ideal testing climate for energy conservation techniques," said Duszynski. "We are much more aware of the performance of our houses due to the extreme cold winter conditions."

Essentially, Duszynski superinsulated an older, two-story home by adding a new roof and outer walls. He filled the space between the new outer wall and the old inner wall with insulation.

"When the project was completed, a totally new superstructure was in place around the old house and the whole house was wrapped with a thick layer of fiberglass," Duszynski said. "It's doing what it's supposed to do."

The new insulation has helped Duszynski slash his electric heating bills in half to about $100 a month.

"The house definitely is warmer in the winter and cooler in the summer," he said. "It's more comfortable to live in. There are fewer drafts and no major temperature swings."

"It really is easy to retrofit an existing house," said Duszynski.

Design and Construction

Duszynski superinsulated a two-story cedar home to R-60. The home, built in 1965, sits in a hillside so that its basement walls are surrounded by earth on three sides. The house only had 2.5 inches of fiberglass insulation in the walls, rated at R-7. The ceiling was rated at R-19.

Duszynski built additional outer walls and a new roof around the existing house. He filled the 16-inch gap between the inner and outer walls with fiberglass insulation. "What you end up with is a superinsulated cavity around the house," he said.

The new 16-foot-high walls, made of two-by-four framing, were built on top of a new concrete footing. The lower half of the wall was covered with all-weather wood panels with an outer face of polyethylene for waterproofing.

The upper half of the walls were covered with four-by-eight sheets of half-inch-thick plywood. Wood shingles were nailed over the plywood.

Two layers of nine-inch-thick fiberglass were installed between the 16-inch cavity between the outer and inner wall. One layer was placed horizontally, like stacked bricks and the second layer was installed vertically between the new wall studs.

The double-paned glass windows were left in their original position and a box was made to meet the new wall. The box sides were painted a creamy white to reflect light through the window into the house.

A sheet of six-millimeter polyethelene was laid across the original cathedral roof, and 12-inch truss-joists were placed across the polyethylene and nailed to the roof. The space between the trusses was filled with 12-inch batts of fiberglass. Two-by-four purlins were nailed across the truss-joists, and 18-gauge sheet metal roofing was fastened on top of the purlins.

Sunspace

The sunspace, built on the south side of the house, is 14 by 28 feet and two stories high.

A six-millimeter layer of polyethylene was laid over the ground, and four inches of blue Styrofoam insulation was placed on top of the polyethylene. A four-inch-thick slab of concrete was laid over the insulation. The perimeter of the concrete slab, however, was raised to eight inches with post supports for the sunspace structure.

The sunspace was made by bolting together six-by-six post and beam framing. The roof was framed with two-by-12 boards, and planked with two-by-four purlins. Duszynski used three-by-18-foot-long hi rib steel roofing with some 12 inches of fiberglass insulation. Finally, he used tongue and groove pine siding of one by six feet to complete the structure.

The window panes, which were 46 by 76 inches, were made from sliding glass door replacement glass. All windows were caulked on the interior to prevent heat loss.

Heat from the sunspace is vented into the house by opening the doors and windows on both the first and second floor of Duszynski's home.

There also are vents on the east and west sides along the top of the window panes to exhaust heat during the summer. Eventually, Duszynski plans to install automatic vents which would open when the temperature reaches 80 degrees during the summer when the heat is not needed in the house.

Performance

Duszynski says both the home and the sunspace are performing as expected. The home is not drafty and he has not had any noticeable temperature differentials between the living room floor and the loft area.

Better yet, his winter electric heating bills have only averaged $100 above his typical summer bills.

Much of the project was designed as it went along. Although he had a basic idea of what was to happen, the problems encountered were not totally known, Duszynski said.

The first problem that occurred was the visqueen on the exterior of the all-weather wood foundation. This material began to slide down the wall as the ground around the house began to settle. He had to dig two feet down all along one side of the house and add more visqueen to protect the wall from ground moisture. Duszynski has since found several alternatives. One is to cover the foundation with asphalt coating prior to the visqueen for additional protection, A second is to put another layer of visqueen over the first, but not fasten it at the top. This allows it to slide down along the first one as the ground settles. Third is to use a new superstrong, nylon reinforced material which will not break loose from the top and slip.

The sunspace also functioned well. But he discovered that there was never any extra heat available for the home between November and mid-February, months where sunlight is limited to four hours daily.

"I am not sure yet just how much heat is able to be produced by this sunspace, but during the next year I hope to monitor with instruments the temperatures throughout the sunspace," he said. "It's doing what it was intended to do."

Video Tape

The appropriate technology grant also provided funds to make two half-hour video tapes, which were produced by KUAC television at the University of Alaska-Fairbanks.

One film is a documentary of some of the steps Duszynski took in super-insulating his home, and the other describes how Duszynski built his sunspace. The video tapes have been shown on public television in Fairbanks, Juneau and Anchorage.

Among problems the film crew had were unpredictable weather, coordinating everyone's schedules for filming scenes, and getting good footage.

"There was one day when we worked all day on just five minutes of footage and felt that none of it was usable," Duszynski said. "But most of the time it was fun as well as work."

"The super insulation program has been aired about five times in Fairbanks and the sunspace film once," Duszynski said. "So I'm happy with the result. It said what I wanted it to say."

Tips

Duszynski has several suggestions for similar projects. They include:

- Put an asphalt coating over the foundation before adding the polyethylene for additional protection against moisture. Buy polyethylene with nylon threads in it.
- Do not use any type of thermal storage for sunspaces in far north climates because it usually decreases the available heat from the sun for the house in early spring. A wooden, insulated floor would allow all additional solar heat to be directed into the house as soon as it was available.
- Be prepared to spend more time making a video tape than expected.

Funding

U.S. Department of Energy	$ 5,759
State of Alaska	31,277

Grant Recipient

Terence L. Duszynski
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Fairbanks, Alaska 99701

Chickens provide greenhouse heat supply

Chickens can keep a solar greenhouse warm when the thermometer plummets to sub-zero temperatures in the Interior of Alaska.

But it's a risky proposition.

Just ask Elizabeth Hart, author, photographer, mother of three, and owner of a roadhouse in Ruby, Alaska, about 250 miles west of Fairbanks and 50 miles east of Galena.

She tried to heat her solar greenhouse with a flock of 135 chickens. And it worked—until ammonia from the chicken wastes started killing the plants and sub-arctic temperatures began freezing the hens.

The setback, however, has only temporarily postponed Hart's dream of someday supplying this Yukon River community of 250 residents with fresh eggs and vegetables.

"I definitely plan to try it again," says Hart. "I still think it can be done. If I had a family flock of a dozen chickens and a small greenhouse—I think it would work."

Design

The two-story greenhouse was built on pilings and insulated to about R-40. The chickens were housed on the first floor, and the plants were placed upstairs. Heat and carbon dioxide from the chickens was to supply the needs of the plants above.

The 20-foot by 24-foot building was placed on a level, northern-oriented site because Hart was not able to purchase or lease a south-sloping site.

Hart and two others with carpentry experience began construction in the summer of 1982. They hit ice at about one foot and had to use steam drilling to dig holes for the wooden foundation posts, which were anchored to the building with heavy bolts.

The walls were insulated to R-40 by installing sheets of plywood, plastic, building paper and two sheets of Thermax-brand insulation. The roof and floor were padded with fiberglass, yielding an R-60 value, to prevent the chickens from getting chilled while on the floor or in elevated roosts. And the double-paned, acrylic plastic windows were padded with a layer of plastic for an added air envelope.

In addition, there were 18 inches of dry sawdust placed on the floor in the 12-foot-by-24-foot chicken coop area. The coop was furnished with nests, floor feeders, waterers and roosts built on the wall from the ceiling to the floor. Sawdust was added as waste accumulated on the floor, creating a compost that helped heat the building.

Thin aluminum reflective material was placed on the white walls of the second-floor to enhance light reflection for photosynthesis. Flourescent lights were placed over the growing beds, which were a foot deep and 2.5 feet wide. Similar lights were placed in the coop. Starting in September, the lights were automatically turned on at 6 a.m. and switched off at 8 p.m. Thermometers also were placed in and outside of the building to monitor the temperature.

Performance and Problems

At first everything went well, despite the gradual drop in temperature from 70 degrees to freezing. The hens laid about a dozen eggs daily, the chickens gained weight, and the three roosters woke everyone in Ruby earlier than they wished.

But then it got really cold.

Unfortunately, the coop could not be maintained more than 40 to 50 degrees above the outside temperature. So when temperatures outside the greenhouse plummeted to minus 40 degrees—it meant the chickens froze in zero-degree weather. The cold killed plants and hens.

"I was hoping that the chickens would be able to keep the temperature up above freezing," Hart said. "But I think the ceiling was too high. If I had lowered it, there would have been less area to heat."

Lack of sunlight compounded Hart's heating woes. The sun is quite low in the winter because of the latitude (64 degrees north) and hills to the south which block the available light. In fact, no direct sunlight hit the greenhouse between November 15 and January 15.

As a last resort, Hart installed a heater and lowered the ceiling a few feet, which raised the temperature about 10 degrees. But it wasn't enough. More chickens died and the rest stopped laying eggs.

"I feel that a coop has to be at least 40 to 50 degrees for egg-laying, and I could not provide this temperature and also be cost effective," she said. "The electric bill was several hundred dollars a month and that was too much. So I gave away the chickens for meat."

Ammonia gases released from the chicken wastes proved to be another handicap. Even with a foot-thick layer of fresh sawdust, the ammonia vapors accumulated so heavily at times that it poisoned Hart's tomatoes, beans, lettuce and flower plants within hours.

"It was terrible," Hart said. "They'd just turn black and die. It was like a stab in the heart. I had gorgeous flowers in there. Absolutely gorgeous. Some lasted a week. And some lasted a day. But the chicken ammonia killed them."

Hart learned from the Cooperative Extension Service in Fairbanks that a similar ammonia problem had developed when another person tried to heat a greenhouse with pigs. The extension service told her that a limestone filtering system could remove the poisonous gases. But Hart couldn't afford the system.

Instead, she installed a fan, which helped disperse the gases, but directed excessive airflow onto the plants. Another person suggested that she turn the compost heap more frequently. She tried this too, but found that turning a compost heap 12 feet wide by 24 feet long by 18 inches thick was a lot more work than she had bargained for.

Tips

Hart says several things could be done to improve on her experiment including:

- Lowering the chicken coop ceiling to three to four feet except in the immediate areas of feeding/watering and roosts.

- Placing dropping pans under the roosts (instead of sawdust) so these can be emptied.
- Installing a tight wood stove with a protective mesh guard around it. Buy at least two cords of wood to last seven months.
- Installing an automatic fan system in the greenhouse and a fan in the coop. Also, experiment with a filtering system so that the heat—but not the ammonia gas—would circulate around the plants.

She also recommends Rhode Island Red chickens as a breed that can withstand Alaskan winters.

Funding

U.S. Department of Energy $14,260

Grant Recipient

Elizabeth A. Hart
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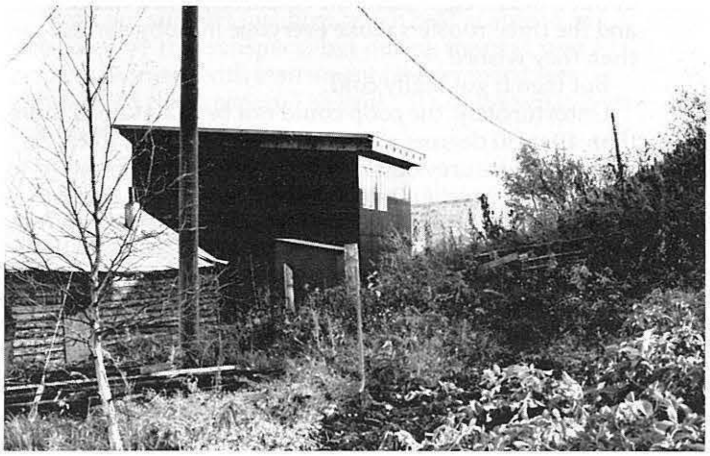
Fairbanks, Alaska 99701



A side view (left) of the two-story greenhouse. A flock of 135 chickens (bottom left) produces a fowl odor. At bottom right, grantee Elizabeth Hart at home. Below, the Yukon River flows near the Hart homesite.

Waste heat increases growing season

Two hundred miles northwest of Anchorage, near the limits of navigation on the Kuskokwim River, lies McGrath, a small community of about 500 year-round residents. But more than just a Bush community, McGrath is also the commercial and transportation hub for the entire Middle Kuskokwim region.

Like many remote communities, McGrath is plagued with high energy costs and a lack of fresh fruits and vegetables during the winter months. Early in 1981, Larry Wiggins (Executive Director of MTNT, Ltd, at the time), started a program that he hoped would reduce both of these problems. MTNT, Ltd. is the local for-profit Native organization for the area and owner of the local electric utility.

Realizing that 70% of each gallon of diesel the utility bought was wasted up the exhaust pipe or heats the air from the radiator, Larry Wiggins looked at ways to capture wasted energy. Such a waste recovery system would benefit the community by improving the utility's performance. Soon a heat recovery system and heat transporting pipeline was installed. This system is used to heat the buildings (residences and offices) of the Federal Aviation Administration (FAA) in the central business district. The savings in heating fuel, alone, has amounted to almost 40,000 gallons a year.

With the heat recovery system in place, Wiggins began the second phase of his plan, the construction of a commercial greenhouse that could grow vegetables year-round. This greenhouse would be heated with recovered waste heat and would supply both McGrath and the other villages in the region, bringing in additional income to MTNT.

The project involved designing and constructing the greenhouse structure, developing a way to supply and control the recovered waste heat to the greenhouse, developing a horticultural program that ensured maximum usage of the greenhouse, and determining the overall economics of the project.

Design and Construction

The greenhouse is a 42-by-84 foot clear span building situated near the McGrath power plant along an east-west axis. This axis is due to the low sun angles experienced at these latitudes, even during the summer months. Inside, the greenhouse is divided into five separate growing areas, as well as a potting room, a sales/office area, and an emergency boiler/heat exchanger room.

One of the major problems confronting the designers was permafrost. The greenhouse design called for heating pipes to be implanted under the soil of the growing benches. Heat radiating downward could quickly destroy the entire project by melting the permafrost, causing the foundation to shift. To protect the permafrost, a thick gravel and sand base was laid, followed by two inches of styrofoam insulation. The styrofoam is covered by another two-inch protective layer of sand, and high capacity drain pipes were installed around the perimeter.

Primary heat is through four, five-tube grids laid out in the bedding soil to provide (four) separate, but controllable, heat zones. An aquastat switch controlling a small circulating pump keeps each zone at the set temperature. The aquastat allows small variations in ground temperatures for optimum growing conditions.

To avoid the risk of heat recovery system failure and to reduce the chances of freeze burn if doors were left open during the winter, a secondary back-up heating system was installed. These overhead mounted units use heat supplied by an emergency boiler and are rated high enough to keep the greenhouse warm even with total failure of the underground heating system.

The two-by-six framed, double-glazed structure has two four-by-five foot ground level openings at each end of the greenhouse which are used for summer ventilation. These openings are manually operated as the need exists. Two louvered openings and large exhaust fans are also mounted high in the gables at each end of the building to remove heat without causing drafts at the plant growing level.

A special "cool room" was built to provide optimum growing conditions for new sprouts and budding plants. This room was insulated so that ambient temperatures could be closely controlled. A propane carbon dioxide generator is also included in the cool room design.

The small potting room has a deep sink and ample storage shelves and work spaces for potting new plants or repotting seedlings.

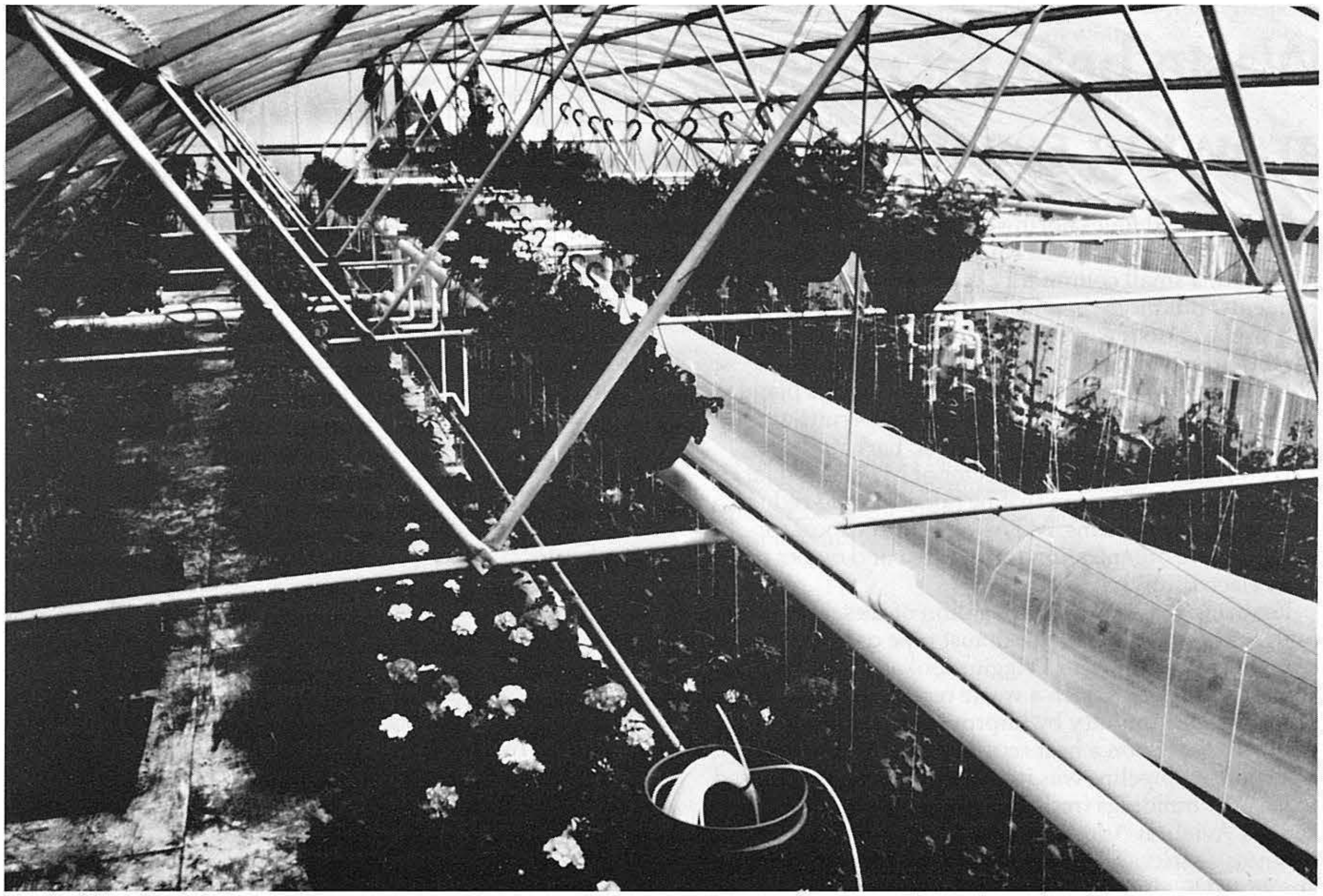
The emergency boiler room (in addition to the boiler), has a heat exchanger and storage tank for warming the 40-degree well water prior to use. The water is heated to about 70 degrees, fertilizer is added, and the mixture is then applied to the plants using an efficient, automatic drip watering system. Storage space also is available in this room.

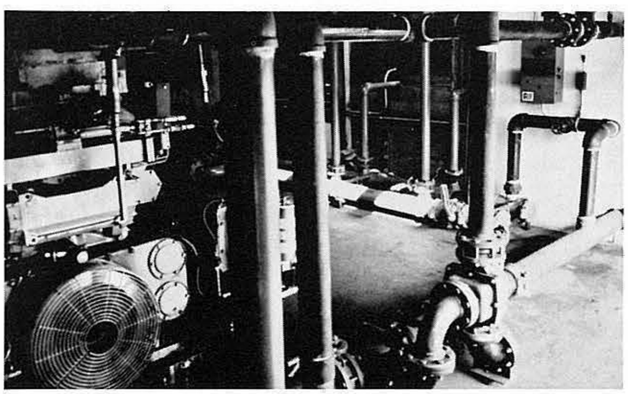
A 10-by-20-foot office is attached to the exterior of the north wall. This office also is used for over-the-counter plant sales and as a convenience to local residents.

Although the original design did not include artificial light, it was quickly determined that to make the project economically feasible some form of additional lighting was necessary. The three-tiered growing beds were outfitted with flourescent grow-lights and metal halide and sodium vapor lamps were mounted overhead, increasing the growing area by 1,000 square feet. The additional light also allowed the addition of four hydroponic growing tubes on the north wall. These tubes, alone, added almost a quarter of an acre of growing area, for a total of about 4,200 square feet of surface area plus room for 300 hanging baskets.

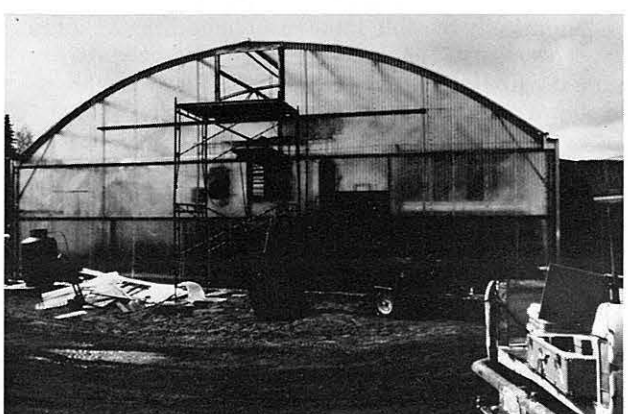
Performance

The greenhouse has been a resounding technical success; unfortunately, the project was cancelled because it had not made a profit during the first year of operation. Many reasons have been presented concerning the





A view (above) of the interior of the greenhouse from the mezzanine. (Bottom left), the exterior of the greenhouse. Heat exchange piping (middle left) is located in the powerhouse.



economic woes of the greenhouse, including unforeseen increased operating costs, poor marketing, size, and poor initial planning. But it seems that community priorities and perception may have doomed the project.

From a technical point of view, the greenhouse successfully proved that fresh fruits and vegetables could be grown year-round in the far north using recovered waste-heat and artificial lighting. According to Harold Pillsbury, greenhouse manager and horticulturist, the greenhouse even exceeded commercial production elsewhere. For instance, tomatoes yielded an average 33 pounds of fruit per plant. Normal average in similar adventures is 22 pounds per plant, he said. Other difficult-to-grow crops, such as cucumbers and peppers, showed similar productivity. However, since the operation was never allowed to go beyond the experimentation stage, it is hard to determine how profitable the greenhouse could have been.

This is not to say that there were no problems with the greenhouse. During initial shakedown it was found that the aquastats were not controlling the soil temperature as accurately as required. The aquastats were temporarily bypassed and newer ones, with a maximum setting of 120 degrees versus the 90 degree type on the originals, were ordered to solve this minor problem.

Soon after applying heat to the four heat zones, it was discovered that there was a heat overlap at the zone edges. A narrow trench was dug between the zones and the trench filled with strips of styrofoam. This effectively cured the heat flow problem.

One last problem was discovered during the winter. The cold weather caused a measurable drop in carbon dioxide production from the propane generator. Heat tapes and a temporary covering of the propane tank easily corrected the carbon dioxide production problem.

The heat retaining ability of the greenhouse worked better than expected. In fact, the six-inch dead air space kept so much heat in that snow refused to melt off the roof during the winter months. Since artificial lighting is used and the structure was designed to handle the additional load, the snow created no problems.

Conclusions and Results

There seems to be a common consensus that the McGrath Greenhouse was a successful application of appropriate technology. The problems associated with this project seem more political than technical. Due to the fact that the greenhouse was only allowed to operate during the trial season and shut down before a commercial market could be developed, the economic success of the concept was never proven.

Because the project did prove that recovered waste-heat from diesel powered generating plants could be used to increase the growing season, it may be possible to adapt the concept to other small villages and towns with similar power plants.

For all of its technical successes, the McGrath Greenhouse did prove that unless the community actively supports a project, it will usually fail. Public support would have forced management to continue with subsidizing operating costs and actively pursue a market for the product. The present management of MTNT, Ltd., is doing just this. Although the greenhouse is temporarily placed on the backburner, the organization is searching for alternatives. Some suggestions have been to produce a high value cash crop such as fresh herbs, or to limit the growing season and thus limit operating costs.

Funding

U.S. Department of Energy	$ 25,000
State of Alaska	175,000

Grant Recipient

MTNT, Ltd. (McGrath, Takotna, Nikolai, Telida, Ltd.)
P.O. Box 104
McGrath, Alaska 99627

Greenhouse crop supplements traditional lifestyle

Two solar greenhouses built in Aniak are helping the Kuskokwim Native Association extend the growing season to eight months.

Now the association is able to start seedlings in the greenhouses in March for growing fresh vegetables, cole and root crops on a farm the association also operates. The area is marked by temperature extremes, permafrost and a short growing season from mid-May to mid-August.

"We've been growing tomatoes and cucumbers and starting our seeds for cold crops and flowers," said Walter Overton, agriculture director for the Kuskokwim Native Association. "About the second week of June we transfer it to our farm."

One of the greenhouses, a 150-square-foot-structure, was built with funding from the Bureau of Indian Affairs. The second, larger greenhouse, which is about 1,000 square feet, was funded partially with federal appropriate technology grant funds. The greenhouse grant, issued in late 1979, was one of the program's early successes, despite a delay from weather at the start of the first building season.

The greenhouse, farm and education programs sponsored by the Native organization will help take pressure off the traditional hunting and gathering lifestyle, which has been jeopardized by a growing population.

Almost all food, including fresh vegetables, must be shipped or barged to Aniak, which is located at the junction of the Aniak and Kuskokwim Rivers. Freight alone can inflate the price of food dramatically.

The association, however, is hopeful that this project will help make the village a little more self-sufficient.

System Design

The greenhouse that was funded with AT grant funds is 20 feet wide by 53 feet long. It has a concrete foundation, a dirt floor, and a 10-by-14-foot arctic entryway.

The walls, Overton said, are eight feet high with two-by-four-studs on the west and east walls. The north wall has two-by-six-studs. The walls and ceiling have six inches of fiberglass for an insulation value of R-19. The exterior is covered with sheet metal, and the interior with three-eighths-inch plywood sheets.

The 12-foot-high, south-facing wall is made of double-paned fiberglass glazing spaced about 10 inches apart, Overton said. It also has a three-foot-high south sidewall constructed the same as the other walls. The roof is covered with roofing paper.

To increase light reflection, the interior walls were painted white. Fifteen, 55-gallon drums in the greenhouse are filled with water for thermal mass.

All interior surfaces are covered with a polyethylene barrier to prevent moisture from rotting the wood.

Overton said the association plans to install an oil-fired stove shortly.

By comparison, the smaller greenhouse funded by the Bureau of Indian Affairs has standard two-by-four wood framing with plywood covering the interior and exterior walls on the north, east and west sides. Six inches of fiberglass provide an insulation value of R-19 to the ceiling and to the north, east and west walls. The south walls are made of double paned glazing with translucent fiberglass. It has an arctic entryway about seven feet by five feet.

Performance

Overton says both greenhouses are working very well and are helping the Native association extend its growing season to eight months.

The AT-funded greenhouse has even stayed above freezing even when outside temperatures plummeted to minus 40, according to the association. In fact, the heat collection/retention of the structure is so good, that an exhaust fan and shutter should be installed to provide adequate ventilation.

Although the original plan called for a completely passive solar structure, electricity for the exhaust fans and grow lights was brought to the site. A road also was added recently, to enhance travel to the greenhouse and garden.

The group also had planned to install a 480-square-foot reflective shield made of two-by-four framing, covered with a lightweight reflective material (Alsinite) on the south side. The shield was to be attached to the roof with a hinge.

But due to high costs and questionable effectiveness, the heat reflector shield was abandoned.

Problems and Conclusions

An extremely wet summer in 1980 delayed construction so much that only the gravel pad and cement foundations could be completed that year. Workers hired for the building season under an employment training program spent most of their time in the classroom. The original plan to complete the structure in four weeks stretched out to two seasons; the greenhouse was completed in 1981.

Another minor problem was a low estimate for the amount of gravel needed for the building pad. The additional gravel for the greenhouse (added to the gravel needed for the road) significantly increased the project's cost. However, the increase was offset by having most of the construction materials barged to Aniak rather than delivered by costly air freight.

The Kuskokwim Native Association has had success farming in remote locations. The Aniak Farm leases about 160 acres from KNA at $1 per acre per year. This property is used to grow vegetables and farm crops for chickens, goats, and other livestock and for forest management projects. All profits are returned to the farm. With about 30 acres cleared and planted, this organization looks to a future of self-sufficiency without loss of cultural independence.

Funding

U.S. Department of Energy $16,534

Grantee

Kuskokwim Native Association
Box 106
Aniak, Alaska 99557

A view of the greenhouse built by the Kuskokwim Native Association (left).

Construction plans put on hold

The community of Kotzebue, hoping to grow fresh vegetables, has been trying to build a solar greenhouse for the past several years.

But they haven't had much success so far.

In 1980, the Kotzebue IRA Council (a village government entity) received an AT grant to build the greenhouse for a future supplemented food source.

The greenhouse is still incomplete however the frame, plywood walls and roof were built and a few windows were installed, but further construction has ceased, and the building sits unused on community property.

The delay stems from site relocations and the loss of the project manager. In fact, Kotzebue IRA manager Jeff Hadley says the entire project may be turned over to another nonprofit Native group for completion.

System Design

The proposed, rectangular greenhouse would be 24 feet wide by 30 feet long, standing 14 feet high at the apex of its sloping clerestory roof.

Some 18 glass panes are planned for the south side of the building to capture the most amount of light available in the late winter and early spring.

Solar heat will be stored in large water tanks inside the greenhouse. Supplementary heating will be provided by an oil-fired heater.

The council is planning to install movable insulating shades to cover the glazing and reduce heat loss at night. Fiberglass insulation will be placed on the walls.

Grow-lights will be added to provide additional lighting when needed.

Originally, the council had proposed to install a wind generator that would provide some 60 percent of the greenhouse's electrical supply, but this idea has been dropped with the stagnation of the greenhouse construction.

Funding

U.S. Department of Energy $21,200

Grant Recipient

Kotzebue I.R.A. Council
P.O. Box 296
Kotzebue, Alaska 99752

This greenhouse in Kotzebue (left) awaits completion.

Recycled tire rubber provides thermal mass

Location

This passive solar greenhouse is located in Fairbanks, Alaska on a flat plateau in the North Star Borough bowl.

Paul Robinson's central goal in this project was to design a structure that could make use of recycled tire rubber—material that otherwise would have gone to waste from a nearby tire retreading plant. The project was designed to enable such a greenhouse to be built on flat terrain, rather than into slopes of hills as is common in the Alaska Interior. The original proposal under the Appropriate Technology grant program assumed that black tire rubber would prove to be superior in absorbing and holding heat, and would thus serve as an efficient heat sink.

Construction

The detached greenhouse was built with a south-facing wall of glass. The north wall (at the back of the structure) was layered with shredded rubber. The floor of the greenhouse was above ground level, with layers of shredded rubber placed beneath. Flower boxes also were lined with rubber, with dirt on top for planting.

A hot water tank was suspended from the ceiling, and vents were installed for cooling as necessary.

Performance

"The greenhouse has exceeded all of my expectations in its performance," said Robinson. "It seems perfect for our Alaska climate; when the sun is high in the warm summer months, the greenhouse can be kept cool by simply opening the vents. In the spring and fall, the greenhouse is much warmer inside than outside. In fact, keeping the structure cool is more of a problem on a sunny spring day than in the middle of summer. This is due, of course, to the design and the use it makes of direct light in the spring and fall and of diffused light in the summer. The project was in working condition in May of 1982, and we made good use of it. We started all of our bedding plants, and quite a few for several neighbors and friends, in the greenhouse from seed. We grew an excellent crop of tomatoes. The greenhouse is not only a good growing environment, but also is a very pleasant place to be," he said.

"I have had one technical problem with the rubber. Basically, it worked very well; however, on some clear and unusually warm days it did get too hot. I removed the rubber temporarily and designed a system that will enable me to move the rubber forwards or backwards, depending on need.

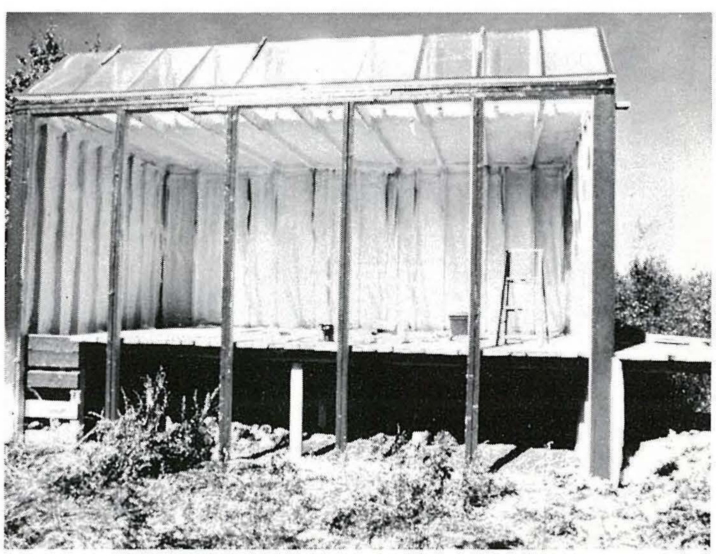
"We used the greenhouse the first year until October 12. With a small heater we could extend our growing season another month in each direction, although I do not think we need to. The greenhouse produces so much that we still have a freezer half-full of last year's vegetables," said Robinson in 1983.

Funding

State of Alaska	$ 1,783.00
U.S. Department of Energy	1,783.00

Grant Recipient

Paul Robinson
P.O. Box 60904
Fairbanks, Alaska 99706



Paul Robinson's detached solar greenhouse (left) is shown here under construction.

"The ground acts as a very big radiator"

John Collette has the biggest tomato farm in the Alaska Interior heartlands—thanks to a specially designed solar greenhouse that heats the ground.

His secret? Maintain soil temperatures around 75 degrees by circulating warm antifreeze through pipes buried in the quarter-acre lot covered by his greenhouses, a commercial enterprise.

"The ground acts as a very big radiator," says Collette, who owns Happy Creek Greenhouses in Fairbanks. "It throws heat off at night."

The design is so efficient that he is able to keep the soil warm enough to produce cucumbers, bedding plants and 30 to 40 tons of tomatoes annually between early March until November. The normal growing season is about 90 days in Fairbanks.

The design has proven successful. In fact, since the first small, prototype greenhouse was completed from the 1979 grant funds, Collette has added two more commercial greenhouses using a similar design.

"It's working very well indeed," Collette says. "It's reduced my operating costs by a substantial amount. My next venture will be to pump warm air through the ground."

System Design

The entire system is dependent on pumping a 50/50 mix of hot antifreeze and water through plastic pipe buried inside the greenhouse. The antifreeze is warmed by a solar collector, which is supplemented with a coal-fired boiler. An oil-fired unit heater also is available for emergency or supplemental use.

The prototype greenhouse is 20 feet by 40 feet with a rib structure formed of one-by-twos sandwiched together. Two layers of six-millimeter, Monsanto 602-brand polyethylene are attached loosely on the outside of the ribbing, separated by an air space that is maintained by a very low pressure fan. This provides insulation similar to thermopane glass.

The polyethylene can withstand temperatures of minus 40 degrees without cracking; and the air pressure keeps the polyethylene taut.

The heart of the system is a 35-foot-long by four-foot-high solar collector on the ground along the south wall. The four-inch-deep solar collector is made of aluminum roofing, painted black, with three-quarter inch baseboard fin tubing and polyethylene glazing.

A ceiling "squirrel-cage" fan also blows warm air that gathers under the roof into the solar collector, which helps heat the antifreeze solution circulating through the copper baseboard tubing in the solar collector.

The antifreeze is pumped through the solar collector to a set of plastic pipes buried in trenches in the floor.

There are 15 trenches, each 14 inches apart, across the east-west length of the greenhouse. In each trench, Collette put four layers of pipe, which are buried at depths of 14, 18, 22 and 26 inches.

After circulating through the buried pipes, the antifreeze flows back to the solar collector via a hot water boiler. The heater is used as a supplementary heat source in fall and spring, when there is adequate sunlight but snow remains on the frozen ground outside.

The heater runs whenever the ground or air temperatures drops below a minimum growing temperature.

Plant growth also is enhanced with a carbon dioxide generator. The unit burns propane, which emits carbon dioxide and water vapor. By maintaining carbon dioxide levels at around five times normal air levels, optimum plant growth is achieved in the greenhouse.

A similar design was used to build two commercial greenhouses, nearly 10 times the area of the AT grant prototype. Each of these greenhouses are some 50 by 150 feet in dimension.

Performance

Collette says he's been pleased with the performance of his greenhouse design. The system maintains ground temperatures at about 75 degrees during his "extended" growing system, which is warm enough to keep his tomato crops thriving year after year.

Moreover, his two commercial greenhouses, are also doing well. The produce sold in Fairbanks grocery stores and the open air market are highlights of his success.

Funding

U.S. Department of Energy $9,484

Grant Recipient

John Collette
SR 20087-A
Fairbanks, Alaska 99701

Community greenhouse provides example

Gardeners will soon have an opportunity to plant their seedlings in a community-owned solar greenhouse in downtown Fairbanks, Alaska.

The greenhouse, designed by the Alaska Federation For Community Self Reliance Inc., should be ready for the community by spring of 1985, says federation spokesman Dick Farris.

It would have been ready by the summer of 1984, except that the organization had to relocate the project after the borough decided to put a building on the old garden site. The group plans to operate the greenhouse from mid-April until mid-September.

"We envisioned the solar greenhouse as a place for starting plants for gardening enthusiasts in the community," Farris said. "We also built the greenhouse as a demonstration project to teach people in the community how to build one for themselves," he said.

Design

The greenhouse is 14 feet wide by 40 feet long. The south, west and east walls are made of double-paned Filon, a brand of hard, translucent glazing material.

The eight-foot-high north wall is made of steel roofing, backed by 3½ inches of fiberglass insulation, polyethylene plastic sheets and plywood.

The sloped roof, also made of Filon, rises to a 12-foot apex. The north side of the roof was designed so that blocks of polystyrene eight feet long by 1½ feet wide could be installed on top of its two-by-four rafters. The roof's south side slopes at a steep angle, and has a 2½-foot-high nave wall.

A solar collector also will be suspended from the ceiling. It is to be fabricated as a 30-foot-long by three-foot-high metal tube cut in half lengthwise (into a half-circle) and painted black for heat absorption. Polyethylene will be stretched across the half-circle to trap solar heat inside the metal apparatus.

The east and west walls of the greenhouse are hollow with a one-foot-wide space between the inner and outer walls to allow for air circulation.

There are also a series of four-inch-wide, perforated drain pipes buried a foot deep in the ground floor. The pipes, spaced one foot apart from each other, will be connected to the east and west walls of the greenhouse.

A one-third horsepower fan will blow hot air down the solar tube into the hollow east wall; the air then will be channeled into the buried pipes. Excess, cool air will, be forced up the hollow west wall.

Thermostats also will be installed to regulate the temperature.

Design Modifications

Originally, the group planned to circulate warm water through pipes buried in the greenhouse floor and surrounding garden plots. The water was to be warmed in the ceiling solar collector.

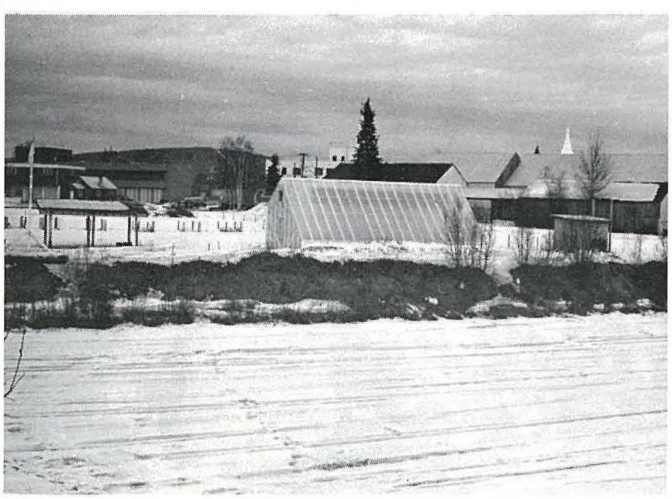
But this plan was abandoned because it was complicated and would have been more expensive to install.

Funding

U.S. Department of Energy	$5,533
State of Alaska	5,533

Grant Recipient

Alaska Federation For Community Self Reliance, Inc.
P.O. Box 73488, Federal Station
Fairbanks, Alaska 99707



The Fairbanks community greenhouse is located on its original site (left) along the Chena River.

A lesson in greenhouse improvement

SAVE I High School is a vocational and technical school located in Anchorage. The project to improve an existing greenhouse structure was undertaken by students, who earned credit for the project as part of their high school curriculum.

Design and Construction

The original project proposal was designed to make the school's existing greenhouse more energy efficient. The students were to design the project, estimate costs, purchase materials and implement the work.

"The situation that we were faced with was a greenhouse covered with a single layer of corrugated fiberglass sheets. There was a gas-fired furnace inside for heat. We wanted to make the structure more energy efficient and increase our growing season," said SAVE's Jim Cunningham.

"We first looked at where we were losing energy; walls, ceilings, and door. Then we opened up discussion for ideas on how we could cut down on the energy loss. We decided that we would put a layer of visqueen on the inside to act as secondary, 'inexpensive' glazing. This was put on all four sides, ceiling and floor.

"Second, we looked at all the little places where we were getting cold air seeping in (and hot air out). We then insulated in those places as well as caulked with a silicone sealant," Cunningham said.

They also took a look at where they might have additional energy losses. The students took a good look at the north wall and ceiling. They decided that since there was no sunlight coming in there, the areas should be insulated. The students measured between each of the two-by-four wall and ceiling studs and cut the expanded polystyrene insulation board to fit.

Expanded polystyrene can be hard to cut evenly; therefore one of the students came up with the idea to seal the material. They decided that a soldering gun would melt through the polystyrene and seal the edge. (Care must be taken in having the area well ventilated, since the fumes are toxic.)

Once the insulation was in place, plastic sheeting was stapled in place for the second glazing. Along the top, a series of wood one-by-two strips were used to keep the visqueen from falling or ripping from the staples.

The students also decided that there was an energy loss through the ceiling and roof during the winter. They installed a series of bent nails in the ceiling rafters, from which styrofoam sheets could be set into place as a drop-in ceiling. This retained more heat inside.

The next phase was to redesign the plant beds. Students set the plant beds on 55-gallon steel barrels painted black and filled with water. These acted as a storage medium to help extend the growing season by releasing the stored heat. "We were also hoping that the release of this heat under the plant beds might stimulate more growth by heating the soil and the roots," said Cunningham.

Instructor Jim Cunningham (below) taught his students how to make their greenhouse more energy efficient.

"Looking at the project overall, the students and I have learned about insulating, vapor barriers, heat storage, construction, solar aspect and solar charting (summer to winter angle)," he said.

Performance

The major points of energy conservation education have been in the following areas, Cunningham said:

- Insulating the *north* wall and part of the *north* ceiling. These areas are energy-losers and should be treated or built as such. The students made the comment that as you drive around the Anchorage area, most of the greenhouses have clear or uninsulated north sides. This project's lesson could apply to these structures.
- A second layer of glazing is much better than a single layer. This is obvious, but the point we are making is that a second layer of glazing can be made of visqueen plastic which is *inexpensive*. Since it is behind another layer of glazing, it is protected somewhat from the elements such as the wind and ultraviolet rays. Our second layer of glazing (plastic sheeting) has been in place for three years and is still in use.
- The third point of interest is the 55-gallon barrels of water. We cannot calculate exactly how much this has saved us in energy, but in any greenhouse you need something to set plant beds on. What better way than through the system we used? We do feel that there was an energy gain and storage through this method.

We feel that our retrofit of a standard greenhouse should be used in most greenhouses that are in this area. Most people are interested in putting together a greenhouse that will not cost them a fortune, and be passive in energy use.

Funding

U.S. Department of Energy $650

Grant Recipient

SAVE I High School
5300 A Street
Anchorage, Alaska 99502

Search for an energy-saving window shutter

Developing insulated window shutters is a dream that inventor Ed McGrath has been pursuing for several years.

"The project still goes on," said McGrath in mid-1984. He is a carpenter and former alternative energy teacher at Tanana Valley Community College in Fairbanks. "I can report that it looks hopeful, but I cannot report any successes."

The biggest obstacles facing McGrath are developing a cost effective design and preventing the shutters from warping after installation.

"In every case that I've built a shutter, it's cost far more than the (cost of) heat lost through the window (without a shutter)," McGrath said. "But I'm still working on it, and I intend to keep working either until I get something, or until it is clear that it just can't be done—at least by me."

Design

Originally, McGrath hoped to build a cost-effective, sliding shutter which would slide up and down over the exterior face of a window. His plans called for installing an exterior second "window," making a sandwich-type assembly.

The shutter was made of a two-inch-thick panel of rigid insulation called Thermax. The panel was covered with Dacron aircraft fabric cloth and heated so the fabric would shrink to fit the panel.

The fabric also was painted to prevent its deterioration by ultra violet light. The edges of the panel were lined with aluminum.

"The shutters were tailored to the windows and they varied in insulation from one-and-a-half inches to three inches," McGrath said.

The shutter could be pulled with plastic coated aircraft cable either manually or with a motor. But McGrath said he had difficulty sealing the hole that he drilled through the wall to install the shutter cable.

McGrath tried using electric motors to raise and lower his shutters, but was unable to come up with a design to keep the shutter up when the motor was turned off. The weather-stripping caused excessive resistance when the sheeting was drawn or raised between the glass panes.

"It turns out that getting a two-way, reversing motor with a break on it is a very expensive proposition, costing a couple hundred dollars for a little bitty motor," he said. "Also, sliding and sealing are antagonistic to each other. It was a basic problem. Make a tight seal and the shutter doesn't want to slide any more."

Experiments with an inexpensive hydraulic air ram system didn't work, either, because he couldn't prevent leakage.

McGrath, however, had some success installing a four-foot-square demonstration shutter for an Energy Efficient Demonstration exhibit at the Tanana Valley Fair. But the demonstration project was not as energy-efficient as hoped.

"Then after eight months, it didn't work at all any more," he says. "The shutter insulation panel had warped and there was nothing to do about that."

Summary

Despite failures and dead-ends, McGrath has learned a lot about building, installing and using insulated window shutters.

"I looked at houses constantly, trying to see if my shutter would fit on their windows," says McGrath. "In far too many cases, the answer was no. I became disillusioned with the sliding shutter. I found that they were

The energy demonstration building (above left) at the Tanana Valley Fairgrounds. Ed McGrath demonstrates his window shutter (above right).

also much more expensive than I had imagined. It wasn't the cost of the shutter, but of the box/glass frame that protected it from the weather."

But he isn't giving up.

In fact, he's been working on a new concept, for which he built a "model" out of cigarette packs, cardboard and tape.

McGrath has had to set his invention aside, but has predicted that, "I will build a cheap successful shutter. And as soon as I have something to say, I'm going to write a little book telling how to build these shutters, and then my work will be done."

Funding

U.S. Department of Energy $2,375

Grant Recipient

Ed McGrath
P.O. Box 73876
Fairbanks, Alaska 99707

Polystyrene beads to prevent heat loss

A special insulation system to reduce heat loss at night is planned for a greenhouse in McCarthy, in the Interior of Alaska.

"We are proposing to construct a passive solar, energy-efficient, attached greenhouse with a usable growing season of March through October," said Jerry Miller, who lives with his wife Judy at May Creek, a rural village near the Kennicott Glacier.

"We will incorporate a bead wall type system which involves blowing polystyrene insulating beads between the glazing at dusk and sucking them back out at dawn using a hand operated pump," he said. "We want to demonstrate how such a system can be energy efficient, practical and inexpensive to build and maintain."

Unfortunately, the Millers had not completed their greenhouse by mid-1984 due to several unforeseen setbacks. The couple, for example, had to move to May Creek after the original project site at McCarthy was threatened by flooding three times within six months.

Health problems further delayed construction of the greenhouse. And, by spring 1984, only the rough ground work and initial foundation had been completed.

"Site preparation has begun and foundation work is currently underway," said Judy Miller.

System Design

The proposed greenhouse is 14 by 36 feet and will be attached to the Millers' cabin. The south-facing wall will have nine four-foot-wide, double-paned bay windows. The windows will be installed at a 77 degree angle to take advantage of the low sun in the spring and fall.

During nights when there is heat loss danger, the small polystyrene beads will be placed in between the double paned windows.

The Millers plan to draw the beads out of the windows with a hand operated pump each morning.

Rocks stacked as plant bedding support will store heat collected by the passive solar greenhouse. Excess heat gathered by the greenhouse also will be vented into the Miller home.

Two automatic vents, on the east and west walls, would be used to remove excess heat. They will begin operating when the temperature reaches 65 degrees.

A wood stove will provide backup heating for the greenhouse in the early spring and late fall.

To supplement the carbon dioxide level in the greenhouse, rabbits will be kept inside; and chickens also could be quartered in the greenhouse during the coldest, darkest winter periods. This would eliminate the need for additional heating for the chickens, and light from the house could stimulate year-round egg production.

"Instead of wintering our chickens, 10 to 15 birds, in a separate hen house, we plan on sectioning off a part of the attached greenhouse," Judy Miller says. "Right now, we compost leaves and fireweed with nitrogen-rich chicken manure to build our soil humus and nutrient level. This process always stops in winter. But we will continue this in our greenhouse."

The couple also may plant some dwarf fruit trees and such crops as tomatoes, cucumbers, squash, peppers, beans, lettuce, carrots and spinach.

"We hope to develop a year-round system of operation," says Judy Miller. "We hope to start our garden crops and plant starts for the cool weather vegetables requiring a long season—Brussels sprouts, cabbage, and cauliflower."

Funding

U.S. Department of Energy $2,882

Grant Recipients

Jerry and Judy Miller
May Creek, Alaska 99588

Home's wall used as giant duct

In 1981, Mark Merrill of Willow was in the process of planning and building a new home designed around maximum efficiency of energy use. He chose to use quality insulation materials, take advantage of passive solar energy, and use abundant wood in a centrally located heating system.

He applied for an AT grant to add one more energy-efficient feature to his home, and in the doing has applied the feature to other homes, as well.

"My project is to fit this house with a device that will recycle heat which would otherwise dissipate . . . and to warm well water in a preheating tank," he said at the time. Very simply, Merrill turned one wall cavity in his house into an air duct that circulates warm air at the ceiling to a crawl space beneath the house, where it warms a rock energy mass.

The air warms the rocks, which in turn pre-heat a water tank. In summer, the rock mass helps cool the house by storing heat. But at night, heat emitted from the rocks helps keep the home warm.

The design is called a residential waste heat recovery system.

"It's working extremely well," said Merrill, a carpenter and builder who lives in Willow, about 70 miles north of Anchorage. In fact, he's so impressed with it that he's installed it in other homes he's built in Willow.

"I've probably built 13 homes with this system in it," Merrill said, including his own home. "I'm real happy with it."

System Design

Merrill built a two-story, 1,208-square-foot home with a cathedral ceiling over the living and dining room, and a clerestory window wall above the stairwell to the second floor.

There is a wood stove in the living-dining room. Sun shining through the clerestory windows heats the opposite wall in the stairwell which is painted a dark color. Electric baseboard heating provides back-up heating.

System components include a fan with a variable speed control, two thermostats, and six tons of three-to-six-inch rock in a wood box surrounding the 42-gallon tank for the well pump.

The unique link of the system is a wall cavity, which is 32 inches wide by 3.5 inches deep. The cavity extends from the top of the wall opposite the clerestory to the rock pen in the 4½-foot-high crawl space.

The rocks surrounding the water tank are in a wood box measuring four by four by eight feet insulated with urethane.

The fan, built into the bottom of the rock pile, is rated at 650 cubic feet per minute. It is a 12-inch round duct fan, which can draw 75 watts at full speed. The fan is controlled by a reverse acting thermostat on the wall opposite the clerestory.

When the temperature rises above a specific level in the clerestory, the pre-set thermostat automatically turns on the fan in the crawl space. The fan pulls air through

The south face of Mark Merrill's house (below) makes use of clerestory windows.

an opening at the top of the wall into the wall cavity and through the rock pile. An opening at the bottom of the rock bin allows the air to continue into the crawl space and back to the living room through a floor register located under the woodstove.

The thermostat turns on the fan to draw the hot air which warms the rocks and the water in the tank whenever the sun is shining or the woodstove is used.

A second thermostat in the living room is set to turn on the fan when the temperature drops to a pre-set level. The fan blows air through the rocks bringing the heat stored in the rocks back into the house through the register under the woodstove in the living room.

Performance

The residential waste heat recovery system has consistently worked very well, Merrill said. In fact, it's helped him slash his electric heating bills in half. The system has been virtually maintenance-free.

Funding

U.S. Department of Energy $1,100

Grant Recipient

Mark S. Merrill
P.O. Box 103
Willow, Alaska 99688

Heat loss reduced with rubber gaskets

Jerolyn Wroble , of Anchorage, was persuaded to undertake the distribution of gadgets that would save on the homeowner's heating bills.

She proposed to give away foam gaskets that seal off drafts from wall plugs.

According to the Texas Power & Light Company, the second greatest source of air infiltration into the home is through outside-wall electric outlets and switches. Eliminating drafts from this source would significantly reduce total air infiltration. The Texas findings were adapted to Alaska in Wroble's pilot project aimed at reducing both energy consumption for heating purposes and energy expenditures by the Alaskan homeowner/ renter.

The use of foam rubber gaskets as insulation between conventional outlet covers and the wall can eliminate 93% of this air infiltration. Although the gaskets were already commercially available at a cost of approximately $2 a package, they were not being rapidly implemented by the Alaskan public. The intent of this project then, was both to increase consumer awareness of the problem and also to provide a safe, inexpensive, simple solution.

Procedure

Accomplishing this goal required three phases of effort: purchasing, assembly, and distribution.

Wroble got bids from five different companies. A total of 31,200 gaskets were ordered from the Fuel Control Corporation, Minneapolis, Minn., the most competitive bidder, at a price of 4 cents each. To ensure that the gaskets were safe, they were taken to the local fire marshal whose review indicated they would not help to support a fire stemming from an electrical outlet. Two-thousand plastic bags, which explained about the gaskets and their installation, were also ordered as distribution packaging. Each packet contained 12 outlet gaskets, four switchplate gasket covers, and one pre-addressed postcard.

The postcard was used as a means of obtaining consumer response on the effectiveness of the gaskets. Consumers were asked to return the card by an established date with any comments they might wish to make. Western Airlines agreed to trade the cost of shipping the gaskets to Alaska in return for being mentioned on these postcards. Therefore, shipping the gaskets and printing of the postcards was accomplished for $226, which was less than half the budgeted figure of $500 for shipping alone.

Distribution of packets was made through the following outlets in Alaska:

Division of Energy and Power Development	Anchorage	125
Alaska Gas and Service	Anchorage	500
Matanuska Electric Association	Palmer	200
Golden Valley Electric Association	Fairbanks	250
The Energy Committee	Juneau	300
City of Aniak	Aniak	50
Miscellaneous (mailed or delivered in person)		500
Total Distributed		1,925

Performance

Judging from postcards and letters, the gaskets were accepted very well both by individuals and agencies receiving them.

There were several requests from consumers about the best method of obtaining more of the gaskets. Many commented on how effective the gaskets had been in eliminating drafts. One consumer reported that he noticed an immediate temperature difference around outlets after installation.

A company that showed the sealers to all the consumers it contacted for on-site verifications of residential energy audits reported their surprise at the number of homeowners who had not been told about the electric outlet energy sealers.

Funding

U.S. Department of Energy	$ 975
State of Alaska	975

Grant Recipient

Jerolyn Wroble
P.O. Box 3404
Anchorage, Alaska 99510

Solar collector has unexpected results

Cliff Cantor tried to convert the southwest wall of his arctic home into a solar heater by covering it with glass panes.

Unfortunately, the solar collector wasn't sealed properly. Mildew and insect problems prompted Cantor to remove it from his home in Bethel, Alaska.

Bethel is a hub community for about 50 neighboring Bush villages and lies on the shores of the Kuskokwim River, one of the major transportation links in Western Alaska. Like much of the state, the growing season here is quite short. But in those summer months the rolling, green, treeless tundra blossoms with hundreds of thousands of wildflowers—in the planet's high latitudes, plant life grows with an intensity not found in the middle latitudes of the Lower 48.

And although sunlight hours are short in the winter, the sun does shine brightly during the day. Cantor, who is an owner of a barge company, hoped to capitalize on this light as a partial answer to his home heating needs.

"We made a kind of jungle in there," said Cantor of his solar project. "I think that portion of the house might have rotted under those conditions. That's why we took it down."

Moreover, Cantor also said he dismantled his experiment because he feared it might have ignited his log walls. At times, he said, the glazing caused temperatures to soar almost to 140 degrees.

"We wanted to see if we could heat up one wall and the answer is yes," said Cantor. "You can do it. But some of the other details didn't work out."

System Design

The solar collector was nine feet high by 10 feet wide, covering the outside of the home's southwest-facing log wall. The glass panel was comprised of several small panes held in place by two-by-four-inch frames, set two inches from the exterior log wall.

The logs behind the glass pane were stained brown to help absorb sunlight and to protect the wood, and foam insulation was applied to seal the edges of the glass frame where the frame abutted the log wall.

Sunlight striking the glass panes warmed the logs, which in turn radiated heat into Cantor's living room. Cantor anticipated that it would take most of the day to heat the logs up, and the heat would be radiated into the house during the night.

And it worked that way for awhile, says Cantor.

But flies multiplied and infested the house through spaces between the logs. An algae-like mildew sprung up in the space between the log wall and glass pane. Soon Cantor's solar collector resembled a miniature jungle swarming with flies.

"Algae grew all over because we had a lot of moisture in it," Cantor said. "And we literally got thousands of flies that flourished. It'd be covered with them sometimes."

In short, it didn't work out the way it was supposed to.

Tips

Although the collector achieved the objective of capturing heat, the concept has room for improvement.

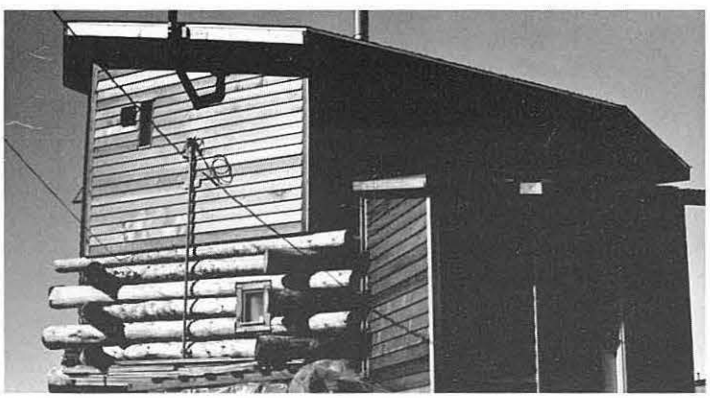
- Design a solar collector that allows air to circulate between the log wall and the glass panes, to prevent decay and mildew.
- Chink or caulk log walls for better indoor heat retention and pest-proofing.
- Place a moisture barrier of heat-absorbing material on the exterior wall surface.
- Carefully seal off all exterior cracks and fissures.

Funding

U.S. Department of Energy	$435
State of Alaska	435

Grant Recipient

Clifford Cantor
P.O. Box 728
Bethel, Alaska 99559



A ladder (top) rests on the south face of the home where a solar collector was installed; (above) the entrance to the house. The slide joint (right) between the entryway and the main house allows the two portions of the building to move separately while maintaining a weather seal. The pivot is a two-by-four under the floor joists.

Solar water heating system falls short in Fairbanks

H. Jack Coutts was faced with two problems when he built his home atop a 1,700-foot hill 15 miles west of Fairbanks: energy costs and water. Like most of his neighbors, Coutts could not afford the expense of drilling hundreds of feet for a well; instead, water was transported daily from work in large containers.

Energy costs in the Far North are traditionally high, and since (as Coutts figured) most of the domestic water used in a typical household is heated prior to use, the cost of heating water is a significant part of the household energy budget.

What Coutts proposed in this grant was a solar collection and storage system that would use snow melted in the winter and rainwater in the summer to supply domestic water needs. Winter snow would be melted using a heat scavenging system constructed in an earlier project. During warmer months, rainwater would be collected and used. A large cistern built under his house would collect the heated water. Coutts figured he could collect enough water this way to supply his yearly needs. The stored, heated water below his house would also help heat his home, further reducing overall energy costs.

Coutts was awarded an AT grant in 1980 to build the solar collection and storage system, monitor its performance, and determine the economics of the project.

The project involved fabricating and installing solar collectors, constructing a 1,500-gallon cistern under his house, and installing the necessary plumbing and monitoring features to control the system's operation and automatically record performance data.

Design and Construction

Three eight-by-20-foot solar panels were designed for the project.

Two man-made water storage tanks supply domestic water. An outside tank is used in the winter to melt snow and during the summer as a rainwater catch basin; it also supplies make-up water to a large inside cistern. The 1,500-gallon inside cistern provides a large supply of clean, treated water for everything but drinking. Coutts still carries drinking water home daily and stores it in the refrigerator.

The original plan of building the solar collectors on the ground and lifting them in position was scrapped after the first panel. The panel's weight and bulkiness proved too much for Coutts, absenting a crane or Bunyonesque assistance. Thus, the remaining two collectors were assembled on the roof, using the roof itself as a structural support. This reduced materials and labor considerably, but also lowered the system's overall efficiency since the second two panels were fixed to the roof's angle and did not directly face the sun.

In order to provide structural support for snow handling and foot traffic, the four two-by-eight corrugated aluminum roofing panels used to back each collector were nailed to eight-foot lengths of wiggle molding. The wiggle molding was in turn attached to 1¼-by-two-inch runners set about 50 inches apart. Four-by-eight-foot by 1½-inch plastic foam insulation boards were placed between the runners under the aluminum. Since the first panel was constructed on the ground and lifted onto the roof, it had an additional one-by-four and two-by-four supporting frame.

A water inlet manifold for each collector was made from one-half-inch PVC tubing wired to the top of each panel. One-sixteenth-inch holes were drilled along this pipe matching each trough in the corrugated aluminum. After painting the upper surfaces flat black to increase heat absorption and adding an outlet collection pipe to two of the collectors, 20 millimeter fiberglass glazing was applied. A caulking compound able to withstand 150 degrees in temperature was then applied to the glazing edges.

The first solar collection panel, because it was assembled differently, was covered with polyethylene sheeting (Visqueen). Unfortunately, this panel will have to be repainted and recovered as the polyethylene became brittle after one year's use and there is considerable weathering of the paint.

The outlet pipe is a 10-foot piece of 1½-inch PVC plastic pipe with a ¾-inch-by-nine-foot slot cut in it that the lower end of the collector panel rests in. This pipe goes to the outside melting tank; panel number one is connected directly to the inside cistern.

The inside cistern is a V-shaped depression in the bedrock below the house. Coutts covered the rock face with smooth cement and 10-mil Visqueen as a waterproof liner. Bacteria control of this domestic water supply was by batch treating with chlorine. Since there was no way to accurately control the amount of chlorine in this water, Coutts also installed a residential water filter with a charcoal element to filter out the excess chlorine before the water was used. The charcoal element needs replacing about once a year. Water in the outside snow melting tank does not get chlorinated because it is used only to supply make-up water to the inside cistern.

The solar collector panels are connected so that panel number three is connected directly to the inside cistern; and panel number two can be connected either in parallel with panel number three, or between panel number one and number three. This is done with a removable piece of PVC tubing. When make-up water is needed, the temporary tubing connects the output of panel number two to the outlet of panel number three. Water from the outside snow melting tank is pumped through an activated carbon filter to the top of panel number two, heated as it flows down the panel, combined with the output of panel number three and delivered to the inside cistern. When the cistern is full, the temporary connection is removed and water drains into the rain gutter, returning to the meltwater tank.

The first solar collector (above) was constructed on the ground.

Because he'd carried water to his home so often, Coutts had already installed many water-saving devices in his house. These included a front-loading washing machine, a quart-flush toilet, and low-flow showerheads.

Thermal control is through two thermostats (Snap Discs) mounted about one third of the way down the back of collector panels one and three. As the skin temperature of the corrugated aluminum reaches 110 degrees, the thermostats close (turn on); they open (turn off) when the skin temperature drops below 90 degrees. When the thermostat on panel one closes, a sump pump in the bottom of the snow melting tank is turned on. Water flows up to the inlet manifolds of collector panels one and two. Panel number one free drains back into the snow melting tank through the rain guttering system. Panel two either free drains back into the snow melting tank, or into the outlet pipe for collector panel number three, depending on whether or not the removable PVC coupling is installed.

When the thermostat on panel three opens, domestic water flows through a control solenoid valve to the collector's inlet manifold and then through the collector. Domestic water is supplied by a pressurized shallow-well electric pump and a 12-gallon pressure tank.

Because the water supplying collector panel number three is straight from the pressurized domestic water system, the thermostat mounted on this panel controls both the inlet water supply and a special drain solenoid valve. When the temperature of the aluminum exceeds 110 degrees, the drain solenoid is closed and the supply solenoid is opened. Water flows through the collector until either the skin temperature of the aluminum drops below 90 degrees, or until a 24-hour control timer shuts the panel off. The 24-hour timer opens the drain solenoid at the end of each solar heating day—at approximately 6 p.m. nightly.

The timer and thermostatically controlled solenoids are required for freeze protection of the tapped pressure system supplying collector panel number three. Since collector panels one and two are essentially free draining, freeze protection is provided when the temperature of the corrugated aluminum drops below 90 degrees, opening the thermostat and shutting off the sump pump. The collectors free-drain into the rain gutters and back into the snow melting tank.

Performance

With the sun shining, the controlling thermostats generally close when the ambient temperature of the air between the fiberglass glazing and the corrugated aluminum exceeds 45 degrees. This is usually sufficient to cause the temperature of the aluminum to get above 110 degrees. However, during rainy, cloudy, and cooler days when the outside temperature is below 60 degrees, the ambient temperature rise is usually not enough to actuate the thermostat and allow heat collection. Because of the problems associated with the polyethylene covered panel, the actual performance of panel number one is less efficient.

A dual probe thermograph, a type of self-recording thermometer, was used to measure water temperature at both the surface and the bottom of the inside cistern. A minute totalizer was also installed to record the total time water actually flowed from the inside cistern through solar panel three. Data was collected from both units between July 2, 1981 and August 18, 1981. Although this time period experienced poor solar heating conditions, it was found that heat was still collected for an average of 14.6 hours per day.

Since heat recovered is the product of the flow rate, flow time, temperature difference between input and output water of the collector, and specific heat, the heat captured during the test period was calculated to be 430,000 BTU's. Although it sounds like a lot, when compared to system costs and energy cost savings, it was determined that the solar collection system would not pay for itself during its rated 20-year lifespan. Even amortizing the cost of the system, assuming a 10 percent interest rate, over 10 years would not make the project cost effective.

If the economics were figured during a warmer summer, the solar panels would obviously perform much better, due in part to the heat transferred to the cooler water from ambient air. A similar installation at a lower altitude might also tip the scales in favor of solar heaters, especially if they are tilted to face directly into the face of the sun; however, the increased costs of such a system may offset any solar gain.

Conclusions and Problems

Based on the data collected during the summer of 1981, these solar collectors in semi-arctic environments are not an economically sound investment. However, for those who can obtain inexpensive materials for use in an improved design, a similar project may be worth the effort. Coutts recommends that these people design a house with solar heating as an integral part of the structure, such as optimized roof slope and direction (with a black painted roof) and below-foundation water storage or radiant floor heating.

One last word of advice from the grantee is that ground heat storage should not be considered if the house is built on or near permafrost.

Funding

U.S. Department of Energy	$975
State of Alaska	687

Grant Recipient

H. Jack Coutts
Mile 348 Nenana Highway
Nenana, Alaska 99760

Solar heat works well in Copper Center

Copper Center residents no longer have to worry about buying oil to keep their Kenny Lake Community Library warm now that they have a solar water heater and a wood-fired boiler.

The solar collector helps keep the library at a comfortable 60 degrees almost year-round in this community of 500 people, 80 miles north of Valdez in Southcentral Alaska.

During the first winter of the solar system's operation, the librarians supplemented the solar heat with a water boiler. The boiler, which formerly burned oil, was converted to burn wood and coal. It used three cords of wood and a ton of coal, most of which was donated.

"We now use only wood, coal and solar," said resident Brad Hennspeter. "That's saving us money, plus it's a renewable resource."

Specifically, the community no longer has to spend some $1,200 annually on heating oil for the library. The solar heater also has prevented the library from freezing up in winter despite sub-zero temperatures of minus-60 degrees.

"It's working excellently," said resident Sam Lightwood, who supervised the solar construction. "Solar is much more efficient. It's the way to go."

System Design

A solar collector and a wood/coal boiler are used to warm water in a 1,000-gallon tank housed in a room of the library. Heat radiating from the water is blown by a fan into the main library reading room, which is 23 feet by 31 feet.

The steel water tank is six feet high and five feet in diameter. It was coated with epoxy inside and painted with a dull red primer on the outside.

The 105-square-foot solar collector, which has four glass panes, was mounted upright on the south-facing side of the library roof. The collector—six feet wide by six inches deep by 16 feet long—has a series of half-inch copper pipes sandwiched between sheet metal and thermopane glass. The interior of the solar collector was painted black to absorb sunlight.

The water, circulated by a Grundfos pump, flows from the bottom of the water tank up to the copper tubes in the solar collector. Electronic sensors activate the pump whenever water in the solar collector is warmer than the tank water.

Hot water from the solar collector, averaging 80–110 degrees, returns by gravity flow to the water tank through a three-quarter-inch copper pipe.

On very cold days, however, the librarians have to supplement the solar system with a wood/coal boiler. The water flows by gravity from the water tank to the boiler and back to the water tank via a separate, 1.25-inch copper pipe.

A snap switch located in the water tank room automatically cuts off the fan when the tank room air temperature drops to 75 degrees.

The steel water tank radiates heat as it warms up. The heat is blown into the main library room by a 36-watt fan which was placed inside of an 8-inch galvanized floor duct. The fan is controlled by a thermostat, which also has a manually-operated variable speed control.

The room housing the water tank has double-wall construction and superinsulation. The exterior wall was framed with two-by-fours, and was insulated with eight inches of fiberglass. The interior has four-inch stud walls with two inches of insulation. A six millimeter polyethylene sheeting also was installed on the interior as a vapor barrier. Sheetrock covers the vapor barrier. The roof is made of corrugated aluminum.

Performance

Overall, the solar-heated water tank has worked very well, keeping temperatures at around 60 degrees. Moreover, the library's fuel bill has been substantially reduced because the facility no longer has to rely on expensive oil. They also save money by receiving volunteer contributions of wood and coal. By comparison, the library spent more than $1,200 on oil for fuel annually before installing the solar collector.

Inadequate air circulation between the water tank room and the main library is the most serious problem which has surfaced.

Lightwood said that one of the cool air ducts should not have been placed near the same vent as the hot air flue because the hot air tended to be diverted back into the tank room.

Lightwood said he plans to plug the old vent and install a new one elsewhere in the library.

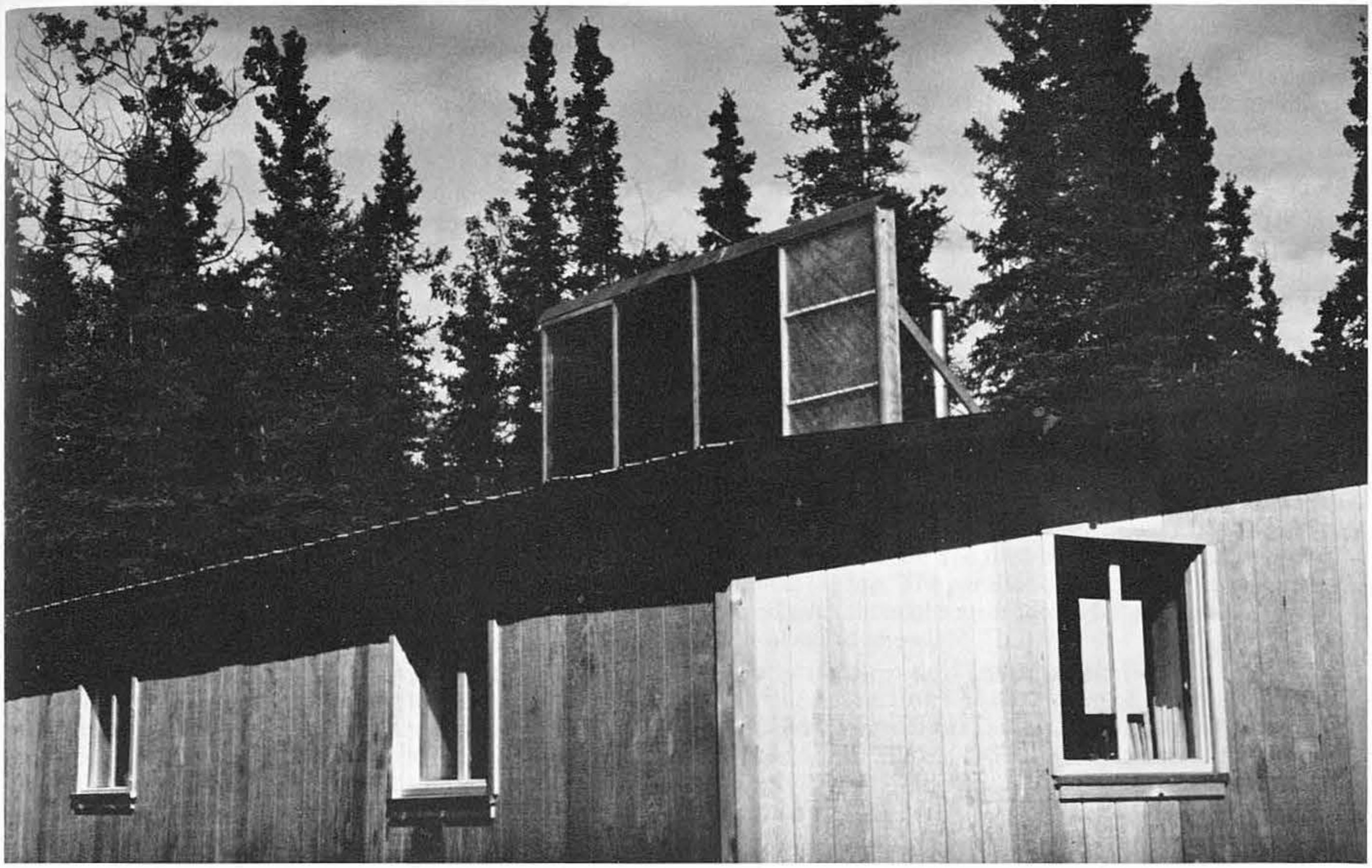
Another drawback of the system is the amount of time it takes to initially heat up 1,000 gallons of water. Lightwood said it often took about six hours to heat the library to the 60 degree range.

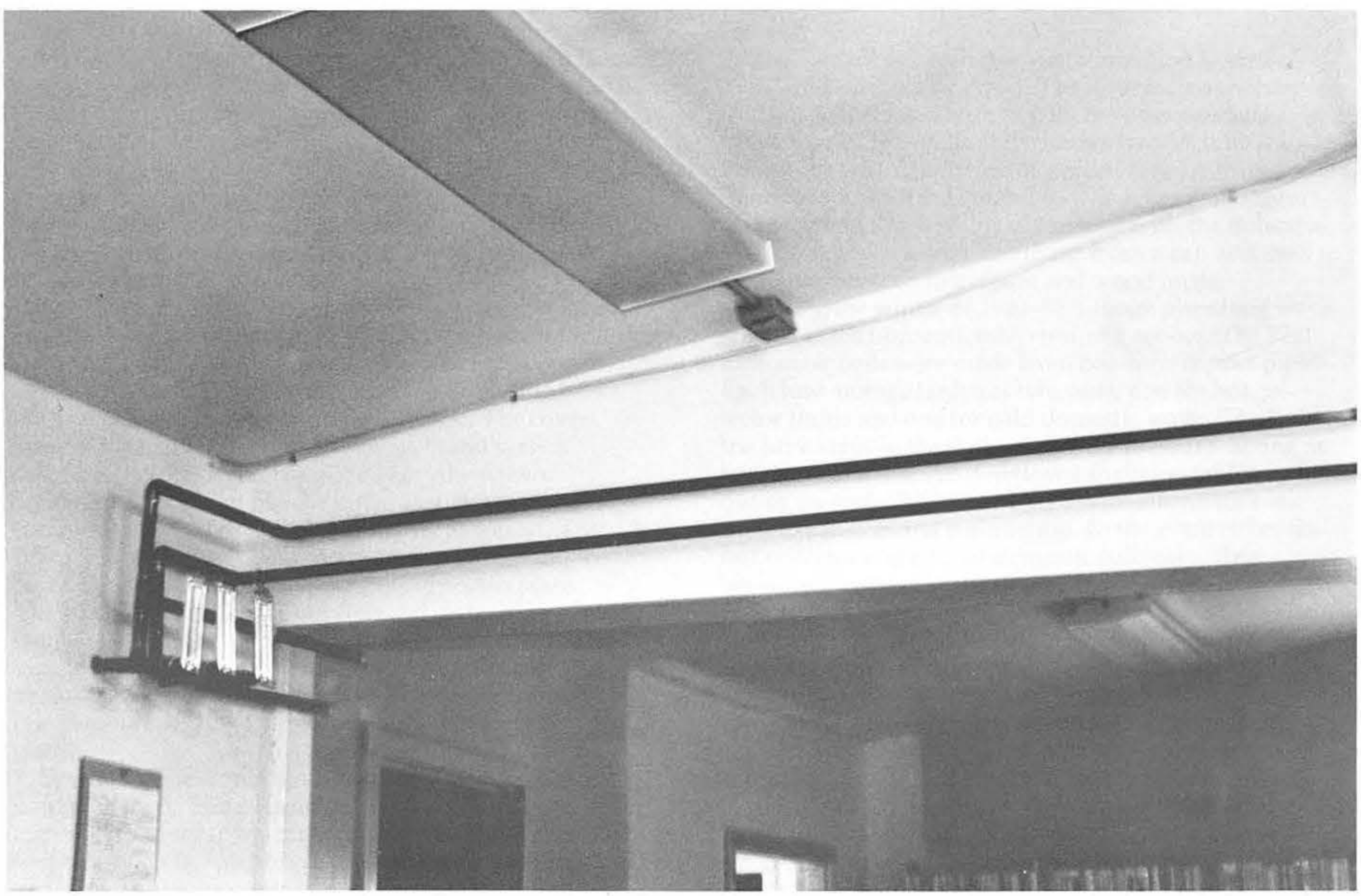
However, once the water heater is hot it stays warm for a long time. In fact, since its installation in June 1983 the library has not frozen up at all.

"Once we have the 1,000-gallon tank warm we can leave the building for a weekend and when you come back on Monday morning the temperature (in the building) may be in the low 30s, but it hasn't gone down to freezing," said Hennspeter.

"I think it's very cost effective," Lightwood said. "I highly recommend it for any kind of a building. We have had plants in the library all winter. It works well."

Solar collectors (top right) were mounted on the roof of the Kenny Lake Community Library. (Bottom right), collector piping inside the library.





Tips

Several tips were offered by project participants in their evaluation of the solar system:

- Install the solar collector upright. This reduces stress on the glazing, minimizes the chance of rain leaks and reduces snow accumulation.
- Be sure to allow plenty of air in the boiler when burning coal, which requires more air than does wood. Otherwise, coal, particularly soft coal, tends to emit a lot of smoke.
- The water tank will sweat when it is first fired up.
- Don't fill the water tank completely. There should be some space for water to expand as it heats up. Also, a heat shield is needed beneath boilers if the floor is made of flammable materials.

Funding

U.S. Department of Energy $2,242

Grant Recipient

Kenny Lake Community League
Kenny Lake
Star Route, Box 231
Copper Center, Alaska 99573

A comparison: Three solar water heating systems

The Municipality of Anchorage and the Western Building and Construction Trades Council are evaluating the feasibility of three different concepts in active solar water heaters.

The solar water heaters are in the center of the Anchorage bowl. Two are attached to a municipal office building at 3500 Tudor Road. One is attached to the Plumbers and Steamfitters Apprenticeship School at 610 Potter Drive.

System Design

Three separate collector systems were designed. Design criteria included: a) the three systems must range from the very simple to the complex and sophisticated; b) the systems must be appropriate to residential use in both new and existing structures; and c) each system must provide supplemental domestic hot water heating for 100 gallons per day, for domestic hot water demand at 120 degrees.

Each system has a different type of solar collecting heater on the building's south side. The heat from the collector is captured in an antifreeze solution and piped to a heat exchanger inside the building. This heat is stored in a tank filled with water. As there is a hot water demand, heat is extracted from this tank through a heat exchanger and piped into the domestic water system. All three systems must have a conventional water heater to back-up the solar collector.

System 1. The "breadbox" system is within the scope of some "do-it-yourselfers" utilizing simple principles and equipment, and easily understood and adapted by the layman of average ability. Solar capture effectiveness is less than the other two systems.

The "breadbox" has three basic parts: water tanks, an insulated box and the cover glass. The three water tanks were new electric hot water heaters modified by removing the metal cover and insulation. The tanks and inside of the insulated box are painted flat black. The cover glass in the "breadbox" (and Solaroll-brand system described below) is double glazed acrylite panels.

System 2. The "flat plate" system is somewhat more complex than System 1, but not highly technical. The "flat plate" has three basic parts: an absorber plate, the cover glass, and insulation under the absorber plate. The absorber plate is a Solaroll-brand material, a plastic mat, similar in thickness to an inner-tube, with quarter-inch diameter tubes in the mat. The design allows the absorber plate to be glued against the side of the building, thus eliminating the need for insulation under the plate.

System 3. The "concentrating tracker" is a high technology system. Completing the picture of available approaches to solar water heating is the only justification for this design in Anchorage. Design drawbacks to a high technology system include the level of effort required by competent design professionals, and the mechanical devices needed to accomplish the tracking are expensive and failure-prone.

The "concentrating tracker" has three basic parts: an absorber pipe, a parabolic reflector, and a tracking system. The absorber pipe is a flat black metal pipe enclosed by a glass tube. Within the pipe is a coil which allows cold antifreeze to circulate down to the foot of the parabolic reflector and then back up to the collection pipe at the top. The parabolic reflector is a curved trough lined with slices of mirror which reflect sunlight toward the absorber pipe.

Construction and Installation

All construction was done through the Western Building and Construction Trades Council with volunteer union labor. The majority of work occurred in coordination with their apprenticeship classes, which occur several months each year.

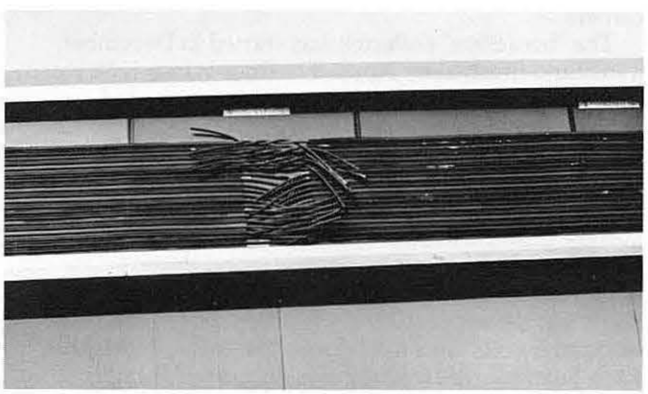
Footings for the "tracker" and "breadbox" were built in October, 1981. Footings were four cement posts for the "tracker" and four cedar posts for the "breadbox." All the posts were at a depth of four feet and anchored in cement.

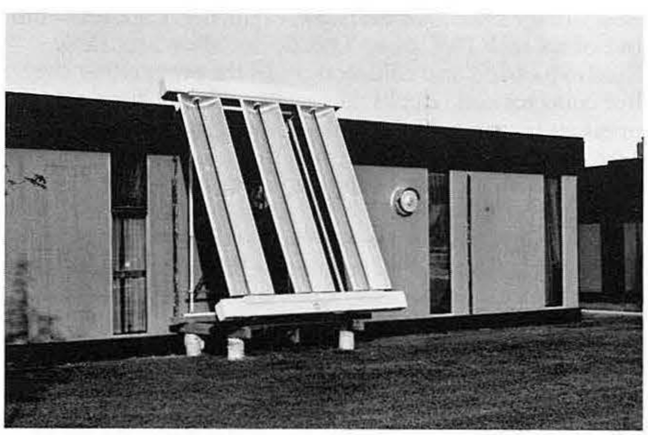
The "breadbox" collector was started in December, 1981, and finished by April. The floor is two-inch by six-inch joists insulated with five inches of expanded polystyrene. The walls and roof are two-inch by four-inch studs with 3½ inches of polystyrene. A three-quarter-inch Thermax brand (polyisocyanurate) sheet was attached to the inside of the roof with the reflective surface exposed inside. Urethane from a can was used to fill joints between Insulfoam and wood joists.

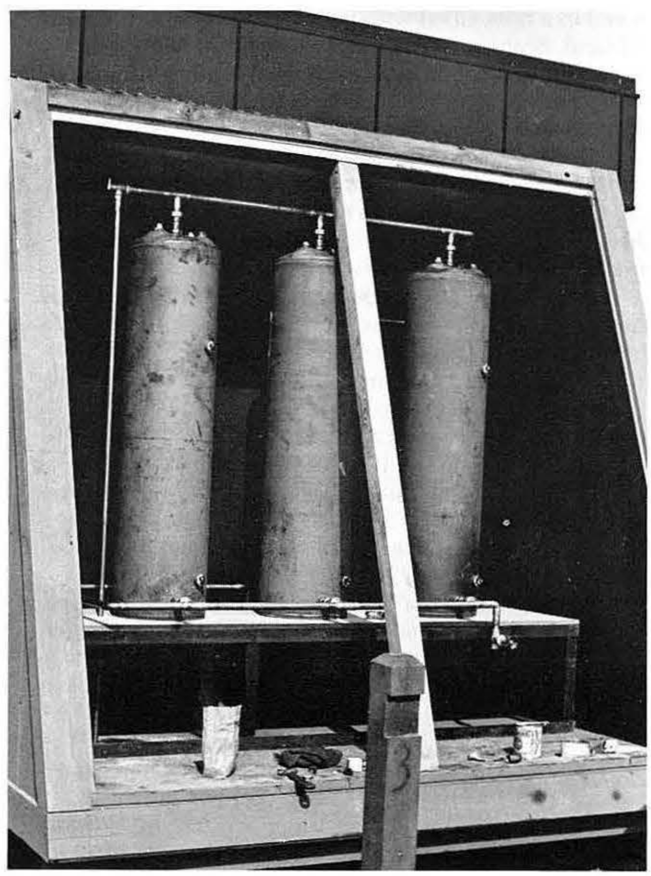
During the winter of 1981-82, off-site plumbing was started at the apprenticeship training school. The heat exchanger coils were made from one-inch copper pipe. Each heat storage tank has two coils, one for hot collector fluids and one for cold domestic water. The fluid in the tank stays in the tank, at gravity pressure, acting as heat storage mass. An overflow/expansion tank was built out of six-inch PVC pipe. This device allows for tank fluid expansion and contraction. In the event either the hot collector coil or cold domestic coil leaks, then pressure increases in the tank would trigger a float-valve-activated alarm.

The heat storage tanks for the "breadbox" and the Solaroll system were fabricated from one-eighth-inch steel. A 40-gallon storage tank was sufficient for the "breadbox." The Solaroll required a 150-gallon storage tank, partially because it has less fluid mass in the collector exposed to the sun.

On-site plumbing began the summer of 1982. The 350-pound "Tol-Tec Tracker" collector unit was erected on the ground. This collector was partially assembled by the manufacturer and was easily erected in six hours







by two men. Minor problems with missing bolts and poorly machined pieces were easily overcome using an electric drill, files, and locally available bolts. Six men placed the unit on the cement footing. Additional bracing was bolted to the tracker frame for wind protection. Plumbing between the collector and mechanical room is one-inch copper pipe hung in the floor crawl space. After soldering the pipe together, the plumbers insulated the pipe with half-inch thick Armstrong armaflex. Installation of the heat exchanger tank, collector fluid recharge tank, expansion tanks and other equipment used 11 square feet of floor space.

Three water tanks, connected in series, were installed in the "breadbox." The tanks rested on a steel platform and were braced and bolted in place with angle iron to withstand earthquake vibrations.

In January, 1983, electricians began installation of conduit, breaker boxes and meter bases for the tracker. Wiring was not completed because of insufficient electrical detail on the "tracker" control system.

The mechanical area of the Solaroll system was installed in January and February, 1983. After installation, the Municipal Fire Marshall found the permit was incorrectly approved by their office for this system. In June, 1983, the plumbers removed this system for eventual reinstallation.

The "breadbox" was also moved during this time period. The plumbers found insufficient space available for the "breadbox" mechanical area. Using a forklift and trailer, the "breadbox" was moved to the Plumbers and Pipefitters School and installed.

Current construction by the Electrical Workers Apprenticeship School on the "tracker" was expected to be completed by spring, 1984.

Work to complete control wiring on the "breadbox" and to reinstall the Solaroll mechanical was scheduled to begin in April, 1984.

(Previous page) Peter Poray (top) explains details of the bread box collector (right). The assembled collector (bottom left) in place. Sunlight strikes the Solaroll (middle left).

Problems

Problems peculiar to this project in Alaska were:

- Design data on the "tracker" was incomplete. The "tracker" was made by a new company that folded in 1982 after three years of business. These new technologies have problems: parts were missing and some electrical parts were unavailable locally; some mirrors in the parabolic reflector were cracked; three shipments of glass tubes, which go around the absorber pipes, were broken in shipping; electrical diagrams were incomplete; the manufacturer disappeared, but the designing electrical engineer was found after a two-state telephone search.
- Getting the design approved took four months. This was the first solar collector building/mechanical permit given by the Municipality.

Modifications

Several modifications were made:

- Design specifications asked for galvanized heat storage tanks. No firm galvanizes tanks in Anchorage, so paint was used to rustproof the tanks.
- The "breadbox" system was relocated to another building, due to inadequate space in the closet housing the existing water heater.
- Viewing access to the heat exchanger, storage tanks, pumps, and controls was changed twice. Less viewing access now exists because of the need to maintain an adequate fire barrier between the mechanical area and public areas.

Funding

U.S. Dept. of Energy	$16,472
State of Alaska	15,872

Grant Recipient

Municipality of Anchorage
Municipal Energy Coordinator
Pouch 6-650
Anchorage, Alaska 99502

Solar powered pump increases efficiency

Dois Dallas, of Dallas Engineering, completed a project in Fairbanks, 1.2 miles from the University of Alaska, using solar energy to heat domestic hot water.

System Design

In Phase I (1981-82), solar collectors were installed and integrated into a heat exchanger-domestic hot water system which was capable of being alternated (for source energy) from solar/propane to electricity. The alternating cycle selected was weekly for one year (52 weeks).

The prior energy source was all electricity for both domestic hot water and space heat for this residence (a log house). In addition to purchasing and installing the solar collectors and heat exchanger, it was necessary to purchase and install a propane hot water heater and a propane furnace. Phase I was 100% passive, incorporating a thermosiphon system and no moving parts.

The solar collector is a serpentine design with half-inch copper tubing soldered to a metal collector plate. The collector is mounted at a semi-fixed angle on the ground in front of Dallas' garage. The heat exchanger is mounted above the height of the collector on the inside garage wall.

Phase II (1982-83) implemented a change from 100% passive to semi-active by adding a pump powered by electricity from photovoltaic cells. No external electricity and no differential controllers were required. The photovoltaic panel, DC motor, and pump work in tandem. Only the intensity of the sun's rays controls the flow by producing more or less electricity.

Operation, Performance, and Problems

The system operated throughout Phase I and II without major problems. Temperature recording charts show that for the week of April 20 to 27, 1982 significant Btu's were transferred to the domestic hot water system. (Note that this was during the 100% passive phase.) Other measurements (May 11 to 18, 1983) illustrate that by employing the circulating pump, powered by the photovoltaic panel, more of the potential Btu's were transferred to useable storage than was the case with the 100% passive system.

Some 87 college-level students have been involved in collecting and analyzing data during operation of the system. For most of these students, it was their first introduction to the basic procedure for capturing Btu's and electricity from the sun.

Classes for future students will be offered by Tanana Valley Community College if there is sufficient student interest.

The project was featured in KIMO-TV's "Alaska's People" and a tape of the program is available in the Alaska State Film Library.

Modifications

Changes that are indicated from the data collected are:

- Preheat storage volume should be enlarged and insulated better.
- Life-style changes are mandatory if full advantage is to be taken of solar Btu's when they are available. For example, 3 p.m. is probably the optimum time to take showers, wash clothes, use the dishwasher, etc.

Tips

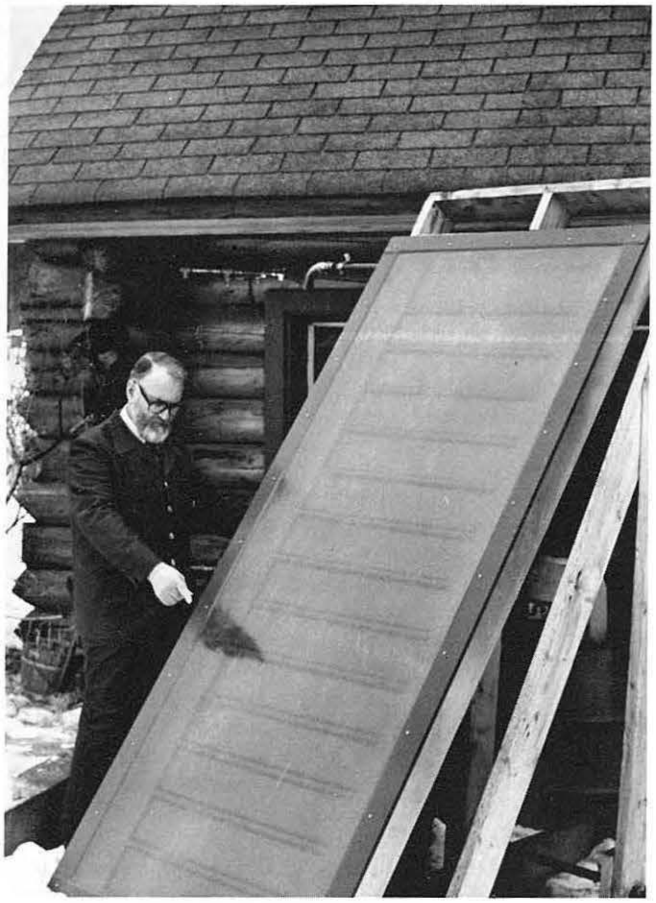
- Propane as a source of fuel for space heating (at local prices) is approximately 20% cheaper than electricity.
- Solar gain from a passive system is not attractive in Fairbanks with a payback of 24.5 years based upon the 1984 cost of propane.
- If there is another disruption in the supply of crude oil which results in a quantum leap in price to $60 per barrel or more, then solar energy (augmented or pumped with photovoltaic energy) would be economical for domestic hot water in Fairbanks.

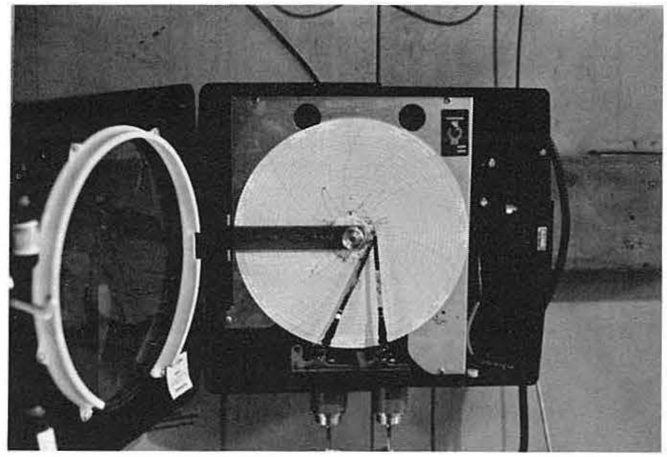
Funding

U.S. Dept. of Energy	$4,040
State of Alaska	6,935

Grant Recipient

Dois Dallas, Dallas Engineering, Inc.
SR Box 30140
Fairbanks, Alaska 99701





Dois Dallas (left) explains Fairbanks solar applications. (Above), a temperature recorder for the solar collector.

Automobile radiator reduces home fuel bills

Mark Miller has reduced his fuel bills by preheating his home's hot water in a solar collector made of car radiators.

Initially, he had hoped that if the novel project proved successful it could become a springboard for building similar systems throughout rural Alaska.

"The system also was to illustrate that it could be an unobtrusive addition to a suburban home," said Miller, who works for the State Department of Commerce in Juneau.

Unfortunately, the project did not turn out to be commercially viable. But it is helping Miller save on his home heating bills.

"The project was not a spectacular success," Miller said. "Nonetheless, my collector continues to function for my home, and given the few component parts, will probably continue to do so for years to come."

Design and Construction

Six radiators were set inside a wood frame box in two rows of three each. The frame is insulated to a thickness of six inches in the back and sides, and four inches along the interior wood ribs. It is covered with one-quarter-inch plexiglass and sealed with a silicone seal.

The radiators, backed by sheetmetal, are filled with antifreeze. Hoses, held in place by stainless steel clamps, circulate the antifreeze as it warms up through the linked radiators.

Heat collected by the radiators is stored in phase change salt in 20 polyethylene plastic tubes in a shed below the radiators. The tubes, which are filled with eutectic salts, are six feet long by 3.5 inches in diameter.

The salts turn to liquid as heat is absorbed. Compared with water, the pound-for-pound storage capacity of each tube is four-to-one, and by volume, five-to-one.

Water that needs to be preheated flows through a separate piping system sandwiched among the thermal salt-filled tubes. The water circulates through two sets of "W" shaped tubing made from three-quarter-inch copper pipe. Afterwords, the preheated water flows back to the home's domestic hot water heater.

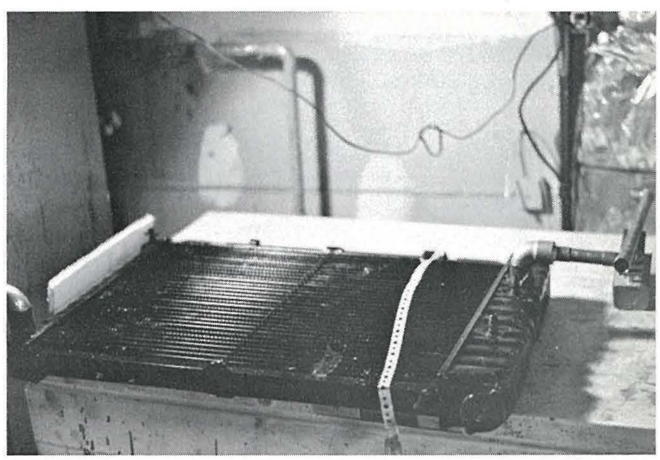
A small water pump, expansion tank, zone valve and pressure relief valve also were installed in the solar loop. Many of the final connections were made with flexible copper fittings. A sheet metal "V" roof was placed on top of the solar collector to prevent snow buildup.

Modifications

Miller says he could have cut the 200 hours he spent on the project in half and slashed the project's costs through a few modifications.

For example, he recommends using plastic pipes and rubber hosing instead of copper pipes, and connecting the hose to the pipe with "O" clamps.

The radiators also could be stacked on top of each other instead of being placed in separate compartments.



Mark Miller constructed a solar collector (left) using old car radiators (above).

Another alternative would be to build two separate wood frames that could each hold three radiators, instead of housing them together in one box. The two boxes could be connected with plastic pipes. Also, it would be easier to install two wood frames on the house than putting up one 700-pound unit.

Tips

When Miller applied his design to the realities of materials and construction, he developed other useful tips for future reference. In his words:

- Do not attempt this project if you are afraid to solder copper pipe, do not like metal cuts, hate fiber-glass insulation, or have little free time.
- Build a sheet metal "V" roof over the top of the system to prevent excessive weathering and snow buildup.
- The system can be built with a propane torch, pipe cutter, soldering brush, hammer, tin snips, drill gun and a 10-ton crane.
- Copper must be clean and dry. Once you cut your pipe with a pipe cutter (don't use a hacksaw or your grandchildren will be finishing your project), clean the pipe and connections with fine steel wool. Clean the inside joint-connector, and join the pipe and connector together.
- Do not try to solder copper feeders to radiators. Car radiator connection points already have been soldered. Thus, when you heat up the radiator intake to solder on the feeder, the high temperature weakens all the other joints and the radiator should be junked. Chasing weakened joints is a thankless task.
- Seal small radiator leaks with "silver" seal or another auto radiator sealer.

Funding

U.S. Department of Energy	$1,375
State of Alaska	1,375

Grant Recipient

Mark A. Miller
4324 Mendenhall Blvd.
Juneau, Alaska 99803

Palmer's energy farm proves up

Tom Williams is creating an energy-efficient farm.

Already, he's producing electricity with a wind generator, and drying bales of hay with a solar heater.

"I've been doing these things all my life," says Williams, an attorney and farmer. "My father was into this when I was a boy. He was always innovating and creating new things for the farm."

Williams is continuing that tradition on his family farm in Palmer, just north of Anchorage. He's also planning alternative energy projects for a second, 640-acre farm he's developing on nearby Point MacKenzie.

Finding the time to spend on his projects while running a law office in Eagle River and meeting the demands of his family is an on-going challenge he faces daily. He's also had to contend with a fire that destroyed his law office last year, and a malfunction in his wind generator.

"But things are working out. This particular farm was designed around a huge solar collector. Since we have the heat I'm trying to use it in several different ways." He conceived the project and applied for the AT grant funds in 1980.

System Design and Performance

The 10 kwh Jacobs wind generator sits atop an 80-foot-high tower. Its three, 11-foot-long blades are made of laminated Sitka spruce and can withstand gusts of more than 125 mph. The generator is designed for the blades to feather and turn sideways to the wind when the wind speed reaches 45 mph.

The generator can supply Williams' farm and house with all the electricity it needs. Any unused power is sold to the local electric utility, the Matanuska Electric Association.

From installation in February, 1982 to July, 1984, Williams' system has produced about 10,000 kwh of power, of which 2,200 kwh were sold to the electric utility.

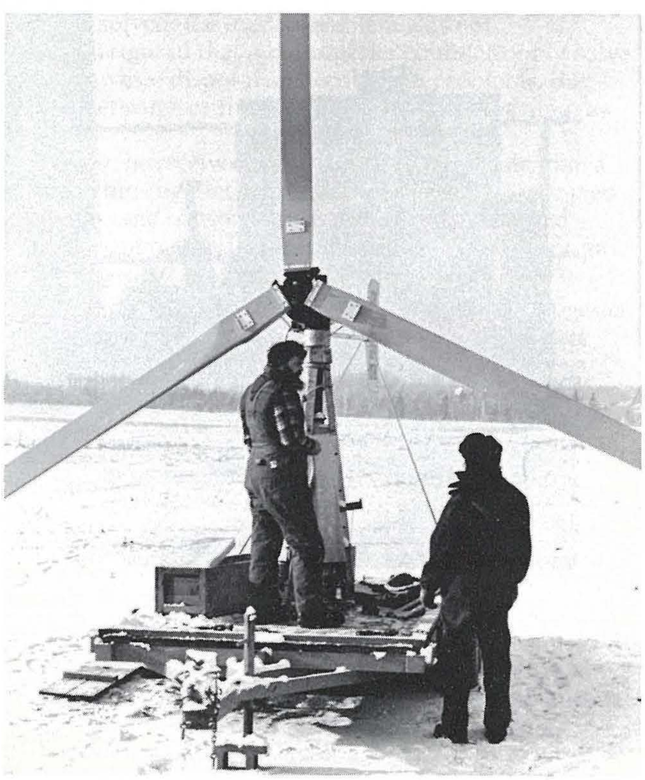
Unfortunately, Williams has to replace the Jacobs Mastermind control unit which keeps the power produced by the wind generator suitable to combine with the utility power. Nonetheless, Williams said the wind generator has worked well.

"I am personally pleased with its production efficiency," Williams said. "It's almost paid for the mortgage on it."

Another project Williams completed was constructing a new barn that is a solar grain and hay dryer. Corrugated plastic roof glazing is used in place of metal roofing to turn the whole rafter area into a large hot air solar collector.

A Habco crop dryer powered by a four-cylinder Wisconsin engine was suspended from the ceiling. This commercial fan blows the air warmed by the solar collector into a wood crib (four by four by 10 feet) buried under several hundred bales of hay.

The hay dries as the warm air flows from the wood crib through the haystack. About 400 bales were dried



Installers (left) prepare the wind generator; (above) snow covers the fiberglass roof of the solar barn.

from September through October in 1982 with this solar heater.

"When baling hay, we normally find about 10% of the bales to be too wet to store," Williams said. "Those bales are carefully stacked in such a manner as to be mechanically dried by forced air. This method, while somewhat expensive, is extremely effective and creates a very high quality hay."

But, Williams said, there is a more efficient way to dry the hay. The hay, for example, should be stored inside the barn on top of a perforated wood floor. That way warm air could be channeled from the ceiling to underneath the floorboard. The air would flow up through openings in the barn floor and dry the bales of hay.

Williams also has a solar grain drier, which utilizes the warm air from the solar collector. The drier, which is 12 by 16 feet, has a perforated floor. A three-horsepower "squirrel-cage" fan blows warm air from the solar collector through a pile of grain.

"This device has not functioned properly because our two-horsepower motor has not been capable of driving the fan, except for a three-minute period before it overheats and cuts out," Williams said. "We have another fan on order and hope to demonstrate its ability."

Another unique system Williams installed was an alcohol still. "It is a manufactured 80-gallon reflux column still," he wrote. "It is capable of producing eight gallons per hour of 130 to 160 proof alcohol . . . We are presently using a series of fermentation vats, using both potatoes and grain as the basic source of vegetable matter," he said in 1983. Effluent (wastes) from the still are used as cattle feed.

Performance and Tips

When Williams first conceived of a farm that could be a demonstration for various energy-saving procedures and devices, he had no idea of the notoriety it would receive. By 1983, he said, more than 20 reporters had interviewed him about his experiences and plans, and more than 200 visitors had come to the farm to learn more about the project. By 1983, the farm supported 25 head of cattle and seven horses.

Williams says his experience suggests several improvements:

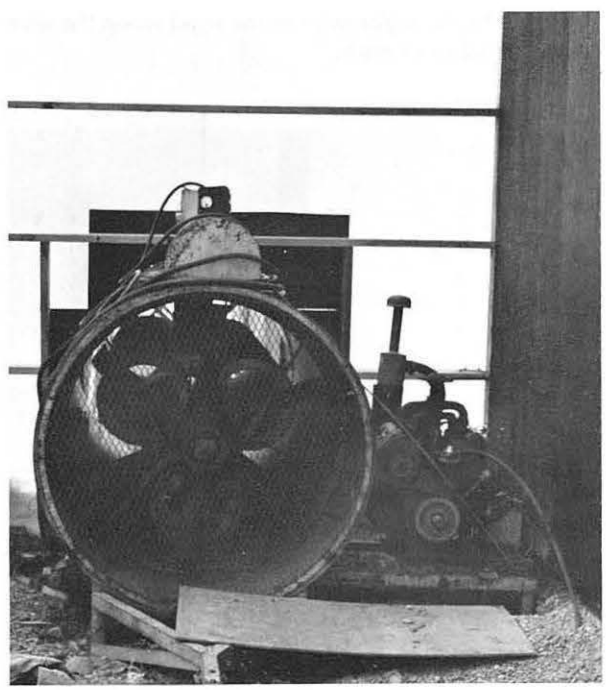
- Dry the hay inside the barn.
- Install a slotted, perforated barn floor so that warm air can be circulated from the ceiling, under the floor and up through the hay stack.
- Before building a wind generator, make sure it's cost-effective. Chart local wind currents and determine energy needs before making the investment.

Funding

U.S. Department of Energy	$16,476
State of Alaska	33,440

Grant Recipient

Thomas E. Williams
SRB-Box 7470
Palmer, Alaska 99645



Tom Williams' farm (above) near Palmer. A gasoline fan powers the hay dryer (right).

Crab waste produces methane gas supply

Charles Vowell first moved to Unalaska in 1967, employed as a plant engineer for one of the local canneries. In those days, cannery wastes were simply dumped into the bay. Unfortunately, the cannery wastes did not float out to sea as expected; they immediately sank to the bottom and formed huge deposits of decaying matter.

During this period, Vowell also noted that soon after a dumping occurred, bubbles began rising to the surface. He didn't think much about it until a couple of years later when, after attending an alternative energy conference, he realized that those bubbles were methane gas. Vowell thought that if he could somehow harness this gas, he could help solve one of Unalaska's major problems—high energy costs.

Unalaska, an island about 800 miles southwest of Anchorage, is the home of America's third largest fishing community. This island, like many in the Aleutian chain, is a windy, treeless bump in the ocean. Since Unalaska and its neighbor city of Dutch Harbor are fishing and cannery centers, work is seasonal and the cost of living high. Everything that doesn't come from the sea has to be shipped in.

The cannery wastes have caused problems in Unalaska before. The Environmental Protection Agency has determined that the waste disposal method was causing harm to the fragile ecology of Unalaska Bay and the agency ordered the dumping in the bay stopped. The canneries complied with this order by simply pumping the effluent to the mouth of the bay and also barging it out to sea. Although the immediate problem of pollution within the bay was solved, the overall problem was not.

Vowell figured that a bio-digester could not only solve both the waste disposal and ecological problems, but help offset some of the high energy costs of the area, as well.

In 1979, he received a grant to design and fabricate a methane bio-digester at Unalaska. The project involved the design and construction of the bio-digester, and developing a method to clean and store the methane gas.

Design and Construction

Vowell decided to build a continuous feed bio-digester using as much local material as possible to keep costs down. Using primarily crab gurry (offal), the system would consist of a 10,000-gallon digester tank, a water pump to keep the material suspended, a hot water heater and heating coil for thermal control, an old boiler for low pressure gas storage, carbon dioxide and hydrogen sulfide scrubbers, insulation, and the necessary piping and controls to operate and monitor the system.

Vowell calculated that his system would have a rated output of between 900 and 5,100 cubic feet of methane gas per day, with a heat value of about 900 BTUs per cubic foot net output after scrubbing (cleaning emissions). These figures are based on an average of 1.4 to 7.8 cubic feet of solid matter per loading. The actual output would be monitored by a standard gas meter placed between the methane generator and the low pressure boiler storage container.

In keeping with the philosophy of using as much local material as possible, the support stands for the digester tank were made from old dock pilings. The digester tank, hot water heater, piping, and boiler were acquired from the local canneries. The heavy equipment required to move the tank and other articles was rented from the city of Unalaska. Most of the labor was provided by Vowell himself.

One modification to the original design was the low pressure storage system. The boiler that was to be used became unavailable, forcing Vowell to find an alternative. He located 41 empty propane tanks which he mounted upside down on a rack. A small, low-pressure compressor was connected to them. Although this solved the storage problem, it lowered the system's efficiency because it added the energy consumption of the compressor to operating overhead.

A mixing tank with a vacuum flush mechanism was installed at the input to the digester. This flushing device, which works much like the home lavatory, ensured that sediment would not build up at the input end of the tank and reduce system effectiveness.

At the end of a digestion cycle, the remaining sludge was drained off into a holding tank. This sludge was subsequently disposed of by dumping into a landfill.

The system was designed to be relatively simple to operate. A window mounted in the digester allowed visual observation of system operation. The window was important to anticipate scum build-up. The scum indicates that the anaerobic action has ceased. Recharging and monitoring would only take about an hour's work each day.

Performance

Although the methane digester was operated for only a short period in 1980, Vowell feels that it was a resounding success. Thirty days after he first began loading the digester, "it was quite satisfying to sit and watch the gurry bubble," through the tank window. The crab wastes supplied by the East Point Seafoods cannery produced usable quantities of methane gas that required almost no scrubbing. Although the system was only filled to 10 percent capacity, it produced about 100 cubic feet of gas daily—more than a single house could use.

Another aspect of the gas produced by this system was the lack of odor associated with fish-charged methane digesters. The gas had almost no odor before or after burning. However, the crab wastes only lasted until the end of crabbing season. After that, ground salmon waste was tried.

Although salmon is easier to handle than crab and digests faster, the gas output of about 600 cubic feet of gas per barrel of salmon waste was of marginal quality. It had a foul odor and required both carbon dioxide and hydrogen sulfide scrubbing. Even then, so little methane was produced that it was determined that salmon, or other fish-only wastes, are not worth the effort.

Another problem with the experimental system was its location in relation to supply. Moving the digester closer to the canneries and piping the crab wastes directly to the digester would improve its efficiency considerably.

In addition, Vowell tried a couple of modifications to hasten the digestion of the crab wastes. Since most of the crab wastes contain shell pieces about a half inch in diameter, a grinder was installed to chop them into smaller pieces. It wasn't long before that idea was scrapped. The grinder tended to clog constantly, adding labor and maintenance woes to the project.

Gas storage also was a constant problem with this project. This was partially due to the unavailability of the large used boiler and partially due to the unexpected high quality of the gas produced.

Conclusions and Problems

Although Vowell rated his project a technical success, he readily admits that it was an economic bust. "It's a shame, because the digester could offset about 25 to 30 per cent of their fuel costs." Vowell thinks that if he had access to a lab with hard data on quality and quantity of gas per pound of waste, he could have developed the necessary projections. "These people (the canneries) operate on a yearly basis, and unless you can prove a quick payoff, it's very hard to convince them to use your ideas," said Vowell.

Another problem facing Unalaska is its location. The traveling dignitaries that could have supplied the type of support this project needed, never came to see it. "A similar project in Homer, would have made the front pages," he said. Yet, Vowell feels that it's the remote locations that need the help.

During the operating period, the large pump used to fill the digester from the East Point Cannery failed. This made Vowell believe that a less exotic, easier to feed batch type digester may be more economical for these operations. Since the crab and other shellfish are seasonal, running the digester throughout the year didn't make sense. Crabs and shrimp, although they were not actually tested, "have a shell, and that shell is the real source of the carbon" needed to make good methane. Salmon and bottomfish do not have the extra carbon and therefore produce low quality gas, requiring lots of extra scrubbing to remove excess carbon dioxide and hydrogen sulfide gasses.

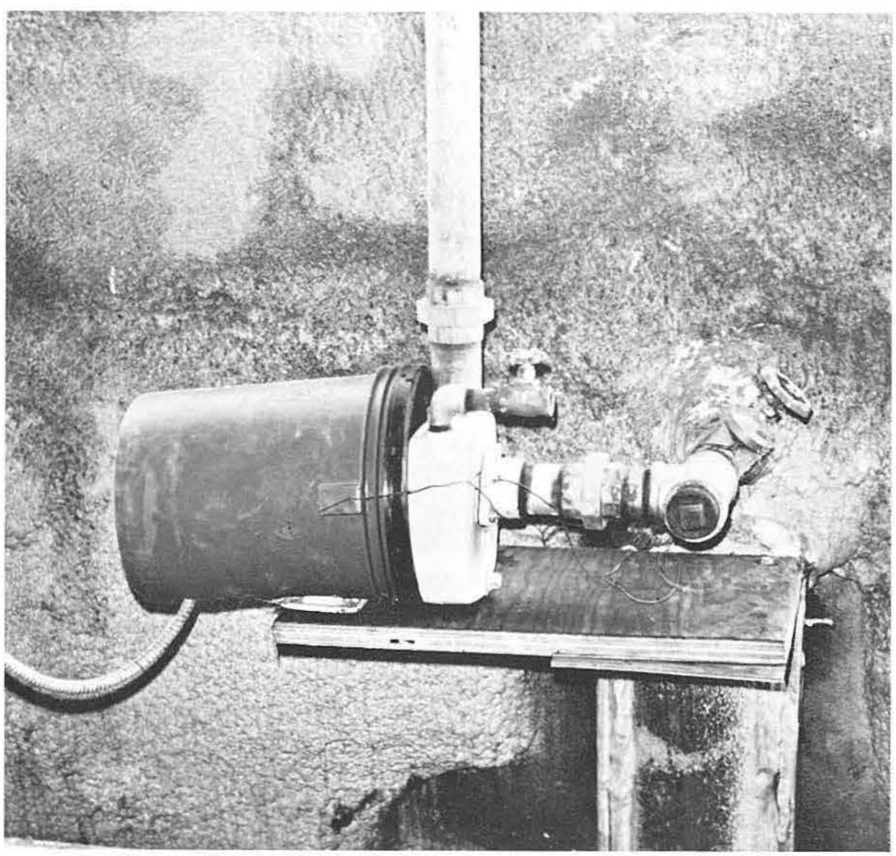
A secondary market was hinted at with the sludge byproduct. An accidental spill one year resulted in a bright green splotch of grass the next. The bio-digester output could be packaged as a high-quality fertilizer, helping offset operating costs, Vowell believes.

Funding

U.S. Department of Energy $11,800

Grant Recipient

R. Charles Vowell
801 Airport Heights #226
Anchorage, Alaska 99504



A plastic bucket (above) covers the electric motor of the digester pump.

Design allows for continuous gas production

Doug McKee is recycling pig waste for new uses. He's converting it into methane gas to heat his barn, and spreading the leftover, nitrogen-rich sludge on his fields for fertilizer.

"I had read in some farm journals that people (Outside) were using manure to make methane gas and it seemed like it was a good concept," says McKee. "We wanted to use the methane to heat the barn."

Keeping the pigs warm on McKee's 300-acre farm isn't as easy as it sounds. The McKees live at Mile 20 on the Chena Hot Springs Road, which is near Fairbanks, where winter temperatures can plummet 40 degrees below zero.

During winter, Doug and his brothers used to have to get up in the freezing cold to make sure a wood stove was still keeping their two-story, 40-foot diameter barn warm.

But McKee now hopes he'll be able to make enough methane gas that his family members won't have to worry about the old wood furnace anymore.

"It'll be a lot more convenient," said McKee. "So far we haven't had any trouble. Everything's been going like it's supposed to." Results from first use of the digester in mid-1984 were not yet available at press time.

Design and Construction

Pig manure is converted to methane and nitrogen-rich sludge inside of a specially-made methane digester tank. It's housed in a 20-foot-by-40 foot metal building that sits on top of a concrete slab. He bought the building from an Alyeska Pipeline Service Company subcontractor for about $6,000 and invested another $6,500 on construction, electrical wiring and urethane insulation.

The methane digester is composed of several parts including a 1,000-gallon predigester, a 7,000-gallon main digester, a methane storage tank, and a water boiler.

The system McKee built is a continuous flow digester. This means he adds a load of about 150 gallons of pig manure to the 6,000-gallon tank several times a week to maintain continuous methane gas production.

"The main advantage of our design is that there is no interruption in the production of methane gas," said McKee.

Pig manure flows by gravity from the barn to a pit beneath the floor of the building that houses the digester. The manure is then pumped from the pit into the predigester tank where it is heated to 95 degrees by hot water circulating through 125 feet of three-quarter inch polybutylene pipe.

Gradually the oxygen is removed by bacteria thus yielding an anaerobic material. This is important because methane gas will not be given off until all of the oxygen is eliminated.

After a couple of days in the predigester tank, the manure is pumped into the main digester, which is a converted railroad tank car insulated with three inches of urethane. The 95 degree temperature is regulated by a thermostat in both digester tanks by circulating boiling water through 150 feet of three-quarter-inch polybutylene pipe. It takes about a month for the manure to pass through the main digester.

The methane, an odorless, colorless gas, rises to be stored in a tank on top of the methane digester. The gas is piped from the storage tank to a boiler (housed in a

separate fireproof room) and used as fuel to heat water for circulation through pipes that heat the methane digester and the barn.

"I plan to put a big radiator in the center of the barn with a fan behind it," McKee said. "The hot water will circulate through the radiator and the fan will blow the heat through the barn."

The liquid sludge that remains in the digester is gravity-fed out of the main digester tank into a honeybucket. McKee spreads this nitrogen-rich sludge on his fields as an organic fertilizer. Recycling human and animal organic wastes in this way has become common practice across the U.S.

"One of the places I think a digester would be real useful is on small farms where a person only has a few acres of land and doesn't really have a place to put the manure," said McKee. "The digester would come in real handy on a small farm."

Problems

The only serious problem McKee has encountered occurred shortly after he fired up his methane digester for the first time in the fall of 1983.

Large barley hulls that had not been ground up enough to be completely digested by the pigs clogged the system and prevented the manure from flowing properly. The hulls are made of tough cellulose which can not be digested very well by bacteria, as well. And the hulls stuck to the heating coils, preventing the heating coils from warming up the tank.

McKee, however, fixed the problem by installing a finer screen for his feed grinder. Now, he doesn't have to worry about barley hulls clogging the digester.

Tips

McKee has the following suggestions for those who may try a system similar to his:

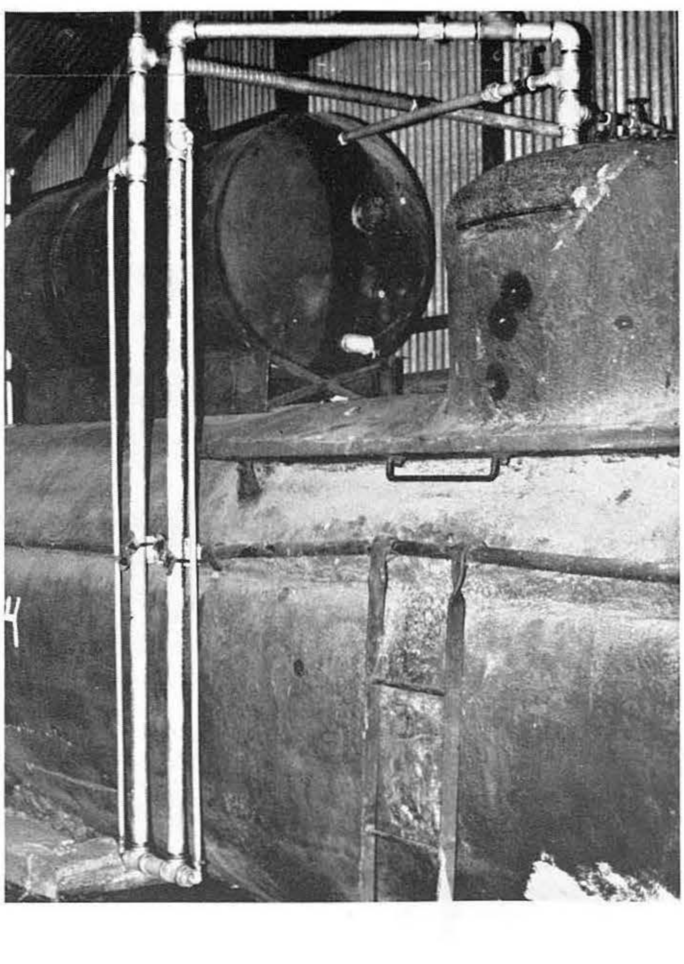
- Methane is a highly flammable gas. Make sure the system does not have any leaks before filling it with manure. Check for leaks by pumping compressed air into the digester and pour diluted dish soap around each one of the welds and pipe joints. Bubbles in the soap indicate a gas leak.
- To prevent manure from forming layers of scum, install a bar with paddles across the center of the predigester tank. Connect the bar to a handle outside the tank so it can be rotated periodically. The apparatus works like a mixer, breaking up scum at the tank bottom.
- Clean or wash out the sludge pipe periodically, to prevent sludge from freezing solid in the pipe during winter.

Funding

State of Alaska	$15,000
U.S. Department of Energy	15,000

Grant Recipient

McKee Inc.
20 Mile Chena Hot Springs Road
SR Box 50985
Fairbanks, Alaska 99701



Methane originators (previous page). A gas collection dome (left) sits atop the digester. (above) McKee stands next to the insulated digester tank.

Solar power helps count fish

As Alaska's Bristol Bay region prepares for the onslaught of fishermen, processors, boat tenders, and others who follow the great salmon runs into this world-renowned fishery each summer, a team of biologists sets the stage for the large commercial fishing season to begin.

The rivers that are tributary to the great Bristol Bay region along the Alaska Peninsula, together with lakes upstream, are the spawning grounds of these millions of salmon sought the world over.

Because the fishery is managed on a sustained-yield basis, the season does not open until enough salmon have escaped upstream to sustain the species. The fisheries biologists who count these fish struggling upstream herald the opening of the season. Days before the first fishing nets ply the waters of Bristol Bay, the Alaska Department of Fish and Game has set up camp waiting for the fish to arrive.

But until the Department of Fish and Game's successful experiment with solar panels, fish tracking operations in the field were both cumbersome and costly.

None of the remote field sites in the Bristol Bay region (the test area for the application of solar power to the salmon counting process) is connected by roads or served by commercial electrical power.

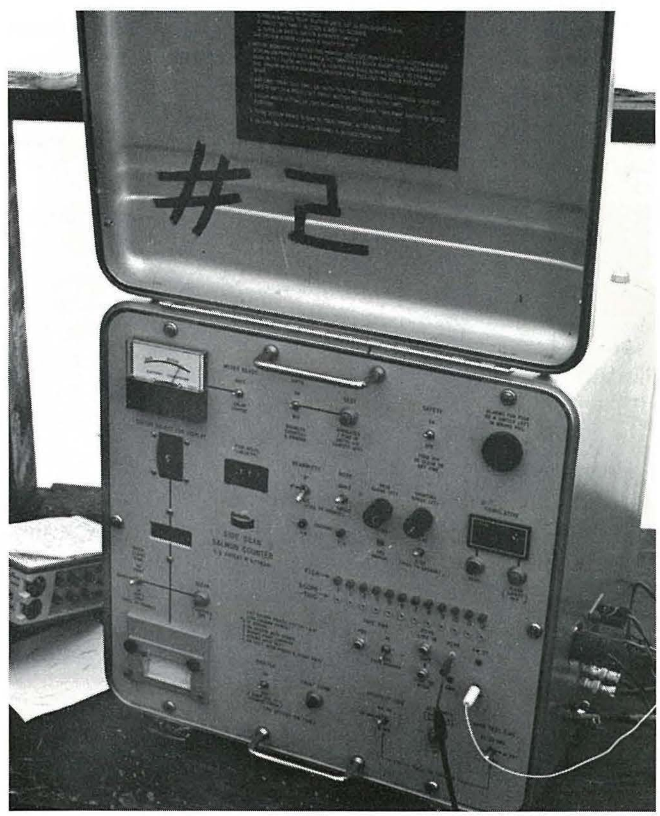
The electricity that is needed to run sonar salmon counters, refrigeration units, radios, spotlights, and range marker lighting systems has traditionally been generated by portable gasoline engines.

The gasoline, along with the generation units and replacement batteries for lighting systems, had to be shipped to the field sites by float planes or boats. Not only was this time-consuming, it also added to the already high cost of fuel.

The agency's experiment with solar panels, however, has shown the practical benefits of this alternative energy technology for salmon tracking operations. Operational expenses for fossil fuel consumption and transportation were reduced, and the need for hauling around most of the bulky power supply equipment was eliminated.

Before Fish and Game began its solar energy project, biologists collected and analyzed power requirements over a several year period for sonar salmon counters, marker lighting systems, refrigeration and radios, to match power supply with demand.

Mean solar radiation for June and July, the time of year when migrating salmon are counted, was collected from 1961 through 1969 at the Lake Aleknagik camp near Dillingham, and from 1966 through 1977 at Lake



The solar panel (above left) being rotated into the sun; (above right) the sonar fish counter is powered by the solar panel.

Iliamna.

The mean June–July air temperature recorded at camps at Cape Newenham, Iliamna, Dillingham, King Salmon and Intricate Bay from 1961 through 1979 was 51.6 degrees.

Average daily available solar panel power output was calculated at 22.4 ampere hours or 270 watt hours.

Power requirements for the salmon solar counters, according to Bendix Corp., manufacturer of the counters, are .038 ampere hours a day for adult salmon counters and .25 ampere hours a day for smolt counters.

Twenty ampere hours of power a day are needed for refrigeration, based on the operation of a cooler at a setting of 35 degrees for 10 hours a day, with an ambient air temperature of 51.6 degrees.

Radio communication needs are 10 hours standby daily, plus two to four transmissions a day, each averaging three minutes. The total radio power requirement is 2.3 ampere hours a day, based on 1.3 ampere hours for broadcasting and 1.0 ampere hours for standby.

The use of solar panels to power marker lights came as an afterthought to department officials, so electrical requirements weren't known.

However, they have worked well when connected to a 12-volt storage battery which is connected to one solar panel.

Solar electrical panels have been utilized successfully at a number of remote field sites throughout the Bristol Bay region:

Portage Creek	Radio, adult salmon sonar, cooler
Nuyakuk Salmon Tower	Radio, two spotlights
Togiak Salmon Tower	Radio
Igushik River Test Fishery	Radio, cooler
Wood River Smolt	Smolt sonar counter
Gechiak River Wier	Radio
Kvichak River Smolt	Smolt sonar counter, radio
Naknek River Smolt	Smolt sonar counter, radio
Egegik River Smolt	Smolt sonar counter, radio, cooler
Ugashik River Smolt	Smolt sonar counter, radio, cooler
Ugashik Salmon Tower	Radio, cooler
Nushagak District Range Light	Strobe range light

A normal counting site will have three people temporarily living at the location. Three solar panels, each connected to its own battery, supply the power for two sonar counters and the radio. The two sonar counters are located on either side of the river; thus, it is very efficient to have the separate solar panel/battery units located at the point of use.

The radio is located in a third tent usually separated from where the counters are located.

At Nuyakuk, sonar counters are not used. Instead, counting towers built on the edge of either side of the river are used for visual counting with a hand counter. At night, the spotlight using power from the solar panel/battery units enables the biologists to see the fish swimming up river and count them.

At those sites which utilize electric coolers, two solar panels have been used to charge batteries. However, these coolers tend to use more electricity than the 10 hours a day originally planned.

This causes severe battery drain, since two solar panels alone can not provide an adequate direct power supply.

One or two solar panels provide adequate power to operate equipment and recharge batteries at camps with salmon sonar counters and/or radios only.

The use of solar panels to recharge range marker lights for fishing district boundaries was tested after their successful use with other equipment. One test light was maintained throughout the fishing season with solar power alone.

Solar panels to power field camp equipment for tracking salmon populations are now standard equipment at most Bristol Bay field sites.

Technical notes

The equipment utilized in this project is outlined below:

Solar Panel: Arco Solar, Model AS1 16-2300, power rating 2.3 amperes per hour.

Cooler: Koolatron, Model P34A thermo electric cooler with 24-litre capacity, 16 by 12 by 11½ inches, with an adjustable temperature setting range of 25 degrees to 125 degrees with a maximum outside temperature drop of 50 degrees, power requirement of four amperes per hour during drawdown and less than two amperes per hour when cycling at holding temperatures.

Range Marker Light: Pennwalt Automatic Power, Model PA240 Strobe light at eight ampere hours per night.

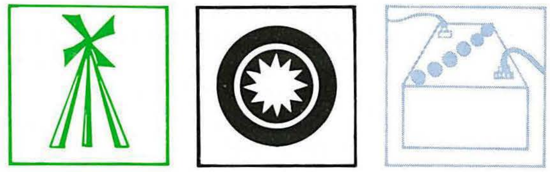
Funding

U.S. Department of Energy $9,736

Grant Recipient

Alaska Department of Fish & Game
333 Raspberry Road
Anchorage, AK 99502

Capturing energy above the Arctic Circle



James Schwarber is converting sunlight and wind into electrical power at his log cabin above the Arctic Circle.

In fact, he likes his photovoltaic panels so well that he's selling similar solar products through his business, Remote Energy Systems, when he isn't out hunting and trapping.

"It all started when I wanted to keep batteries charged in the woods," says Schwarber, who lives near Kobuk, about 350 miles northeast of Fairbanks. "I got a wind generator and when I found it was not satisfactory, I moved up to photovoltaics," cells that convert sunlight directly to electrical energy.

The combination of power sources keeps his bank of 12-volt marine deep-cycle batteries charged year-round. The photovoltaic, for example, even produces a trickle of power between November and February when the sun doesn't rise above the horizon.

Schwarber says he has more than enough power at his remote cabin for his lights, two-way radio, short-wave radio, vacuum cleaner, water pumps and 12-volt electric chain saw.

Design

Schwarber chose a four-foot-square, Arco Solar ASI-16-2000 photovoltaic module panel, mounting it on a five-inch diameter spruce pole that rises 11 feet above his log cabin roof. The four-module solar panel, which weighs about 50 pounds, was attached to the pole with an SPM-4-65 pole mount.

The solar panel was installed above his roof to minimize shading and to keep it out of the reach of pawing grizzly bears.

Schwarber used No. 10 AWG UF cable to link the solar panels with three 105 amp-hour, 12-volt, Gould deep-cycle marine batteries, which are connected in parallel series.

And he ran a No. 4 copper wire from the top of the mounting pole to a ground rod driven seven feet into the earth below the pole. He also grounded the four solar modules to the No. 4 ground wire, and added six guy wires to the pole for stability.

A Winco 1222H 200-watt wind generator acts as a backup power production system.

Schwarber could have chosen other equipment for his dual-energy-source configuration, but the project gave him what later became the opportunity to "field test" a new commercial product and service.

Performance

Overall, Schwarber says his photovoltaic system and wind generator are working very well. In fact, he has plenty of power to supply his simple electrical needs at the trapping cabin.

Two minor problems, however, surfaced about a month after Schwarber set up his photovoltaic panels. Three silicon cells on one panel cracked and several solar cells had discoloration, but there was no moisture in the cells. It appeared that the discoloration may have been caused by a chemical reaction of the components in the module, and a defect in the Tedlar backing may have contributed to the cracking.

"So far, I have found that the photovoltaic array and wind generator complement each other well," Schwarber says. "Periods of peak solar energy and peak wind

James Schwarber's trapping cabin near Kobuk (above); a solar collector and a wind generator (left) are placed out of the reach of bears.

energy rarely coincide, which results in a more continuous production of electricity than either system provides alone."

Good data has been collected on the system, thanks to a 10-amp ammeter he connected to the cable linking the solar panels with the battery bank. On occasion the output from the solar panels was about 10 amps, or about 10 percent greater than the manufacturer's rated output.

The solar panels can produce approximately 60 amp-hours of electricity on a clear summer day. When the batteries reach 15.1 volts, the Arco battery protector relay is tripped and the charging current is lowered to .5 amps or less and the voltage is dropped to 13.8 volts.

During heavy overcast days, the system's output was minimal ranging from 0.3 to one amp all day. Partly cloudy, hazy or lightly foggy days resulted in moderate to high outputs.

But the important thing, Schwarber says, is that even in mid-winter when there is no sunlight the photovoltaic system continued to produce power from stray night light. This means he doesn't have to worry about his battery bank going dead and freezing up when he is away on hunting trips.

"I have found that I can leave the photovoltaic array hooked up to an Arco battery protector to protect the batteries from both overcharging and freezing," he says. "This I find to be one of the most valuable aspects of photovoltaics—safe, reliable, unattended charging of batteries is possible.

"Another valuable aspect of having a photovoltaic array is its ability during clear weather and low load periods to fully charge up the battery bank in a smooth and controlled fashion," says Schwarber. "This will result in maximum lifespan of the batteries, which are difficult to ship and expensive to buy."

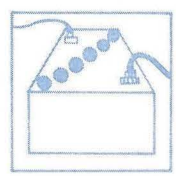
Funding

U.S. Department of Energy $1,850

Grantee

James A. Schwarber
P.O. Box 81997
Fairbanks, Alaska 99708

Electric lights a wilderness luxury



Susan Rainey got tired of relying on gas lanterns to light her log house. So she invested in a photovoltaic energy system.

"And I love it," says Rainey, who lives at mile 326 of the Parks Highway, 42 miles from Fairbanks in the shadow of Mount Denali (McKinley). "I just walk in the house and turn on the lights. I'm ecstatic with it."

Rainey, a former alternative energy newsletter editor, became interested in solar energy through volunteer work she did at the University of Alaska-Fairbanks.

But it wasn't until she discovered that the nearest power connection for the house they were building in 1981 and 1982 was 16 miles away that she decided to install the solar panels at her home. With her 1981 AT grant Rainey purchased the system. Since her home was not finished, a neighbor used the photovoltaic panels until Rainey's house was finished.

Now she doesn't have to rely on gas lights or electrical hook-ups anymore.

"They've held up real well," she says. "We had no problems with it."

Design

Ten ARCO ASI 16-2300 solar panels were mounted on top of Rainey's roof to get the maximum amount of sun exposure and to minimize shading from nearby trees.

Each panel is rated with a peak of 37 watts so that when she uses all 10 panels she has a 370-watt peak output from her array, which is about four feet wide by 10 feet long.

The power is stored in eight, 82.5 amp Gould batteries. An inverter converts the photovoltaic alternating current into direct current for the home's appliances.

Performance

So far, Rainey says she's pleased with her photovoltaic setup. She says it produces electricity even on cloudy and rainy days.

Better yet, she says the system has not broken down or malfunctioned.

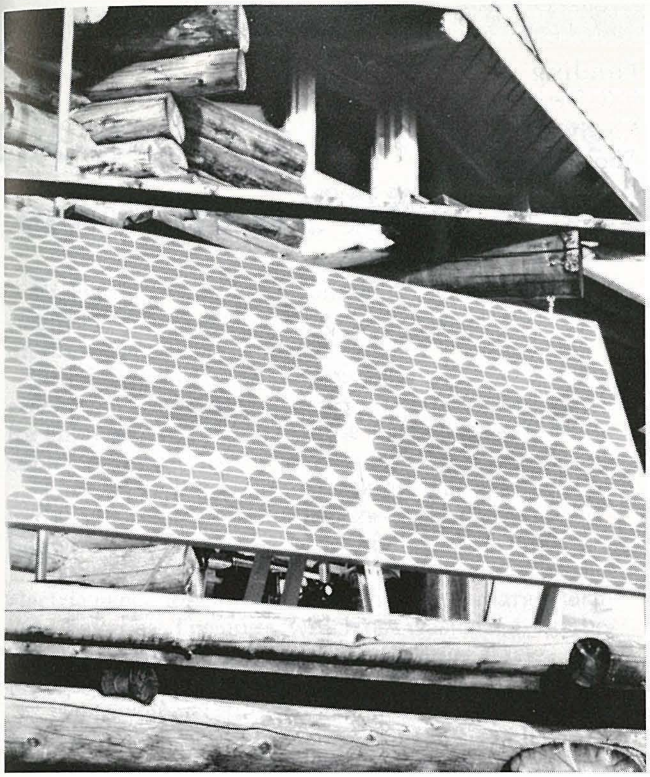
"They work fine," she said of the panels. "I'm ecstatic about it."

Funding

U.S. Department of Energy $5,800

Grant Recipient

Susan E. Rainey
P.O. Box 81182
Fairbanks, Alaska 99708



Susan Rainey's solar collectors are temporarily mounted on a neighbor's house (left).

Photovoltaics perform well in Alaska Bush

The high cost of shipping oil and gas to his remote cabin prompted Thomas Vaden to install solar panels.

He also wanted to show that solar power is practical for isolated cabins in the Interior, such as his wilderness survival Solo Creek School at White River southwest of Tok.

"We've been very satisfied with the solar panels," says Vaden, an Anchorage elementary school teacher. "They're efficient and there's no maintenance.

"If you were looking at summer recreation cabins where you were gone a lot, you could put in one panel and a couple of batteries and you'd have all the power you'd want for weekends."

But he's had his share of obstacles to overcome.

Bush pilots were reluctant to transport his batteries for fear that the battery acid might spill and ruin their plane. A fire also destroyed one of the two solar panels he installed.

Vaden also learned that it's better to purchase more solar panels and fewer batteries. He said he didn't need 17 batteries for his two solar panels. Buying more than five batteries creates a storage problem because the batteries must be stored outside of the cabin because of hydrogen gas emissions.

"One can't store a lot of batteries in the house because they produce an explosive gas and they will freeze (outside) after minus 60 degrees," he says. "I would recommend having four solar panels and four batteries. That's more than enough for a two-room dwelling with 50 and 75 watt lights."

System Design

Vaden installed two commercially built Solarex brand solar panels on top of two cabins. The two 12-volt panels, 17 inches by 42 inches, can each produce 3.5 amps when the sun is shining.

The panels are connected to a bank of 225-amp, deep-cycle batteries. Power from the batteries provides electricity for operating the lights and radios.

Initially, Vaden planned to store his bank of 17 batteries in a separate building heated by a wood stove.

But he abandoned this plan because of the possibility that flames from the wood stove would ignite the gas emitted by the batteries.

Vaden says he's considering putting his batteries in an underground pit with foam insulation. The ground, while cool, will not get so cold that the batteries will freeze and crack.

A gasoline generator and charger for the battery bank provide emergency backup.

Performance

The solar panels have operated well for the past several years, producing more than enough electricity for lights and radios.

Unfortunately, a fire destroyed one of the cabins with the solar panels early in the summer of 1984. Vaden does not know what caused the blaze.

The second solar panel, however, is still producing electricity at another cabin. He said the solar panels also have not required much maintenance.

Tips

Vaden says he's learned several things from his experience including:

- To avoid storage problems, consider using less than five batteries so that they can be stored inside the home.
- If more than five batteries are used, store them in an insulated pit outside the cabin as a safety precaution against explosive gas produced by the batteries.
- Consider purchasing battery seals which will contain any gas produced by the batteries.

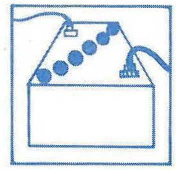
Funding

U.S. Department of Energy $5,705

Grant Recipient

Thomas H. Vaden
Solo Creek Wilderness School
5827 S. Tahiti Loop
Anchorage, Alaska 99507

Electric current from wood stove heat

W. Findlay Abbott is experimenting with making electricity from heat by using thermoelectric generators on his woodstove.

"It's right in the same class as solar cells," says Abbott, an Anchorage resident who makes architectural models for engineering firms, "the same technology as semi-conductor materials."

"I knew about it because my father was a scientist who had a research lab and studied thermoelectric. I've known about it for most of my life."

So far, he's still experimenting with different thermoelectric generators and has used them to recharge flashlight batteries. The units, which use waste heat, can be installed in many places including heating stacks, stove pipes and exhaust pipes.

"The thermoelectric generator is silent, maintenance-free and produces electric current as heat is radiated from the stove to the room," he says. "A remote household could be virtually energy independent; fire hazards of candle and kerosene lighting also could be eliminated," he said.

A thermoelectric generator is essentially an extension of the thermocouple, a device found in gas heating systems. It was discovered long ago that when two dissimilar-metals are fused at one end, a small electric current can be measured at the other. This is because each element on earth has a different electrical property, much like humans have different blood types. When making thermocouples, materials are chosen to produce a stable and predictable current value over a specific temperature range. By monitoring the current with a precision meter, it is possible to accurately control processes that use both extremely high and extremely low temperatures.

Thermoelectric devices use the same principle as a thermocouple except that they exploit the ability to produce electricity and not the stability of the electricity produced. In thermoelectric generators, the two dissimilar materials are chosen to produce a maximum amount of electricity over a certain temperature range. The chosen materials can be either metal or semiconductor alloys, depending on the temperature range at which the thermoelectric generator will operate.

The generators are formed by layering flat plates of these materials with some form of insulation between each layer, usually ceramic. Wire leads fused to the outer surfaces of each layer are tied together so that output of the device is the combined output of all the wafer layers.

System Design

Abbott's thermoelectric generator is comprised of a set of solid-state, semi-conductors sandwiched between ceramic and steel plates. Steel plates are used in this design because it is virtually impossible to attach output leads directly to semiconductor materials. Other materials that can be used include platinum and rodium, copper and constantan (an alloy of copper and nickel), and iron and constantan.

The six-inch-by-10-inch thermoelectric unit needs to be placed against a hot surface, such as a wood stove. These units, however, can withstand temperatures only up to 400 degrees.

As heat flows through the unit, the temperature difference between the stove side and the room side of the device causes current flow. This power is then stored in nickel-cadmium batteries.

"Thermoelectric generators are solid-state devices which convert heat to electricity without moving parts, when the heat flows through certain dissimilar conductor materials in junction," says Abbott. The thermogenerative properties of the materials cause current flow (electricity) to be produced.

"A small percentage of heat produced by a normal wood stove could generate enough electricity for several light bulbs and a radio," he says.

Performance

Abbott says the thermoelectric units appear to work quite well for recharging small batteries.

"It works. I produced a trickle charge for a battery," he said, but added that he's still experimenting with larger applications.

Funding

U.S. Department of Energy $805

Grant Recipient

W. Findlay Abbott
538 M Street
Anchorage, Alaska 99501

Gold miner tries new boiler system

Keeping a home warm in the Alaska Interior where one has to live without such modern amenities as heating and plumbing is a tough proposition.

But innovator John W. Greene, Jr. has developed a baseboard heating system that keeps his home a snug 74 degrees—even when outside temperatures plummet to minus 42 degrees.

"In fact, I believe we have the most comfortable house in the Interior and it is all done without electricity—no pumps—just a wood-fired boiler," says Greene, an engineer and gold miner who lives in Eagle.

"It's working pretty well," he said. "But I'm still trying different things. I'm an engineer and I have to tinker with things."

Design

Greene keeps his house warm by circulating a hot water and antifreeze solution in a continuous loop between his furnace and baseboard heating units that are placed along the floor of each room.

The heart of the system is an eighth-inch, steel-plated boiler he put on the concrete floor in his basement. The boiler, which uses three-foot-long logs, has a two-inch layer of sand in place of a grate. The sand holds the heat and directs it back into the fire, making it easier to burn "green" wood. There also is a one inch thick water jacket on top of the stove.

The water and antifreeze flow into the bottom of the boiler through a three-inch-diameter steel intake pipe, which has a series of welded nipples. Each nipple provides for connecting three-quarter-inch copper pipe, which links the colder-water return pipe with a similar heated-water supply pipe at the top of the firebox. There are twelve separate copper pipes inside the firebox.

The antifreeze heats up as it flows through the copper pipes leading from the bottom to the top of the firebox, traversing the flames.

At the top of the firebox, the heated water and antifreeze rises up a three-inch-diameter steel pipe, which passes through the water jacket. The steel pipe ends in a T-section with welded steel nipples connected to three-quarter-inch copper pipe.

Each branching copper pipe makes a loop through a different section of Greene's home, channeling hot water through fin type baseboard heaters.

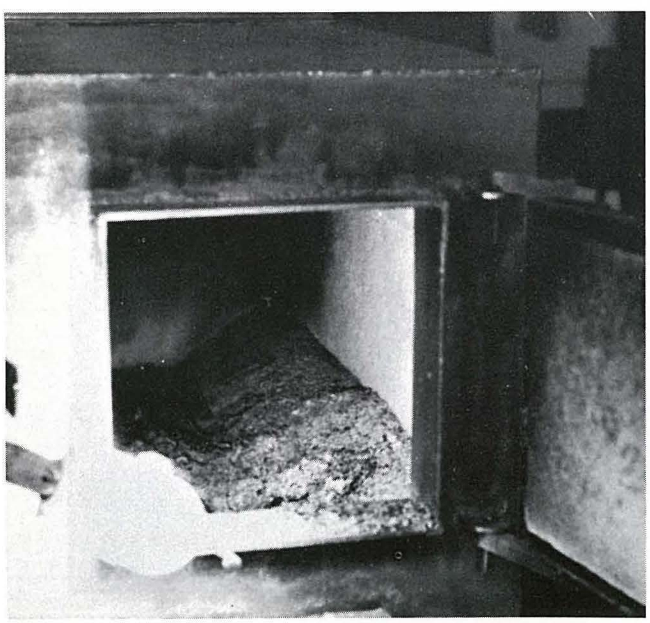
Greene also installed a valve at each nipple-copper pipe junction to control the amount of hot water circulating through each loop, enabling him to regulate room temperatures.

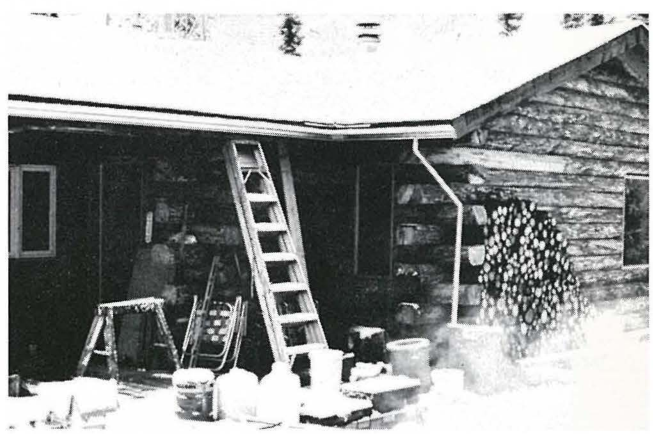
The hot water/antifreeze solution bubbles upward from the boiler to the first-floor and moves horizontally through the heating baseboards before flowing back into the furnace.

"It is really important that the hot water line coming out of the furnace rises to the first floor baseboards, and when the antifreeze gets to the end of the heating loop it must go down to the furnace," Greene said. "To avoid water or air traps (that don't allow the water to circulate), you don't want to have ups and downs in the pipes."

The building codes that apply to boilers do not normally allow an individual to construct a boiler without going to the major expense of having the unit rated by the American Society of Mechanical Engineers (A.S.M.E.).

But Greene doesn't have to worry about the issue because he built an atmospheric heating system. The furnace creates no pressure when the antifreeze is heated





An early version of the boiler (left) before a refractory liner was replaced with sand. (Above), winter sets in at Greene's cabin in Eagle.

because it is open to the air via an expansion tank located above all the piping in a bedroom closet. The tank is a small garbage pail with a loose-fitting, removable lid that was welded atop a three-quarter-inch copper pipe connected to the heating system. The tank maintains pressure on the system, while making it easy to replenish the water and antifreeze.

Performance

Overall, Greene says his heating system has performed very well. It keeps the house evenly heated and has not required much maintenance.

"The coldest outside temperature that I have been able to test the system in has been minus 42 degrees," Greene says. "The temperature inside the house was held at 74 degrees over a 24-hour period. No electricity was used in the system either in the control or in the pumping of the hot water (antifreeze).

"I had to fill the furnace with wood once every eight hours," he says. "The house was even more comfortable than a normal city home with baseboard heat because with this system the hot water flows through the baseboard units continuously at a lower temperature than with a gas or oil fired system, thereby giving you a very stable temperature in the house."

Greene also tried building a heat storage, but it didn't work out very well. He dug an eight-foot square hole in his cellar floor, placed three-quarter-inch copper tubes in it, and filled it with sand. He had hoped to pump hot antifreeze through the heat storage so that when he was not at home, the heat storage would keep the cabin warm after the boiler fire stopped.

Unfortunately, the pipes leaked and he had to abandon the project. But he said he doesn't need the heat storage because his log walls retain heat well.

Tips

Greene has several suggestions to make from his experience:

- Don't use fire brick in the furnace. The fire burns longer—and better—without it.
- Don't use a grate in the fireplace. A couple of inches of sand inside the furnace works a lot better. The sand holds the heat and reflects it back into the flames, increasing combustion efficiency, especially for green wood.
- Make sure the copper tubing does not have any unnecessary bends or traps which can prevent the antifreeze from flowing.

Funding

U.S. Department of Energy	$2,300
State of Alaska	2,300

Grant Recipient

John W. Greene, Jr.
Box 62
Eagle, Alaska 99738

Design goal: Energy efficiency

David Newcombe doesn't believe the oil supply is going to last forever.

That's why he's busy experimenting with alternative energy. Recently, he built a wood-fired boiler to provide heat for his home in Wasilla, about 45 milies north of Anchorage.

"I've also built wind generators and I'm playing with solar voltaics," says Newcombe, a heavy equipment operator and maintenance welder. "I'm interested in alternate energy in general."

So far, his wood-fired boiler is successful. Another boiler he built for a neighbor has been operating smoothly for the past four years.

"I see so many inefficient wood burning systems around that I thought that there must be a better way to go," says Newcombe. "It seems to be working real well. It heats a whole house."

System Design

A 1,000-gallon-water tank that's six feet high and five feet in diameter is fitted with a firebox. The tank is made of 1/8-inch steel plate.

The boiler unit, which was placed on top of two inches of styrofoam, is in his basement.

The firebox, also made of 1/8-inch steel plate, is two feet by three feet in size. An eight-inch-diameter steel pipe with 1/4-inch wall extends through the water tank, to a chimney above.

The firebox, which is lined with 1.5-inch thick fire-brick, is divided into two combustion chambers by a steel plate that slides in and out of a sidewall. The divider helps create a downdraft to make the fire burn hotter.

The water tank is insulated with nine inches of fiber-glass so that the water temperature drop during warm periods is less than two degrees a day.

Domestic water is heated through a 60-foot-long coil of half-inch tubing suspended near the top of the water tank. The drinking water circulates through the copper tubing and is warmed as the water is flowing to a faucet through the pipe.

Eventually, Newcombe also plans to circulate hot water from the tank through a baseboard heating unit to help heat his home.

Performance

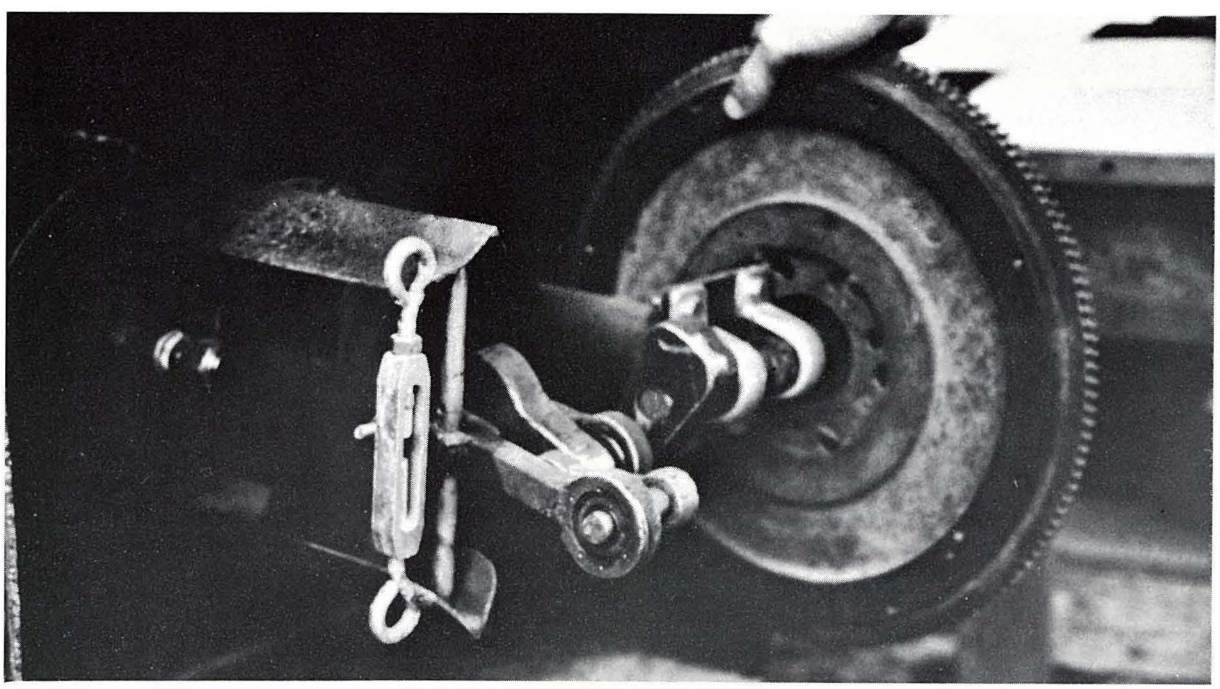
"Smoke and creosote are almost nonexistent," says Newcombe. "Heat storage lasts two to seven days depending on demand, and the wood consumption is lower than that of the Earth Stove used previously."

Funding

U.S. Department of Energy $2,547

Grant Recipient

David R. Newcombe
Box 871663
Wasilla, Alaska 99687



The hand-made Stirling engine David Newcombe added to his boiler.

Steamboat to ply the Holitna River

Long before Grant Fairbanks moved to his 40-acre homestead near Sleetmute on the Holitna River, steamboats were the major form of summer transportation. By Fairbanks' time, steam had given way to faster gasoline and diesel engines and the airplane. Cheap petroleum had put the old, slow, wood-burning paddlewheelers out of business.

Then came the oil crisis with its dramatic rise in petroleum-based fuel prices. Every penny added to a gallon of gasoline brought a corresponding jump in transportation costs. By the late 70s, transportation charges were about to put supplies and fuel out of the reach of the homesteaders along the river. Fairbanks felt that the time was ripe for a return to steam power.

Sleetmute and the Holitna River area are surrounded by thousands of acres of natural renewable resources—fast growing birch and spruce forests. Furthermore, Fairbanks knew where he could get a boiler. He figured that by bartering, many homesteaders who were priced out of the petroleum-based transportation system could use a small steamboat service, paying transportation charges with goods or cash. In an area where wood is more plentiful than cash, this type of system could bring a return on investment.

Fairbanks began to build his wood/waste-oil fired steamboat for use on the Holitna River in late 1980. The project involved constructing and outfitting a flat-bottomed, steam-powered riverboat and maintaining records to help illustrate the usefulness and economics of the project.

Design and Construction

The project was divided into four parts: building the boat; obtaining a boiler and steam engines and moving them to Sleetmute; designing and building a transmission to transmit the power from the steam engines to a rear-mounted paddlewheel; and installing all the mechanical hardware on the boat.

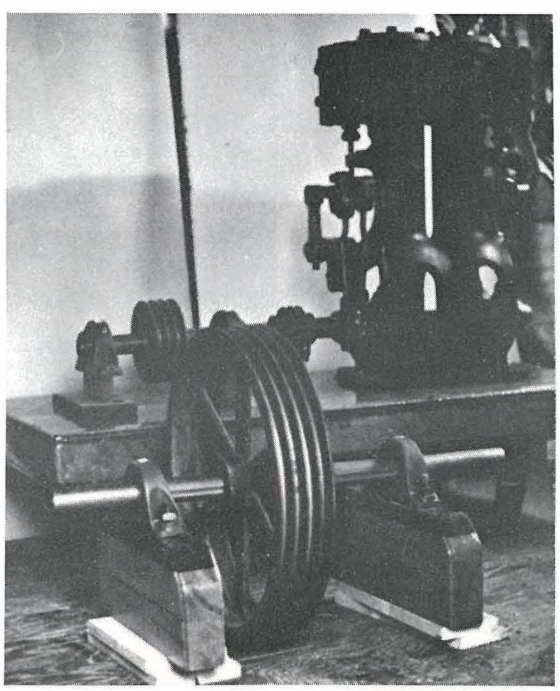
The 38-foot boat (including paddlewheel) is made of three-quarter-inch marine plywood and local spruce donated by an area sawmill. The boat's skeleton is made of 1½-inch bottom planks with two-by-six ribs. Over this skeleton is a skin of plywood. With a beam of seven feet and three-foot sides, the boat could safely tote an eight-ton load while drawing only 10 inches of water.

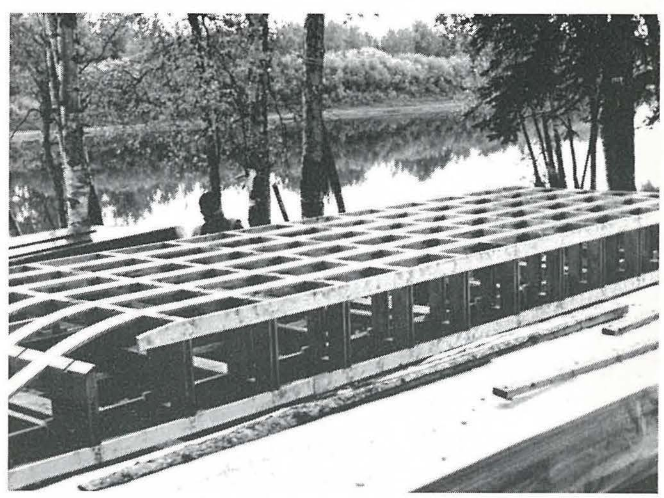
The boat design itself borrowed heavily from the riverboats that plied the Upper Mississippi River near the turn of the century. The Holitna is the same type of shallow, winding river with shifting gravel and sand bars. One modern innovation was added however; the bottom would be covered with fiberglass and resin. All other surfaces are covered with wood sealer and painted.

Although the hull design and steam engines could push the boat at speeds up to 10 miles per hour, river current would reduce this to about four or five miles per hour traveling upstream.

Power for the boat is from a wood/waste-oil fired low pressure steam boiler, two 10-horsepower Sturtevant steam engines, and a large stern-mounted paddlewheel.

A small but strong transmission transfers power from the steam engines to the paddlewheel. The steam engines





A recycled steam engine (left) is to be used to power the steamboat. (Above), work on the steamboat proceeds on the banks of the Holitna River.

have a "square" bore and stroke of five inches and produce their rated horsepower at 325 rpm.

Fairbanks got the engines from a Minnesota firm that had been using them for almost 40 years. They still have an estimated 20 years of life left in them. Simplicity, ruggedness, and the 20-year life make them an excellent choice for use in Bush Alaska.

The boiler was to serve a double life; Fairbanks is also a master woodworker and during the long cold winters, he spends much of his time in his shop. During the times when ice on the Holitna makes riverboat travel impossible, Fairbanks figured to muscle the boiler to his shop to power his tools. When the river cleared each spring, he'd move the boiler back to the boat. Unfortunately, the boiler Fairbanks intended to use for this project was not ASME stamped to meet state regulations and he was left with the problem of getting a new boiler; although the original boiler was already in Sleetmute.

A company in California was chosen to make the new boiler. It would have the same basic characteristics as the original (52 boiler tubes of two inches by four feet) and an operating range from 100 to 150 pounds per square inch pressure (psi). The original firebox for the first boiler would be used with the new one.

As of mid-1984 the boat was nearing completion.

Problems and Conclusions

Fairbanks encountered many small problems during this project; most of all with government certification requirements for his boiler. The need for a new boiler delayed the project a full year and increased costs about $2,000.

Other problems included normal communication problems encountered in the Bush and an abnormally wet summer. The wet summer kept the spruce for the boat's skeleton from drying to a maximum of 15% water content.

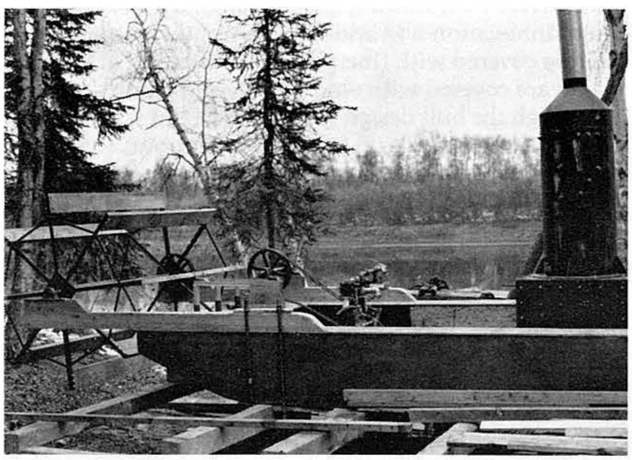
Communication problems stranded the new boiler in Bethel for a couple of months, causing another season delay. But even with the delays, there still seems to be a lot of enthusiasm for this project to ensure its ultimate success.

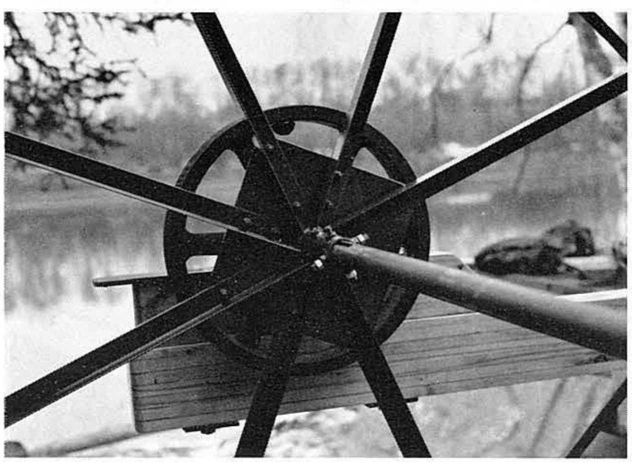
Funding

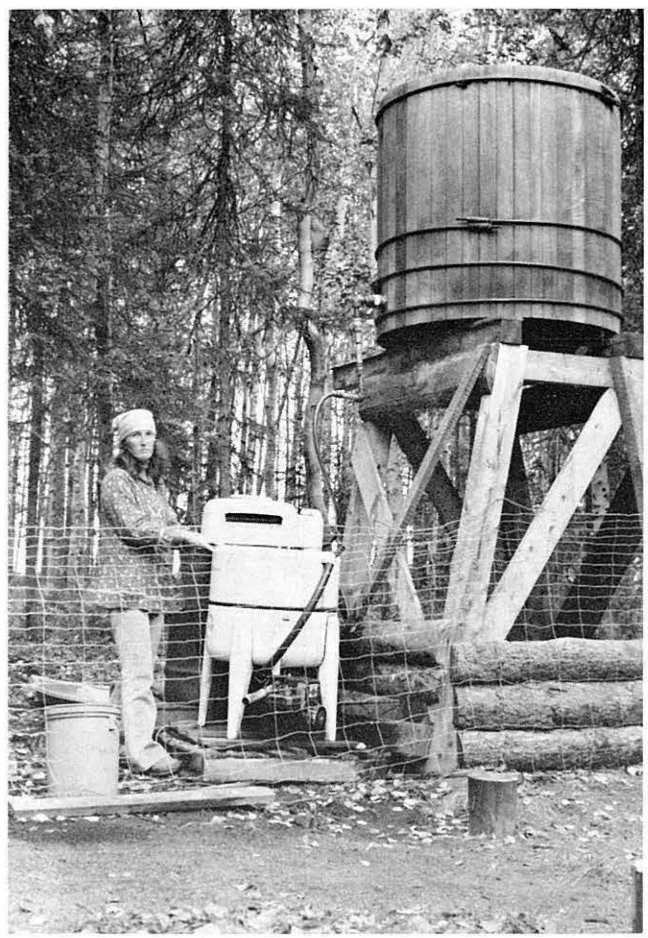
U.S. Department of Energy	$9,145
State of Alaska	9,145

Grantee

Grant Fairbanks
General Delivery
Sleetmute, Alaska 99688







The nearly complete steamboat with paddlewheel, boiler and steam engine mounted (top left). The paddlewheel assembly waits to hit the water and Debbie Fairbanks' washing machine shows that a home-style water tower can serve both household and steam engine uses.

Wood-fired boiler requires fuel supply and attention

A wood-fired boiler and steam engine produces most of the heat, hot water and electricity that Guy A. Matthews needs for his home.

It's also a cost effective way to generate power since most of the fuel supply—wood—is readily available near his home at Tok, the principal road entry to Alaska and Canada's Yukon Territory.

"It works good," says Matthews, a road construction worker, referring to his system. "Running a small steam plant for power is ridiculously expensive. But if it's your power and your heat then it's pretty reasonable."

Steam from the boiler runs a small, five-horsepower engine to produce electricity, which is stored in a bank of 12-volt, deep-cycle batteries. The power is used for lighting, operating power tools, a television and radio.

But the system has its drawbacks. Until Matthews installs automatic controls, he has to be around when the boiler is fired so he can monitor its operation constantly.

"It's not a continuous running system," Matthews said. "It's not something you can throw a lot of wood into and walk away."

System Design

A three-foot-high, 20-inch-diameter boiler sits atop a one-quarter-inch, steel-plated firebox that is 32 by 32 by 24 inches.

The firebox also heats an adjacent, 30-gallon domestic water tank, the garage, greenhouse and entryway. In addition, Matthews supplements his heat with a woodstove.

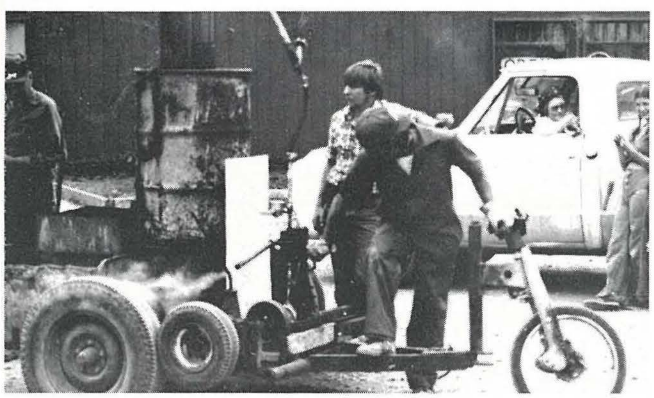
Water in the boiler is heated by hot gases rising from the firebox into the boiler through 70 vertical cast iron pipes. Matthews also installed a quarter-inch-thick steel plate in the firebox so he can slide it under the boiler when he wants to keep the boiler from heating and, instead, direct the heat through the domestic hot water tank.

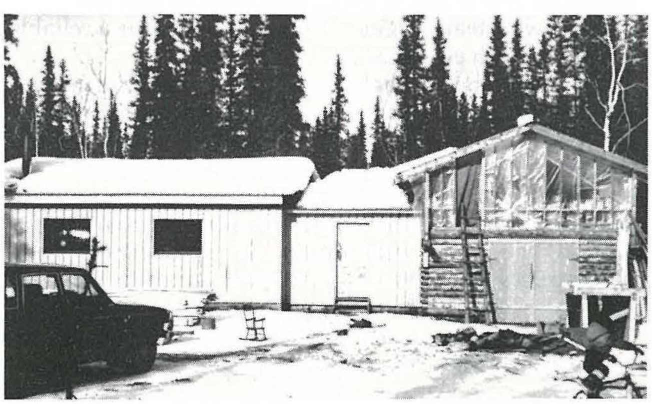
Steam from the boiler drives a 85-pound five horsepower, steam engine. The engine, manufactured by Semple Engine Co., is 18 inches high by 18 inches long. Operational pressures range from 90 psi to 150 psi.

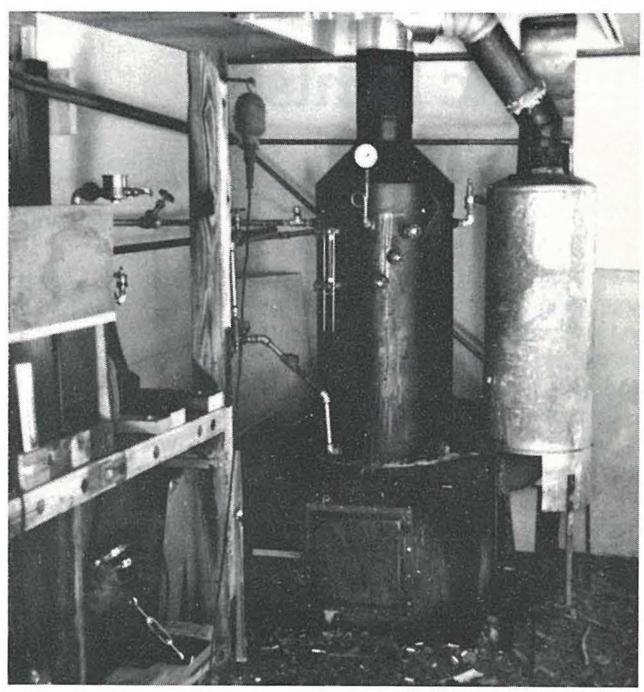
"Once steam is up to pressure, I can maintain the pressure of 100 to 150 psi by throwing in an armload of dry mill wood, giving me about one hour running time," he says.

The alternator, turning at 2,200 RPM, will produce enough electricity to charge a bank of four, 12-volt, 700 amp deep cycle batteries.

The batteries charge according to various settings on the alternator. The charge rate has been varied from 15 amps to a full 65 amps, depending on the battery state of







Guy Matthews pretested his steam engine (top left) in a local parade. (Bottom left), an attached workshop nears completion. A boiler and hot water heater (above) are shown inside the workshop.

charge.

Matthews also connected a static converter onto the battery bank to convert direct current into alternating current providing up to 1,800 watts. He uses the power to operate lights, fans, pump, radios, refrigerator and other household appliances.

Performance

Matthews is so pleased with his steam boiler set-up that he plans to install a similar system in a remote log cabin he's building near Tok.

Eventually, he plans to expand the system by using part of the heat from the boiler for a baseboard heating system.

And despite delays in acquiring the boiler and governors for regulating steam pressure, Matthews says the project is worthwhile.

"For any given alternative energy set-up there are delays and shortcomings," Matthews says. "For certain remote situations, such as mine, steam power for energy gives my family lights to read by and running water for drinking and bathing.

"But the steam boiler and engine are practical only where wood is easier to get than diesel or gas," he said, because of the extra work and attendance required with the wood-fired system.

Tip

Matthews says it's important to insulate the boiler, firebox and the domestic hot water tank to increase their efficiency.

Funding

U.S. Department of Energy	3,302
State of Alaska	6,833

Grant Recipient

Guy A. Matthews
P.O. Box 963
Seward, Alaska 99664

From wood to steam to electric lights

Located on the northern tip of Prince of Wales Island, third largest island in America behind Kodiak and Hawaii, Point Baker is about 150 miles from Juneau and a good 45 miles from Ketchikan. The only way in or out is by boat or plane. This means that fuel to power diesel generators is not only in short supply, but also expensive to transport. Warren Powers figured that there must be a better and cheaper way to generate electrical power and heat.

Prince of Wales Island, like most of Southeast Alaska, is blessed with an abundance of wood. Powers knew that this wood could be used to make steam and, after all, steam boilers generated electricity long before diesel generators. He also knew that if a system could economically produce electricity from forest wastes and reduce dependence on nonrenewable, expensive petroleum products, then such a system could benefit not only Point Baker, but small villages in the region, also.

Powers' project involved designing a wood-fired steam-powered electrical generating system. In addition to the power plant, Warren would build a 900-square-foot house, a 600-square-foot greenhouse, and a heat recovery system that would supply heat to both of them. The heat recovery system would ensure that maximum available energy could be extracted from the system.

Design and Construction

Powers planned to adapt a five-horsepower, wood-fired boiler to fit the requirements of rural Alaska living. This included enlarging the fire box to handle larger lengths of wood (to extend burning time), adding a five-horsepower steam engine, developing a governor to control the engine's speed at 1,800 rpm, and constructing a method of extracting residual heat from the spent steam to warm a small, well-insulated house and greenhouse. A six kilowatt 110/220 volt alternating current generator would be connected to the output shaft of the five-horsepower steam engine. The result would be a reliable source of both electrical power and heat.

The power house enclosing the boilers and steam engines was planned as a 12-by-18-foot structure with a gable roof, built on pilings 10 feet above a tidal flat. This building also will house the hot water tank and heat exchanger that provide heated water to the house and greenhouse. A smaller enclosed five-by-eight building housing the supply water tank is also part of the project. This structure is elevated above the level of the boilers and water tanks.

Two boilers and steam engines will ensure constant heat and power during maintenance periods and in case of emergencies. An additional diesel powered generator is planned in case of total failure of the steam power plant.

A 12-by-24-foot temporary greenhouse was originally covered with Visqueen, but future plans are to cover it with more durable fiberglass. Power from the generator plant will be used to both heat the greenhouse and operate grow lights. These lights will effectively extend the growing season to produce food year round.

Heat for the greenhouse will also be used to keep a small, well-insulated house warm during the colder months. Both the greenhouse and this small, 900-square-foot house will have a 12 volt battery-powered back-up pump system. This assures heat when the alternating current generator (AC) is not operating. All piping used to transfer heated water and steam will be insulated to minimize heat loss.

Problems and Conclusions

The remoteness of Point Baker, Powers' unexpected long illness and difficulties in locating commercially produced boilers that satisfied state safety requirements all added long delays to this project.

Powers still feels that using renewable, locally available resources to generate electrical power and heat makes more sense than shipping in expensive petroleum products. "With diesel fuel costing over a buck and a quarter per gallon, I'd like to find an alternative," Powers said in 1981, and he may still.

Another problem that faced this project was the lack of roads and heavy equipment. Everything had to be moved by small wood rafts or boats to the site location. A block and tackle was then used to move the heavy equipment into final position.

By mid-1984, the powerhouse, water storage house, a temporary greenhouse, and most of the small house were nearing completion.

Funding

U.S. Department of Energy	$7,579
State of Alaska	7,579

Grantee

Warren F. Powers
Box 464
Point Baker, Alaska 99927

Driftwood and boiler to heat home

Few cities in Alaska are tied as closely to the timber products industry as Ketchikan. For this southernmost city in Alaska, timber has long been a mainstay of the economy. When the North American and Pacific Rim economies do well, Ketchikan has a relatively stable economy, supported by both timber and fish.

When fuel and transportation costs climb, depressing demand for pulp products, Ketchikan feels the pinch.

Ken Duckett's wood-fired boiler system, when completed, may fit well into the Ketchikan condition, saving the costs of fuel when prices are high, and making use of abundant timber resources, whatever the oil prices may be. And as an engineer and in the construction trade, Duckett and Ketchikan residents like him must be prepared for what the next season may bring in the workforce.

But Duckett's primary motive for turning to alternative energy was to invest his expertise and time in designing a domestic source of electricity that would save him money.

At the time he applied for the grant in 1980, Duckett was getting ready to build a new house on Pennock Island, about one-half mile from the city of Ketchikan. The nearest commercial electricity was some 1,000 feet away; connection to the system would be costly.

System Design and Construction

Duckett's project plan was simple, using proven (but in many places, outmoded) technology. He planned to build a vertical, low-pressure boiler to produce 100 to 150 psi of steam. The boiler would be fired by driftwood found on tidal beaches in the area. Duckett planned to use the steam to drive a 10-horsepower turbine engine, which would run a four kilowatt electrical generator. Power produced would be stored in a battery bank until used in the new house or any outbuildings.

Duckett planned to replace the gasoline generator that he supplied with 60 to 80 gallons of fuel each month.

Duckett knew the reasons why this "old" technology has decreased in popularity for home power generation: the difficulty of producing steam power at a steady pressure; lack of inexpensive fuel to feed the boiler; and the easy availability of inexpensive commercial power in populated areas. The battery storage components of his design, coupled with the abundance of driftwood in his area, made the steam boiler system practical for Duckett's particular situation, where economical commercial power was not really an option.

Designing for direct current power, Duckett planned his system so that it would provide for a 500 kwh monthly consumption for the house. The boiler, itself, would be used to warm a boathouse, giving Duckett a heated work area.

Duckett's design for construction was, he said, simple enough for any handyman to build, with readily available materials. His plans called for a concrete slab foundation for the firebox, which was to be built of standard fireplace or barbeque brick (Duckett ordered 532 of them). The 20- to 40-gallon hot water tank would be supported in the firebox. Driftwood would be loaded into the chamber through an adequate-sized door made of steel, heavy tin, or an old wood furnace door. The flue could be made of a common eight-inch stove pipe, a five-gallon bucket, or any large steel pipe that can accommodate a damper plate. The taller the flue, the better it will draw to increase burning efficiency. Duckett's plans were not dimension-critical and can be used for a hot water tank of any size of choice.

All the controls for the system are to be mounted outside of the water tank; Duckett plans to install a safety relief valve, a pressure gauge, and a gauge to monitor the system. He also plans a safety relief and blow-off valves to the piping connected to the engine; a manual water load valve, a water shutoff valve, and a check valve to the pump.

The steam will run the 10-horsepower, E-7 turbine Duckett bought from Steam Power Products, along with controls, pump and regulator equipment. He also will use Surrette 308 amp-hour batteries and/or RCA batteries and a four kilowatt generator.

Problems

Duckett was awarded his AT grant in 1980, and by 1983 he was still trying to complete both his house and the boiler project.

His troubles began with the winter after he received the grant. Duckett still was waiting for required design approval by the state Boiler and Pressure Vessel Inspector's Office in Anchorage. Without state approval, Duckett could not order the materials he required.

By March, he had begun placing his equipment orders; shortly after, a shipping strike delayed delivery of the materials he needed to proceed. During the process of building his home and boiler system, Duckett also had to move back to Ketchikan for a period, and accepted employment which frequently took him away from home.

By early 1982, Duckett had set the pilings and scaffolding in place for the water tank, and the house had been framed. The area inside the boathouse was cleaned and excavated in preparation for construction of the foundation for the firebox and boiler. Duckett at this time also followed advice to redesign the project for a 12-volt system instead of the 115-volt system he envisioned.

As of mid-1984 Duckett planned to invest an estimated 120 hours to complete his home and boiler system; all materials and equipment were on site and he was anxious to move into his new home.

Funding

U.S. Dept. of Energy	$4,169
State of Alaska	4,169

Grant Recipient

Kenneth Duckett
P.O. Box 3178
Ketchikan, Alaska 99901

A view of the shop building where the steam engine will be located.

Fishing boat to be powered by steam engine

Michael Broili hopes to install a steam engine on a commercial fishing boat.

So far, preliminary studies indicate that a 10-horsepower steam engine can power a 30-foot boat and generate enough electricity for operating radios and hydraulic systems aboard the vessel.

"I wanted to find out if the steam engines would be more efficient and effective than internal combustion engines," said Broili, marketing and art director for the Alaska Fisheries Development Foundation in Anchorage. "The steam engines are pretty reliable and pretty easy to repair."

Major drawbacks are that the steam engine requires a lot of observation while in operation, and it takes awhile to fire up the engine.

The advantages of steam engines for commercial fishing operators, who have been hit hard by rising petroleum costs, is a potential measurable reduction in energy costs.

Usable steam boiler fuels include wood (wood, chips or sawdust); coal (chunks, stoker-quality or liquified); waste and crude oil; gas; peat; paper and cardboard.

Broili, who has worked in almost every aspect of the fishing industry, plans to build a boat for the steam engine.

System Design

Broili planned to use a boiler and an engine specifically designed for marine use. The particular system he selected, which cost about $7,000, has been in use for more than 100 years.

To test his idea, Broili bought a 10 horsepower, twin-cylinder Semple engine which can operate at 400-600 rpms.

He also acquired a steel-plated boiler, which weighs about 650 pounds, is six feet tall and measures 3.5 feet in circumference. The boiler sits atop a two-foot-square firebox.

Steam produced in the boiler is piped into the engine, where it pushes the pistons up and down. One piston is larger than the other because the exhaust steam from the smaller piston is fed to the larger piston to extract as much energy out of the steam as possible. The pistons are connected to a crankshaft (like an automobile engine) which turns the vessel's propeller.

Belts connected to the drive shaft also spin a separate, 12-volt alternator. Electricity generated by the alternator is stored in a 12-volt, deep-cycle, marine battery.

Performance

Broili says he's confident that the steam engine can produce enough power to propel a fishing vessel and generate electricity for on-board radios and hydraulic equipment.

And Broili said he did not experience any malfunctions or equipment failures during test runs of the engine.

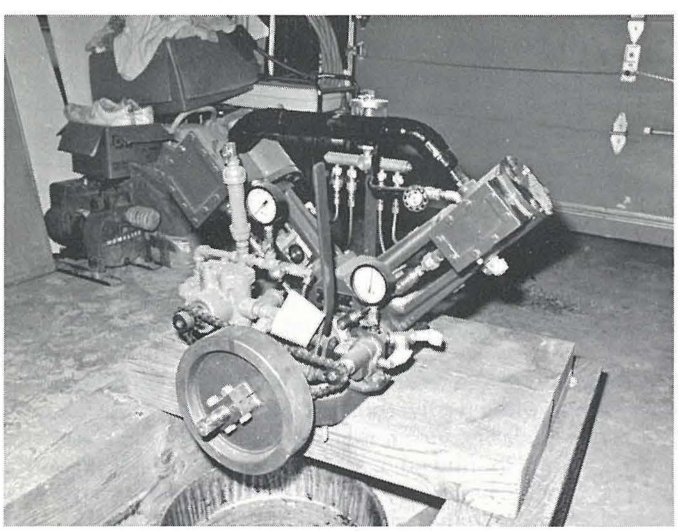
"We think that it could power the boat, and auxiliary equipment and radios," Broili said. "Hopefully, down the line, it's our intention to install it in a boat."

Funding

U.S. Department of Energy	$5,070
State of Alaska	5,070

Grant Recipient

Michael Broili
3011 Lois Drive
Anchorage, Alaska 99503



Mike Broili's steam engine (left) awaits hookup to a boiler.

Outdoor furnace heats home

Wilbur LaPage has slashed his oil consumption in half by building an outdoor furnace to heat his Southcentral Alaskan home.

The novel project is called a Heating and Heat Storage Apparatus (HAHSA) by the manufacturer. It's a concrete block outdoor furnace that burns wood, trash and coal in a large combustion chamber.

Water heated in the furnace is piped back to the house for hot water and baseboard heating.

"The completed furnace works very well," says LaPage, a retired parks and recreation employee for Anchorage who lives on a 14-acre wooded lot in Eagle River.

"Last winter I don't believe I burned more than a cord and a half of wood all winter. But I also burned paper, boxes and other burnable material. And I can hold the furnace heat at approximately 180 degrees for 48 hours."

LaPage, who spent three years building the furnace, says he's been pleased with its performance. He said he purchased the HAHSA system from a Pennsylvania manufacturer after he saw an advertisement about it in a magazine.

The biggest problem he still faces, however, is getting rid of creosote build-up in the furnace's chimney. He has to clean it about every three months.

"If we lick that I think we'll have it made," he said. "When the chimney's clean, it works beautifully. It's an economical system. We've cut our oil consumption by more than 40 percent."

System Design

The outdoor furnace is about 10 feet wide, 12 feet long and 8 feet high. It is housed in a mini-building that resembles a large wellhouse. The chimney stack is about 10 feet high to maintain a good draft in the firebox.

The concrete block furnace has three inner walls, so that it resembles three boxes placed inside of each other.

A firebox with fire brick is the heart of the furnace. It is encased by 21 tons of sand and crushed rock. About 200 feet of plastic pipe are buried in the sand. The sand absorbs the heat, which in turn, heats water circulating through the buried plastic tubes.

The sand is encased by a concrete wall, a layer of styrofoam and an outer shell of concrete block.

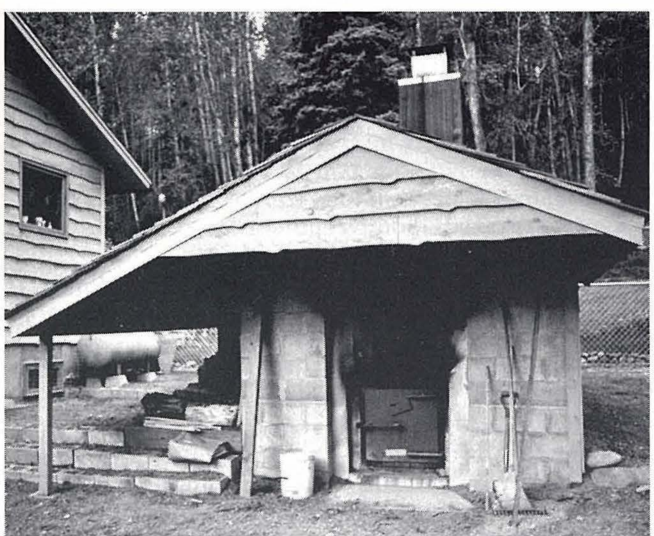
Water circulates constantly between LaPage's home and the outdoor furnace through two separate plastic PVC pipes. One is a ½-inch-diameter domestic hot water pipe, and the other is a ¾-inch-diameter pipe for baseboard heating. Both lines are encased in a wood box insulated with styrofoam and covered with Visqueen.

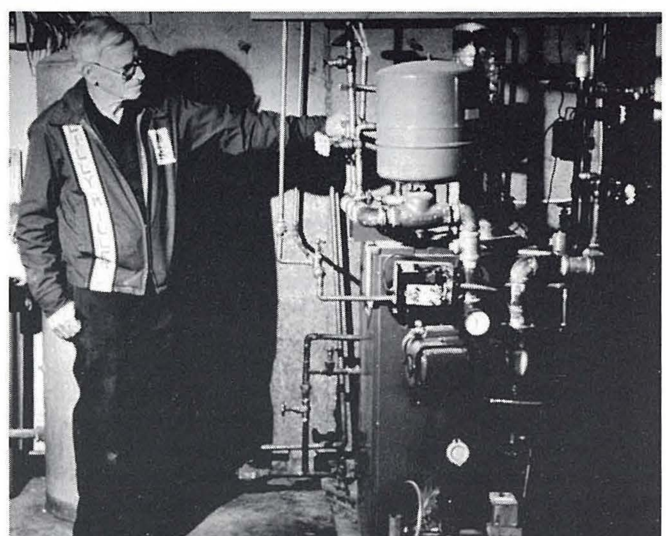
Performance

LaPage says he's been pleased with the HAHSA heating system.

Two drawbacks, however, entail creosote buildup in the chimney, and heating water in the plastic pipes.

"Extreme accumulation of creosote occurs in the chimney and the firebox," LaPage said. "This is one good reason for having the unit separate from the house. The





The HAHSA (above left) is located near to the house it heats. (Above right), Wilbur LaPage explains the tie-in with the boiler.

system is designed to allow for the heavy creosote build-up, but it does have to be burned out or wire-brushed out of the chimney a few times through the winter."

LaPage also says his plastic pipes are not as good as copper pipes. He said the water could heat faster if it were circulated through copper pipes.

"Plastic pipe doesn't pick up heat as quickly as copper pipe," he said. "If I did it over, I would recommend that they pick up the copper and forget the plastic. I think it would be worth the additional cost."

Tips

LaPage suggested several ways to improve his outdoor heating system:

- Use copper pipe in the HAHSA rather than PVC plastic pipe to heat the water faster. [Ed. note: This may not be economically advantageous.]
- Reduce construction costs by doing as much of the labor by yourself.

Funding

U.S. Department of Energy	$2,290
State of Alaska	2,290

Grant Recipient

Wilbur LaPage
P.O. Box 1111
Mile 3.5 Old Eagle River Road
Eagle River, Alaska 99577

LaPage shows off his root cellar

Novel system provides heat and hot water

A so-called heating and storage apparatus is both a furnace and a heat storage system, located outside and away from the home.

In Alaska, where many homes are far from fire protection services, this type of heating system not only reduces chances of burning down your home, it also provides a more efficient heating system than the venerable wood stove. And, because the apparatus is so large, it can supply domestic hot water at the same time it heats your home.

Pat Yourkowski was preparing to build a large, 2,500-square-foot home in Homer and was looking for ways to minimize his reliance on fossil fuels and electricity. His new house would be located on a hillside about 18 miles from town, overlooking Kachemak Bay and the Lower Cook Inlet. This area is known for butter and razor clams, good fishing and exposed coal seams on the bluffs lining the inlet and bay. In fact, at one time in the 1800s, Homer was a coaling station for the Russian and American Naval and merchant fleets serving the northern Pacific. Beach coal has been traditionally used to heat the homes in the area and even today is free for the picking.

Yourkowski figured he could use this local coal and some of the tons of driftwood washed up on the same beaches to fire his furnace and heat his home; a couple of hard-working weekends at the beach could supply enough fuel for the entire year.

Pat's new home would be superinsulated with double exterior walls and insulated interior walls and floors. Yourkowski planned to isolate each room and use a system of controls and valves to regulate heat on an individual room basis. For instance, if an upstairs room was not being used, the heat to that room would be turned down to a minimum. Through interior insulation, heat creep to that room will be minimized, leaving more heat available to the rest of the house without increasing the heat transfer from the system. Pat figured that this design could extend the heat reserve of the system enough to allow weekend winter jaunts without the fear of frozen pipes or house plants.

Design

An apparatus such as this is characterized by its large firebox and massive thermal heat sink—20 tons of sand in Yourkowski's case. Using a controlled burning environment, it should be possible to stoke this device only once or twice a day on the coldest days. Another characteristic of a heating/storage system is its ability to burn multiple fuels simultaneously. Coal, wood, paper, almost anything combustible can be tossed into the firebox. Explosives (petroleum-based products are considered explosive) and items that give off toxic fumes should not be burned for obvious reasons. The heat stored in the massive heat sink of the structure will maintain its temperature for up to three days without additional heat input. Yourkowski planned to design a firebox that would burn multiple fuels without the common drawbacks associated with airtight wood stoves and coal furnaces. These include over consumption or waste, the need for constant attention, and a constant danger of overheating.

In Yourkowski's design the heat output would be conducted to the house through buried, heavily insulated pipes and transferred to individual rooms via standard baseboard heat exchangers (radiators). Using a combination of sound engineering and good insulation, Yourkowski figured he could heat his 2,500-square-foot house (for three to five days) with only one stoking of fuel (wood or coal, or both). This remains to be demonstrated.

In order to take advantage of the earth's natural insulation, about 75% of the system is to be placed below ground level. A 12-foot-deep area was to be dug from the hillside below the house. A concrete slab, eight by ten feet by four inches, was poured for the foundation. On top of this foundation will be a concrete block firebox of three by eight feet. The firebox will be set flush on the front of the foundation and centered laterally. Firebrick will be attached to the inner walls and a piece of one-quarter-inch three-by-eight steel plate will cover the top. The steel will protect both the heat sink and the heat transfer pipes from the hottest part of the firebox and help conduct the heat to all areas of the heat sink.

A large metal stove door will be attached to the front and a chimney in the rear of the unit will complete the firebox.

The thermal heat sink and heat transfer tubing go between the inner and outer walls of the structure. Two types of pipes will be used to transfer the heat; copper where the heat is the greatest and PVC where temperatures are much lower. The use of the two types of tubing was based on economics. In the sides of the heat sink, temperatures would never be greater than 180 degrees, well below the performance characteristics used above the steel plate, where temperatures are hottest.

A cross-grid of PVC pipe will be placed vertically approximately eight inches from the firebox on each side and along the rear of the heat sink. Fine sand will be tamped around the piping for support and heat transfer. The PVC grid will be connected so that water can flow into the pipe, through the entire grid, and then out. The PVC grids will be in turn connected to the copper pipe placed above the firebox.

The copper pipe will be installed horizontally on top of a one-inch layer of sand on the steel plate. Once the plumbing connecting this grid to the PVC grid is in place and pressure-tested, the rest of the 20 tons of sand will be added. The entire structure will then be covered with an insulated roof.

A small pump will be used to circulate the water through the thermal mass to the house system and back.

Air flow to the firebox will be controlled by an old gas tank modified to regulate and preheat outside air before it enters the fire area. Two hoses will be attached to the gas tank. One draws in outside air to be preheated. The other regulates the amount of preheated air allowed to enter the firebox. This regulator/preheater is designed to extract every last calorie of available heat from the fuel.

Problems and Conclusions

Although Yourkowski has started both the house and heating/heat storage apparatus, personal problems have caused a considerable delay in completion.

During the course of construction, Yourkowski decided for economy's sake not to bury the insulated water delivery/return pipes. These pipes will now be supported above ground between the furnace and the house. Because the project is not finished, other modifications may be made in the future.

Since this type of heating and heat storage device has proven itself in other northern applications, it seems probable that once Yourkowski finishes his system he will have an effective, economical heat source for his new house.

Funding

U.S. Department of Energy $3,081

Grant Recipient

Patrick Yourkowski
Box 2136
Homer, Alaska 99603

Winter in Alaska (left) often slows construction. The unique stone arch is constructed of river rock (above).

Windpower supplements local utility

Kivalina is located some 80 miles northwest of Kotzebue on a sandspit that at its highest point is only 10 feet above sea level. The town is bordered on its southeastern side by the mouth of the Wulik River; it is bordered on its western side by the Chukchi Sea, and to the north-northeast, Kivalina is bordered by a shallow lagoon.

Transportation to and from Kivalina is limited to air travel, small, locally-made boats, and snowmachines. During the summer, transportation to and from hunting camps is via many of the rivers located around Kivalina.

Because Kivalina sits north of the Arctic Circle and on the coast just south of the protective shield of the Brooks Range, the temperature seldom falls below minus 40 degrees for very long.

Kivalina's temperatures range in the winter from minus 30 degrees to minus 50 degrees, generally staying around minus 10 to minus 30 degrees. During the summer, the temperature stays around 50 to 65 degrees with a few weeks when the temperatures range from 75 to 90 degrees.

Wind is a daily routine for Kivalina. Usually, wind speeds are around 15 to 30 mph, but once or twice a year, there is a big blow with winds up to 65 and 75 mph.

Under its AT grant, the Northwest Arctic School District used wind power to augment local utility power.

Kivalina's windpower plant is a simple direct intertie system with the utility. The district is utilizing an Enertech four-kilowatt synchronous system that is hooked up directly into a circuit breaker panel.

Construction

The construction and installation phase of this project turned out to be the toughest and the most time-consuming aspect of the whole operation. This was due to a lack of experience with tower construction, a lack of consistent workers, and weather.

The project was initiated in 1979, when the school's science teacher reflected about the local wind conditions and applied for an energy grant in hopes of constructing a system to harness the winds—to convert the wind's energy into electricity that would power a greenhouse where fruit and vegetables would be raised for local consumption.

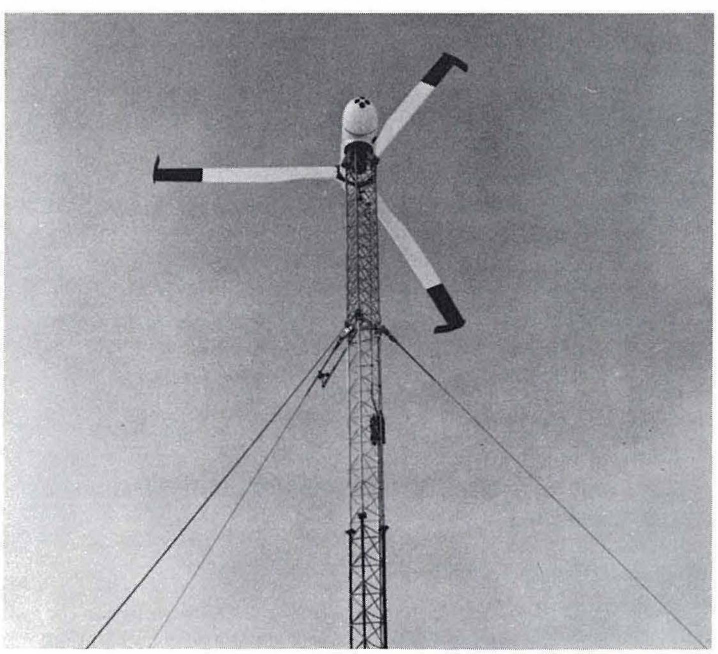
When the new principal and science teacher arrived in 1980, the tower sections, guy wire, tower parts, dead-man beams, plates and accessories for raising the tower and guy wire warning tubes were on-site.

In order to complete the project, the tower base needed to be dug in place, one last dead-man trench needed to be dug; and the tower raised. Further, a generator needed to be ordered to replace the proposed wind system that was made by the Dakota Wind company, which had gone out of business.

Student help accomplished a good part of early stages of the project.

David Aldrich, who guided the project along, described the work in detail:

"First, we started digging an eight-foot-deep hole to accommodate the tower base beam. This beam, an eight-



The height of wind power success in Kivalina.

foot by 12-inch by 12-inch timber, was to be buried except for about one foot, which would stick out above ground level.

"It was necessary to dig prior to the cold months of the year; the ground starts to freeze towards the middle of October," said Aldrich.

"We went out every day and spent 45 minutes digging the sandy ground. It was slow work. The ground was hard. As we dug, the sides of the hole caved in; thus, we ended up with a wide hole that needed shoring up to prevent the hole from being filled up.

"When we got down to the six-foot mark, we struck water. We dug out another two feet of ground while standing in cold muddy water. We finally set the tower base beam into the hole and poured concrete, sand, and gravel around the beam to steady and strengthen our base. But before we could raise the tower, we had to dig one more dead-man hole. Winter had started, as had the cold winds and snows that accompany it. It wasn't until the late winter and early spring that we could get out and dig the last dead-man hole.

"It was late September of 1982 before the complete base and dead-man systems were in place. All that was left to do was raise the tower," Aldrich said.

"We attempted to raise the tower in pieces. I bolted together five of the six tower sections, secured a line to the tower, passed the line to a nearby telephone pole, and secured the line on the other end to the town's bulldozer. To make a long story short, the tower was on its way up when the bottom kicked out causing the tower to fall and bending four of the five sections.

"We repaired three of the sections. One section was beyond repair. It looked as if the tower wasn't going to be raised. But the manufacturer, Enertech, had changed the tower design, requiring a stronger section to be installed. Following the arrival of the last elements of the wind system was much-needed technical help in the form of tools and technical ability; that winter we raised the tower and secured the generator on top using a gin pole.", said Aldrich of the final step.

Because the generator is synchronous, it relies on proper voltage from the utility power. Alaska Village Electric Co-op (AVEC) provides the school electric power, and the voltage from their system was only 180 to 206 volts at the school, which was not adequate to operate the wind system, which requires 220 volts.

After a step-up transformer was installed, the system was fully operational by February 19, 1983.

Performance

The wind generator has been in operation now for a year. It has produced up to 60 and 70 kwh worth of electricity in a day, when the wind has blown 20 mph for a full 24 hours. The system has worked as claimed.

The only modification required on the machine was the addition of a foam-rubber pad along the bottom edge of the generator access door. During operation, the door would vibrate striking the bottom cowling piece and creating a very noisy growl; the foam made the machine a very quiet running machine.

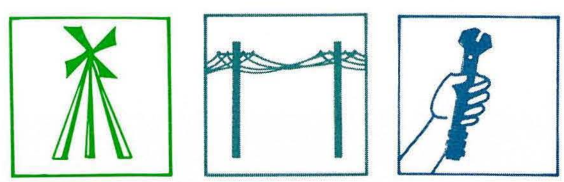
Funding

U.S. Department of Energy $18,377

Grant Recipient

Northwest Arctic School District
McQueen School
Kivalina, Alaska 99750

Wind generator impresses villagers



Building a wind generator in a small Eskimo village on the Bering Sea coast can be a turbulent undertaking.

Just ask the students in Karl Lund's advanced science class in Hooper Bay.

Every step of the way—from acquiring the wind generator to installing it—they encountered one problem after another. But despite the setbacks, they successfully completed the project.

And for a year, the generator produced electricity for the local health center. A videotape of the project also was produced by KYUK and is available in the state film library.

"On September 29, 1982, the school celebrated the 10,000th kilowatt hour of production by consuming a commemorative cake made by the home economics class," said Lund. "The city of Hooper Bay was so impressed with the performance that they purchased a Jacob's (wind generator) for use on their city building."

But then another setback occurred.

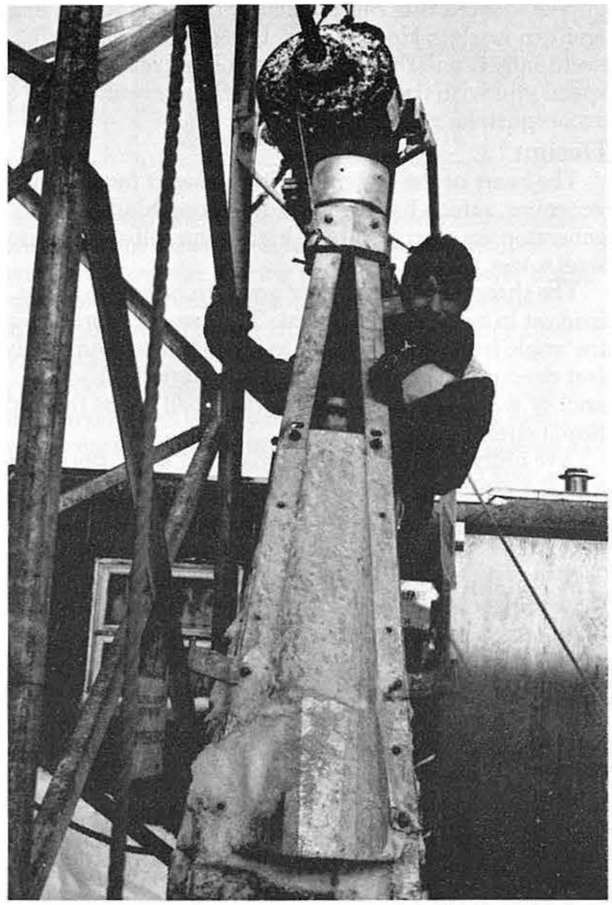
The regional school board, headquartered more than 100 miles from Hooper Bay, voted to shut down the wind generator for fear that children could be harmed if the blades broke. The board, acting after the wind generator's blades had broken twice already, also ruled that the generator be moved off school grounds.

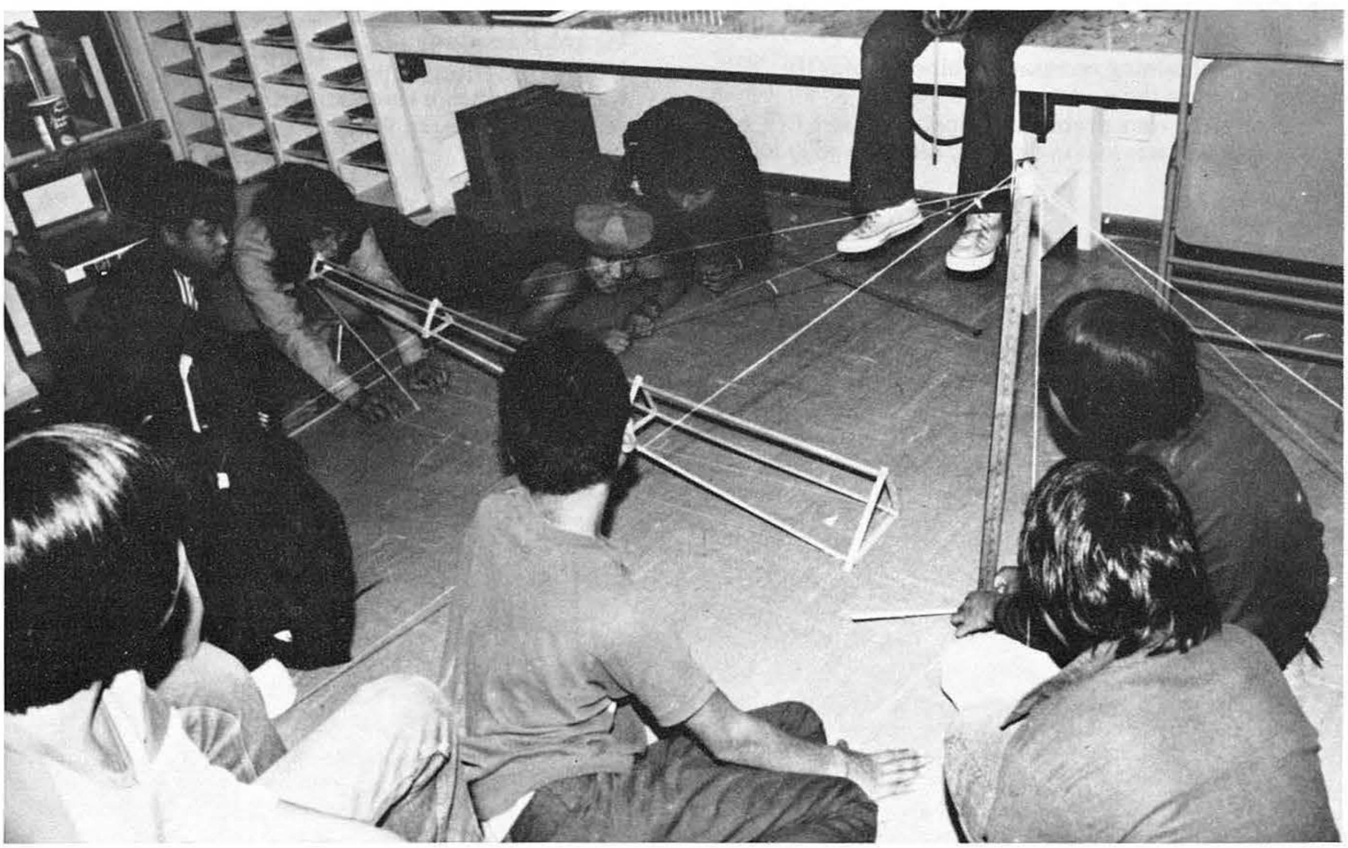
"I'm very sad about it," Lund said. "The regional board is afraid of the liability factor in case a blade came off. I didn't anticipate this. Otherwise, the students wouldn't have gone to the trouble to do the project."

For the past year, the wind generator has not been functioning because the project has not been moved to a new location. The city is seeking funding to build a road to a site where the wind generator can be safely operated.

But despite the setbacks, Lund is optimistic about the project.

(Next page). Cement and parts (top left) are moved to the tower site. (Middle left), a village tower raising. A student (right) prepares the generator for hoisting. Students (bottom) calculate how to raise their tower.





"We showed that this particular brand of wind generator can work in Hooper Bay," Lund said. "And I think eventually it will fly. Things in the Bush never grow at a speed you wish they would. But I think eventually it will accomplish its goal."

Design

The heart of the system is a 10-kilowatt Jacobs wind generator, which has three, 11-foot-long blades. The generator sits atop a 60-foot-high Rohn self-supporting steel tower.

The three legs of the tower are each bolted to angle iron set in two tons of cement. The cement surrounding the angle iron was poured into drum barrels buried six feet deep in the tundra. The bottom barrel of each anchor was expanded into a bottom bell shape for additional strength.

"We didn't penetrate the permafrost," said Lund. "It's on top of a sand dune."

A 26-foot-high gin pole with two block and tackle pulleys was used to hoist the tower upright. A second 14-foot-long gin pole attached to the tower was used to lift the 1,000-pound wind generator up to the top of the tower.

"We had to do it by hand," said Lund, adding that they erected the tower between September and November of 1981. "We didn't do anything by machine. Probably a third of the 200 students at the school helped pull the tower up. And because it was a learning experience, almost everything had to be done twice before it was correct."

The wind generator was intertied with the local electric company, the Alaska Village Electric Cooperative, so that none of the electricity was stored in batteries.

The power was used for a local public health community clinic; surplus power was fed to the utility free.

Problems

Delay in obtaining necessary equipment was the biggest obstacle the students had to overcome.

In fact, there were problems almost every step of the way. The tower was lost in delivery, cement and gravel weren't available locally, and other necessities were shipped to the wrong village.

"Finally, everything looked good," Lund said of the progress at the time. "But wait! United Transportation's barge broke down unable to ship material to Hooper Bay. Part of our tower and cement arrived in Hooper Bay via Nome instead of Bethel. The other part of our tower was mistakenly shipped to the neighboring village of Chevak and arrived in Hooper Bay via barge three days later."

Performance

The generator has performed well since its installation, providing power for the community's health clinic. The average windspeed has been 15 mph, but it has ranged as high as 70 mph.

But six months after installation—and after producing 12,750 kwh—the governor in the wind generator broke, causing the three blades to splinter. Apparently, the tail hydraulic governing mechanism froze in the cold weather. The blades were prevented from turning out of the high winds to reduce the pressure on the blade.

The distributor, Four Winds, replaced the governor and installed shorter, 11-foot-long Sitka spruce blades free of charge since the equipment was still under warranty.

Unfortunately, the generator froze again.

"There was another freeze-up," Lund said. "We decided to let the wind break it loose. We had a 50 to 60 mph wind and it broke it loose, but one of the blades hit the tower.

"We're on our third set of blades now," said Lund, adding that the system "worked fine" and will do so again when it's moved.

Funding

U.S. Department of Energy	$12,385
State of Alaska	12,785

Grant Recipient

Hooper Bay High School
Karl Lund, science teacher
Hooper Bay, Alaska 99604

Salmon hatchery aided by windpower

Since May 18, 1982, the aquaculture class at Sand Point High School doesn't have to worry about buying electricity for their salmon hatchery—thanks to a new wind generator they installed.

Power from the wind generator is used to heat and light the school aquaculture facility and to operate a refrigerator, freezer and water heating unit in this small community in Southwest Alaska. The community's 700 residents live on Shumagin Island, near the Aleutian Chain.

"We feel that the windmill has saved the school district a substantial amount of money in fuel savings," said school superintendent Liz Boario, adding that they used to rely on an oil furnace.

"In addition, the windmill has allowed us to heat water for aquacultural purposes on a scale that would have been prohibitively expensive under other circumstances," she says. "After the windmill was fully operational, our utility bills showed a tremendous drop."

Design

The students installed a 10-kilowatt Jacobs wind generator on a small rise above the hatchery. The generator is powered by three wooden blades, 23-feet in diameter, and sits atop a 60-foot self-supporting tower. An anemometer and FAA warning lights are mounted on the tower and the tower's three supporting legs are attached to concrete anchors.

Power from the wind generator is tied to both the hatchery and the public utility system through a control box. This box monitors the hatchery's usage and compares it with the output from the generator. Excess power from the generator is fed to the public utility power grid; however, during periods when power output from the wind generator is too low, the control box supplies additional power from the public utility system.

Performance

The wind generator has performed well, providing more than enough energy to meet the hatchery's needs. The average windspeed during its operation has been 11 mph, with electrical consumption around 200 kwh each month.

It was interesting to note that make-up power usually was required if wind speeds dropped below 11 miles per hour, while speeds above 11 miles per hour resulted in excess power.

There has only been one minor problem with the system. About six months after it became operational, a defect caused one of the propeller blades to crack. Jacobs responded with an entirely new blade assembly designed specifically for the Alaskan environment and there were no further problems.

They also installed an improved spring-loaded tail unit which turns the blade assembly out of the wind, which protects it from wind damage.

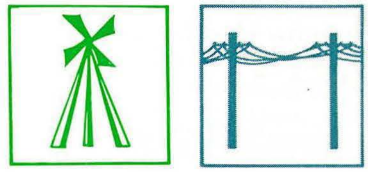
Funding

U.S. Department of Energy	$ 4,734
State of Alaska	15,261

Grant Recipient

Sand Point School
Liz Boario
P.O. Box 132
Sand Point, Alaska 99661

School district harnesses wind



A wind generator is helping the Annette Island School District in Southeast Alaska reduce its monthly electric bills.

Each month, the generator produces about 1,250 kilowatt hours of energy, which is a $50 savings at 4 cents per kwh, says school superintendent Walt Bromenschenkel.

"It's operating well," says Bromenschenkel. "It runs whenever there's wind. The electricity is being fed into the city system.

"Then, on a monthly basis, the number of kilowatt hours generated is calculated and the district is compensated for that by the city."

The generator was installed for the school district and the Metlakatla Indian Community on Annette Island, about 16 miles south of Ketchikan. The community, founded as an Indian reservation in 1887, has a population of 1,150 residents. It remains the only reservation form of government in Alaska, after its residents opted out of the landmark Alaska Native Claims Settlement Act of 1971.

Originally, the community had planned to use the wind generator for lighting and heating one of two greenhouses funded under this grant, and as an emergency energy supply. Some of the power was to be tapped to operate a satellite dish.

Those plans were abandoned during the three years it took to get a wind system chosen and installed. As for the greenhouses, a 100 mph wind storm destroyed one of the greenhouses, and crippled the second one.

System Design

A 10-kwh, Jacobs-brand wind generator with 12-foot-long, laminated spruce blades was mounted at the top of an 80-foot self-supporting Rohn tower. The system was installed by Bill Breese, who represents Four Winds of Alaska in Ketchikan.

The power system is intertied with the community's electric utility.

One greenhouse was installed on a cement pad by the high school and a second greenhouse was installed on a concrete pad near the school superintendent's residence.

The identical greenhouses, both 14 feet by 40 feet, were purchased as kits. They used a metal frame with double-paned plastic glazing on all sides down to the ground.

Performance

The wind generator went into operation in July 1983 and has performed well. As of 1984, the greenhouses remained inoperative.

"The only trouble we've had with the wind generator is with releasing the brakes," says Breese. "They get a little corroded at times from our moisture and salt wind. I use mercury anti-corrosion grease, and it works well," he said.

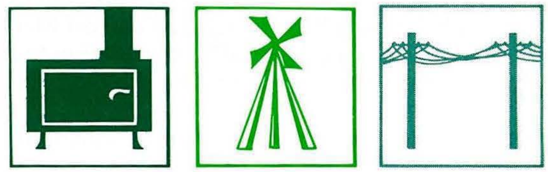
Funding

U.S. Department of Energy	$16,783
State of Alaska	16,783

Grant Recipient

Metlakatla Indian Community
P.O. Box 458
Metlakatla, Alaska 99926

Guard takes conservation to the Bush



In 1981, the Alaska National Guard launched a major program to build wind generators and install wood stoves at its bases in rural communities of Alaska.

The program was part of a statewide commitment to finding economical solutions to the unique problems of operating a remote and dispersed military readiness program.

Today, the program has been largely abandoned by the agency. Two state-funded wind generators have been dismantled, and the wood stoves are being replaced with the original oil-burning stoves.

The reason was the difficulty in ensuring ongoing maintenance and operation of the systems in the Bush. The problem is not an uncommon one in Alaska's rural areas, where a majority of more than 200 villages live a subsistence lifestyle. With unemployment in the Bush averaging as high as 70%, residents in these remote areas place a high priority on subsistence hunting, fishing and gathering that has been passed down over many generations. To ensure an adequate food supply, residents must be prepared when the resources become available.

And although many energy-conservation techniques are straightforward and simple in their technology, it is only in recent years that Bush residents have benefitted from the increased economies of bringing technology to a remote area that supports relatively few people.

"There is nothing wrong with the concept and there is nothing wrong with the equipment," said Maj. Roger R. Patch, director of facilities management division for the State Department of Military Affairs. But when something stopped working, residents would seldom call Anchorage to let the Guard know. In the Guard's experience, "there is a lack of utility conservation in the outlying areas. And there's nothing we can do here in Anchorage that has been able to overcome that."

System Design

A significant part of the conservation program were two wind generators funded by a grant. The Guard hoped the generators would reduce the reliance on expensive, diesel-generated electricity and show that wind power was feasible.

The Guard first planned to construct a five-kilowatt wind generator at Savoonga armory on St. Lawrence Island, but the site was changed to Togiak, a more accessible site. A smaller 1.5 kilowatt Aeropower generator was mounted on a 60-foot tower which was connected to a control panel and battery bank.

Patch said he couldn't find anyone to tend the wind generator regularly at Togiak. The machine broke down when it got out of balance, and the batteries were destroyed when they froze.

The Guard also discovered that the batteries could only supply power for a day or two, not a week or more during periods of no wind as promised by Aeropower, which has since gone bankrupt.

"The failures could have been corrected before we had structural damage, but no one thought to call us," Patch said.

The failure prompted the guard to dismantle the wind generator. A 1.5 kilowatt Enertech wind generator in Bethel was also funded by a grant.

The agency hoped that a readily accessible site with full-time personnel would allow the successful operation of such wind power installations. Batteries also would not be needed because the system was tied directly into the Bethel Electric Utility.

Bethel, with a modern, regional airport and full-time maintenance personnel at the armory, appeared to meet those needs. The Guard also hoped that Bethel would provide more visibility for the experiment, since the community is the administrative, commercial and transportation center for Western Alaska.

Again, no one tended the wind generator. So the Guard dismantled it.

Performance

Despite the lack of local support, Patch says initial findings indicated that wind power is very feasible for many of the state's rural communities.

"The wind generator will work in the Bush and it's economical," Patch said. "I'd go out there every six months or so, and find nothing in operation. I'd fix it, and go back six months later and find the exact same thing."

Problems encountered included governors which malfunctioned, failure of personnel to rotate the generator out of stormy high-speed winds, and batteries which froze because storage buildings weren't heated.

"The problems they had were nothing that could not have been overcome by routine observations of the user," Patch said.

Miscellaneous

Local maintenance support problems also compelled the Guard to abandon several other experiments around the state, although these were not part of the alternative energy program.

The Guard, for example, replaced oil space heaters with wood stoves at Federal Scout armories operated by the Guard at Arctic Village, Delta Junction, Hoonah, Nulato, Shaktoolik, Saint Michael, Kaltag, Huslia, Elim, Ambler, Kiana, Noatak, Noorvik, Selawik and Shungnak.

To help stimulate the local economy, the Guard offered to buy wood from local residents, paying up to $200 a cord. The Guard said it was less expensive to burn wood, rather than the average 3,000 gallons of oil consumed annually at each facility. And the Guard found that at some treeless coastal locations, driftwood accumulations are adequate to meet heating needs.

But local residents generally did not want to spend the time collecting wood to sell the Guard.

Consequently, oil stove heat is replacing the woodstoves.

Clivus type composting toilet systems also have been installed at Selawik and Camp Carroll on Fort Richardson. And the Guard has been adding insulation to all of its older facilities, and retrofitting its armories with double-paned windows.

Furthermore, the Guard has made a complete change from incandescent lighting to fluorescent lighting, and high sodium fixtures have replaced fluorescent lighting at major armory drill halls. The new lighting is more energy-efficient.

Funding

U.S. Department of Energy	$15,070
State of Alaska	15,070

Grant Recipient

Alaska Department of Military Affairs
Facilities Management Division
P.O. Box 5-549
Fort Richardson, Alaska 99505

Danes' experience adds to local know-how

"We're proving that alternative energy is not inaccessible to small towns," said Steve Smiley at the christening of Homer's first commercial wind generator. Smiley, a group of Danish visitors, and numerous Homer residents had just finished building and installing a 10-kilowatt wind generator on the Homer Spit.

The project began when Smiley, the grantee, met Preben Maegaard, Chairman of the Danish Organization for Renewable Energy, at Alaska's first Alternative Energy Conference. After seeing Homer at Smiley's request, Preben convinced Steve that it was possible to build a small scale commercial wind generator in Homer using local talent and materials.

Smiley applied for and was awarded grant funds to apply Danish know-how in Alaska. Denmark is one of the most experienced nations in the use of moderate-size (10 to 20 Kw) wind generators that are tied into local commercial power grids.

Six Danish craftsmen were brought to Homer as part of this project to help design, build and install a 10-kilowatt wind generator. The craftsmen also taught and demonstrated the Danish method for utilizing this renewable energy source.

Although the visible result of the project would be the operating wind generator, the overall purpose of the project was to exchange information between the local Homer residents and the Danes, to help demystify the building process, and to prove that a wind generator could be built with locally available materials and skills.

Design and Construction

An 11-kilowatt, 230-volt three-phase alternating current induction motor driven by a three-bladed propeller, both built at the Cook Inlet Metal Works in Homer, were used as the main components of the wind generator. This unit was placed on a 40-foot-tall steel tower (recycled from a crane boom) on a concrete foundation. Homer Spit was chosen as the project location because it is highly visible.

The project was open for public review and education programs, and also video-taped for future reference. A number of local craftsmen, under the direction of Smiley, also participated in the project.

Although the project initially proposed travel for four Danes, six actually participated: Preben Maegaard, team organizer; Bendy Poulsen, blacksmith-engineer; Hans Pedersen, electronics engineer; Birger Kuhn, woodworker; John Carlsson, mechanic; and Jacob Bugge, design engineer.

Homer residents provided lodging during their three week stay, and the group fit well in this small fishing and tourist town.

A few special items had to be ordered in advance from elsewhere: a Swedish gear box, a German bearing ring, a generator-motor, and wood for the propeller blades. However, the mahogany plywood that was shipped by air from Seattle was of inferior quality, and laminated solid mahogany was substituted for the blades.

The three tapered blades, which the Danish team

The preparations (left) for raising the wind generator near completion (above). A view of Steve Smiley's former house and wind generator.

made in 10 days, feature stainless steel yawl-like feathering mechanisms that automatically slow rotation in excessively high winds.

Most of the metal components used in the project were either purchased locally or in Anchorage, or fabricated in Homer machine shops. For example, the propeller shaft braking mechanism was fabricated from a 1965 Chevrolet brake cylinder found in a Homer junk yard and from a Datsun disk brake caliper donated by a local resident.

Modifications and Performance

For a short time in 1980, the windmill produced power, purchased by the Homer Electric Association (HEA) at 1½ cents per kwh. The power at that time entered the HEA grid through existing electrical lines connected to an alternating current, three-phase induction electrical generator.

Because the lease on the property on the Spit expired, the system was dismantled and put in storage until 1981. In 1982, the State of Alaska provided additional money to have the generator system moved to property Smiley owned at Mile 12 East End Road near Homer. Smiley sold his house on the adjacent lot in 1984, and by late summer that year the idled system lay partially dismantled on the site.

A single-phase Reliance 15-horsepower motor from Debenham Electric had replaced the original 230-volt three-phase unit. And although it was uncertain how this would effect actual electrical output, the new configuration did not seem to present a hook-up problem with HEA.

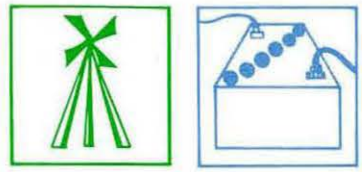
Funding

U.S. Department of Energy	$ 5,000
State of Alaska	25,750

Grant Recipient

Steven Smiley
SRA Box 41-C
Homer, Alaska 99603

Generator hits rough weather at sea



Jon Seager, hoping to reduce his dependence on diesel fuel, designed a wind generator for his commercial fishing boat.

And it worked well when the wind in the Bering Sea did not exceed 30 miles per hour.

Unfortunately, gusts of 40 and 80 mph are fairly common off the coasts near Platinum, a Native community located at the mouth of Goodnews Bay and named for a platinum mine located nearby. Some 53 people live in this windswept community in the southwest corner of Alaska, about 130 miles south of Bethel. The average wind speed is about 16 mph.

"It's a heck of a good idea," said Seager, a commercial fisherman and maintenance worker for the Platinum School. "But when we'd get 40 to 80 knots of wind on the water I couldn't stop the rpms from building up. And it'd burn out a bearing."

Moreover, the wind generator produced noisy vibrations throughout the boat, which may have scared some fish off, Seager said.

"There was just no way of shutting the system down," said Seager, who also has installed a Bergey 1 kw wind generator for his home. "It worked, but it didn't work well enough. So I took it down and put it away in the shed."

Design and Construction

The design for Seager's wind generator was based on the common anemometer. Four, 18-inch diameter fiberglass cups, each three-sixteenths of an inch thick, were used to catch the wind.

Seager bolted the unit atop a wood, two-by-two pole behind the cabin on his 32-foot-long commercial fishing boat. The generator was seven feet above the water line.

The vertical shaft was driven by the cups. The shaft turned a 12-volt DC alternator (salvaged from a Cadillac) with a pulley and V-belt. Electricity from the alternator was stored in a deep-cycle, 12-volt marine battery. The power was used for lights, radios and other equipment.

Performance

The system worked well at low wind speeds. But it tended to spin out of control in high gusts. Also, the generator produced too much vibration, which was not good for gill net fishing. Seager tried using a tension bar as a brake during high winds, but this did not work.

Seager recommends using the normal horizontal wind generator with wooden blades.

Unfortunately, he says a wind generator with cups does not function properly in areas prone to periods of forceful wind.

"I would say it worked quite well around 30 mph," Seager said. "But there was just no way of shutting it down at higher speeds. The idea is super, but not on a small fishing boat."

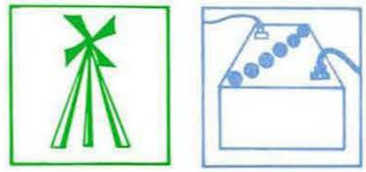
Funding

U.S. Department of Energy	$200
State of Alaska	200

Grant Recipient

Jon W. Seager
General Delivery
Platinum, Alaska 99651

Wind power practical in remote location



"Whew, it's up and working."

Richard Logghe is attempting to harness some of the power in those strong gusty Southeastern Alaskan winds to generate all the electricity he needs at his remote homestead.

"The wind generator is an integral part of our total plan, which includes buildings built from salvaged beach logs, an ice house for refrigeration, wood heat, an attached solar greenhouse and a composting toilet," says Logghe.

Logghe, a carpenter and an electrician, lives with his family in isolated Kasaan Bay, on Prince of Wales Island. He says it's a lot cheaper to produce power with wind than rely on expensive diesel and kerosene.

"A wind energy conversion system is the best way to meet our lighting and power needs without consuming fossil fuels and having a destructive impact on the environment," he said. "A wind system also is easier to maintain and will last longer than a gas or diesel system. Wind power is practical, ecologically sound and relatively inexpensive."

System Design

Logghe planned to put a 24-volt direct current, Aeropower-brand wind generator atop an 80-foot-high galvanized steel tower. The output of the wind generator will be fed to four, six-volt 500 amp/hour storage batteries. The wind generator is actually a self exciting alternator, much like those used in automobiles, but with all the internal components waterproofed to ensure trouble-free operation for long periods of time. The three-phase output from the alternator is rectified for smooth input to the batteries.

The average monthly wind speeds, which range between 9.3 and 4.7 miles per hour, are sufficient to generate electricity. Logghe says he expects to generate between 250 and 400 kilowatt hours of electrical power monthly. The power will be stored in the storage batteries and used for both the house and workshop. A Honda-brand ED-1000 charging unit and a Sentry 2.5 kilowatt, 120 volt alternating current generator will supplement and back-up the wind generator.

Construction and Problems

"We easily put the first 20 feet of the tower up," Logghe said. "But we decided that it would be unsafe and very difficult to build the remaining 60 feet in place. We'll have a helicopter pick it up and lift it into place," he noted in one of his progress reports.

As of mid-1984, Logghe had experienced several delays. These range from a fire that destroyed his cabin—which he spent a year rebuilding—to back problems and unexpected difficulties in obtaining the right batteries and bolts.

As if Logghe didn't have enough problems, when he started asking questions about his new wind generator, he was told that Aeropower was no longer in business. Other owners of the same system also informed him that the engineering seemed poor, especially with the governor-blade system; the epoxy coating on the blades was also said to be less than adequate. The blades, they said, will need recoating and therefore rebalancing.

However, his biggest problem was trying to get a helicopter to lift the remaining 60 feet of tower. When Logghe called Temsco for a helicopter, he found that the one he planned to use was out on contract and wouldn't be back for four months; the only other one available would cost twice as much to rent.

"We gulped and choked a little," said Joni Zimmerman, who also was close to the project. "Then Rich (Logghe) talked to Ken Eichner, owner of Temsco, and he said they'd try to work something out when they already had a helicopter in our area," she said. This would cut the cost considerably.

Knowing that a helicopter would be coming at some time in the future, but not knowing when can be disconcerting for some people. For Logghe, it meant that the tower would have to be built on a level spot on the beach above the tide line. In Southeast Alaska, this is quite a chore in itself.

Friends from Ketchikan and Hollis, a little community across the bay, were supposed to help put the tower together, but neither could make it, so Logghe, Zimmerman, and the rest of the family went to work on their own.

"It was kind of interesting to see the tower on the beach," says Zimmerman, and "our little kids tightening the bolts."

The tower went together with only a few small problems. Some of the leg braces required a little jogging before they fit into place, but within a short time the tower was ready for the helicopter.

Eichner told Logghe when he left that he would contact him just before the helicopter arrived. Unfortunately, the noisy, gas-powered washing machine was running when the radio call was attempted.

"I was out hanging up laundry and I had even hung some over the tower legs," said Zimmerman, "when I saw a helicopter go overhead. A little while later we were launching our skiff to go to Kasaan Village to pick up our mail, when we saw another smaller helicopter coming. It swooped and landed." It was Eichner and his son Dan, telling them that the big one was on its way.

The Eichners prepared the tower, while Logghe and Zimmerman panicked. They could see their friends from Hollis, sailing over to help, but still about four miles away.

"All of a sudden the big helicopter was here." Zimmerman ran to move the kids away from the house windows for safety and to grab the camera. By the time she found it and snapped a few pictures, it was over. The tower was up and the helicopter on its way home. As it left, their friends from Hollis arrived.

A surveyor friend helped plumb the tower over the July 4th holiday and also helped mount the generator. It took two long days, using a gin pole with a rope to keep the generator from banging the tower and a winch. Luckily, everything went smoothly, and by the end of the week, the generator was installed and wired to the control panel. The following day a 20 mph wind gave them more power than they'd ever hoped for.

Performance

"We are really pleased with the performance of the system so far," says Logghe, "although it has only been running for a week and a half." The 20 mph winds produced a consistent 20-to-40-amp charging current.

Although they can't run heavy shop tools and appliances at the same time, the system is able to operate a small automatic washer and dryer (both run on 110 volts alternating current), and Logghe has already made several pieces of furniture.

"We are thinking of getting a small electric hot water heater and a fan for the wood shop," says Logghe. "There was some doubt on the part of a lot of people when we were planning this project, but the performance of this wind generator system has exceeded our hopes and expectations. Our only problem so far is radio interference. We assume that we can figure out something to correct this."

Tips

Logghe offers this suggestion to both potential wind generator owners and wind engineers:

"It would be nice to have some frame of reference in determining what 'excessive vibration' is. Ours doesn't seem to be vibrating much, but who knows."

Conclusion

"The delays were very frustrating, but seem to partly be a result of trying to do a project of this scope in a remote location," says Logghe. "Anytime we want one more tool or piece of hardware—we can't just run to the store. We must wait for our monthly trip to town, which usually takes a minimum of three days.

"Living in such a remote location amidst modern society is a true lesson in patience and perseverance," he said.

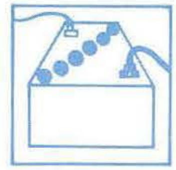
Funding

U.S. Department of Energy	$8,930
State of Alaska	995

Grant Recipient

Richard J. Logghe
General Delivery
Kasaan, Alaska 99950

Floating wind generator a partial success



Like most commercial fishing vessels, The Lady Simpson produces her own electrical power. About the only time her generators are shut down is when she's tied up in port, when power is supplied from the dock. Ken Simpson, the owner/captain of The Lady Simpson, figured that there might be a better and cheaper way to supply some of that electrical power. Frank Simpson, Ken's brother and a wind power specialist, offered to help design a system that would use wind power to offset some of the vessel's electrical needs.

Frank Simpson's project involved selecting a suitable wind charger, constructing and installing a control box and power transfer switch, and building the deep-cycle battery bank.

Design and Construction

The design called for placing a small, 24-watt, 14 volt direct current wind generator on top of the wheelhouse. The output of the wind generator would be connected to a control box and transfer switch in the wheelhouse and the output of the transfer switch would either go to the deep-cycle emergency battery bank or the vessel's main battery bank. A control box would monitor the condition of the emergency batteries. Electrical power would either be applied to the emergency batteries, or, if the emergency batteries are fully charged, to the main battery bank.

Unfortunately, The Lady Simpson sank in the Bering Sea in November 1981. Ken Simpson soon had a second Lady Simpson on the way and Frank's wind generator system was an integral part of its design.

The wind generator, a Model 24-14 Sencenbaugh, is mounted over the wheelhouse atop a short piece of galvanized pipe. The rigidly mounted system is placed near the left edge of the bridge (roof) to ensure that it did not interfere with the radar and other communication systems.

Frank used galvanized pipe to reduce salt water corrosion effects. The wind generator was not given any additional protection because of its aluminum housing. The short, strong propeller blades are also of aluminum.

The power output cables from the wind generator are run through the back of the wheelhouse to a control box mounted on the rear wall. The power transfer switch and battery charge monitoring devices are mounted inside the control box.

The battery pack, because of its weight (more than 150 pounds) is mounted on the wheelhouse cabinet. These batteries are able to supply 350 amp hours of power at 12 volts direct current and consist of two, six-volt, deep-cycle marine batteries connected in series.

Performance

The "floating wind generator" has proven partially successful. It does provide more than enough power to keep the emergency batteries fully charged and has on occasion been able to charge the main battery system. The emergency batteries are also away from any danger of fire or explosion in the engine room. However, because this is a new boat, some of the original design specifications have had to be modified. The new Lady Simpson is a tender/crab boat and as such requires much more power than the little wind generator is able to produce. Even when the vessel is in port, a small diesel generator or shore-based power is needed.

Ken found that the power available from the deep-cycle batteries was much greater than his main battery bank. This prompted him to improve his main battery bank and also connect the ship's radar and other important systems to the emergency batteries.

Since no provisions were made to monitor fuel flow, it is virtually impossible to accurately determine fuel savings, if any. However, because the wind generator is used occasionally to supply power to both the emergency and main battery banks, it can be assumed that some fuel savings does occur, however marginal. Frank stressed that the main purpose of the system was to provide a safe, reliable power source for emergency communications at sea and that fuel savings is not an important part of this project.

Conclusions and Problems

Overall, the construction and installation of the system does provide a safe, reliable power source for emergency communications; however, it did not produce the interest the developers hoped for. Frank offered a few ideas on this subject. He felt that if a method of monitoring fuel savings was incorporated into the original project, more interest would have been generated. Fishing in Alaska is a high cost adventure and devices that show no return on investment, even if they mean improved emergency communications, are largely ignored.

The size of the wind generator may also have something to do with the lack of interest. If the wind generator's output were increased to supply more power, reducing the need for shore-based or ship generated (diesel) power, the system's impact on the fishing industry might again be different. Unfortunately, since this model wind generator is no longer manufactured, it is hard to say if a larger unit would improve interest.

Another problem that surfaced after The Lady Simpson put to sea is that the wind generator tends to get noisy during high wind conditions. Ken Simpson is planning on either modifying the original mount with rubber noise insulators, or moving the wind generator to the front of the boat.

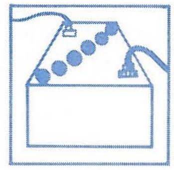
Funding

U.S. Department of Energy	$498
State of Alaska	498

Grantee

Frank Simpson
2005 East Third Ave. No. A
Anchorage, Alaska 99501

Wind powered telephone system

On the shores of a bay by the same name, Cold Bay is 226 miles southwest of Anchorage. It is the gateway to Izembek National Wildlife Refuge and the world's largest eel grass beds, where up to 50,000 lack brant geese (the entire North American population) feed during their annual migrations. Bracketed by volcanoes and on the tip of the Alaska Peninsula, there's not much out here except grass, brown bears, the brants, the sea and the wind.

"There's alot of wind out here. It's usually blowing at 20 to 25 miles per hour about 80 percent of the time," says Frank Simpson, chief engineer for the Interior Telephone Company. And Frank would know, because Cold Bay is also the location of an Interior Telephone Company communication facility.

This facility, in addition to serving the community locally, is one of the few links Cold Bay has with the rest of the world. The others are periodic plane flights from Anchorage and periodic visits by the MV Tustumena, an Alaska Marine Highway ferry.

A remote location, staging area for tourists visiting the national refuge and the larger 3.5 million-acre Alaska Peninsula Wildlife Refuge, Cold Bay is an ideal location for a totally self-sufficient, wind-powered telephone project, thought Frank Simpson, longtime proponent of this renewable resource.

Design

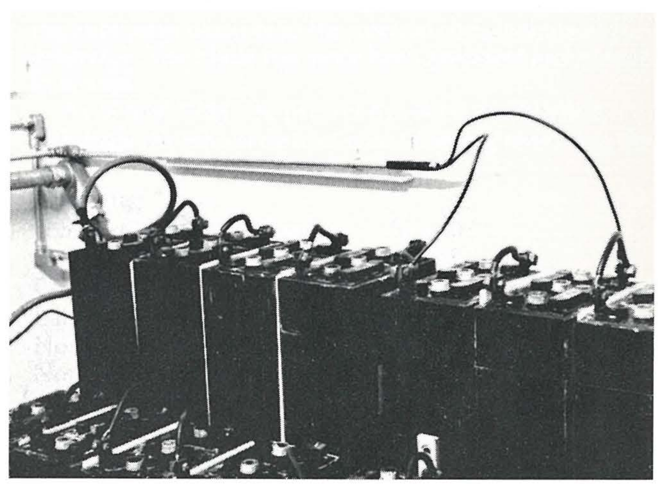
Simpson originally chose a five-kilowatt, Australian-made Dunlite windcharger; however, unexpected price increases brought about by the strengthening dollar, forced him to accept a two-kilowatt model, instead. This caused a couple month's delay in the project right from the start.

The smaller generator is mounted atop a 60-foot, three-legged, galvanized steel tower. Diagonally criss-crossed steel braces reinforce the tower's legs to withstand sudden wind gusts of up to 120 knots.

A three bladed, 11-foot diameter self-governoring propeller assembly drives the generator. Stainless-steel blades are used to prevent marine and environmental corrosion, and because they are extremely strong.

The blades are mounted to an aluminum hub assembly that has a special "shock-absorber" unit to smooth oscillations and a sliding governor. As wind increases, the governor slides on a shaft and "feathers" the blades, slowing down the generator. This action reduces strain on both the generator and the tower.

The wind generator is a brushless, three-phase alternator with a built-in rectifier assembly. The rectifiers change the alternating current produced by the alternator to a direct current usable by the control panel and battery-bank.



Battery storage (above) is located in the Cold Bay telephone facility (left). The Dunlite wind generator is situated next to the telephone building.

The output from the windcharger is fed down the tower and into the telephone central office where it is connected to a control panel. The control panel sends the power to either the 120-volt direct current load, the 350 amp/hour battery bank, or to a six-kilowatt, 120-volt alternating current inverter. The inverter changes the direct current output from the battery bank or windcharger to 120 volt alternating current used by the telephone equipment. The battery bank has priority over the power from the generator, however, and consumes the entire output from the windcharger if battery power falls below 96 volts.

Performance

Although this project was beset by problems in the very beginning, Simpson believes that the wind generator has worked beyond expectations. All the equipment worked with the exception of the six-kilowatt inverter. A design error caused the device to fail and required a new one to be shipped from the Australian manufacturer which took almost five months.

Frank Simpson added a low-voltage monitoring switch to the original design to ensure that the inverter is shut off when the battery-bank voltage is low. This protects both the inverter and the telephone equipment and is a sound engineering practice.

The first four days of system operation were highly successful; the windcharger generated at least 23 kilowatts of power over a four-day period and charged the battery bank up to 110 volts. The voltage monitoring switch is adjusted to shut down the inverter if the battery bank voltage drops below 96 volts and to turn the system back on when the battery charge reaches 120 volts.

Tips

Simpson says it's important to calculate—in advance—the wind speeds and power requirements. Also, shorter (11-foot) blades are preferable in areas of high winds, while longer, 12-foot blades do well in areas which do not consistently have strong winds. The shorter blades are less prone to stress damage in high-wind situations.

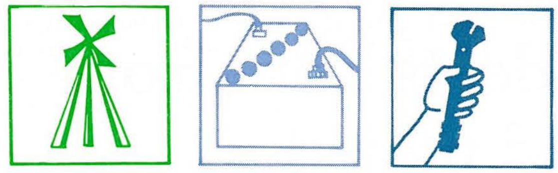
Funding

U.S. Department of Energy	$11,750
State of Alaska	11,750

Grant Recipient

Interior Telephone Company
Main Office
508 W. Sixth Avenue
Anchorage, Alaska 99501

Teacher, students build a wind generator



Two hundred miles southwest of Anchorage, on the south shore of Lake Clark is Nondalton, a small village of about 400 residents. Lake Clark is in the center of an area noted for trophy fish and game, as well as incredible scenery. Only the drone of the diesel generators and the Native fishing boats break the serenity.

It was those noisy diesel generators and the rising cost of the fuel that feeds them that first got John Norton, local school teacher, to begin searching for alternative ways to generate power. Although a large powerful wind generator could provide electricity for the entire area, Norton was looking for a system that could be used by single households.

Soon after he began talking about his ideas, he found that little knowledge existed in the village concerning wind-powered electrical generators. Rather than giving up, Norton decided that it would be beneficial to construct a small wind generator system with the help of local high school students. It would introduce them to alternative energy systems and, more important to Norton, it would help teach the youths alternative ways to solve problems. Such a project would benefit the community by reducing electrical costs and contributing to the educational program in the village.

In 1981, Norton was granted AT funds for the selection, purchase and installation of a small wind generator system at the Nondalton School.

Design and Construction

Norton decided that the wind generator system should be similar to one that could run a typical village home. This way it would educate and demonstrate to the village that wind generated electricity is a viable alternative to petroleum-based power sources.

Norton began by researching weather records for the previous 30 years and found that the wind averaged between 8.3 and 14.8 miles per hour. The windiest month was January and the calmest, July. Next, he searched for a wind generator that would operate within these wind averages.

A Bergey 1000 48-volt direct current upwind generator was chosen to generate electrical power at a low minimum wind speed in the eight-mile-per-hour range; 12-foot diameter blades are also automatically braked when the wind exceeds about 30 miles per hour. This automatic braking action is important in an area where regular monitoring is impractical.

The wind generator was mounted on top of a 40-foot, self-supporting tower next to the school building. The generator output cables feed down through the tower to a voltage regulator and a battery bank composed of 20 six-volt, deep cycle batteries connected in series and parallel. The series and parallel arrangement of the batteries was planned to ensure a constant voltage under varying loads.

The batteries also are connected to an inverter, which can change the 12-volt direct current battery voltage to 120 volts of alternating current. This allows standard household appliances to be used without modification.

The relative condition of the system is monitored by a metering system consisting of a microamp meter, a direct current voltage meter, and an alternating current voltage meter. These effectively tell the condition of the batteries, the output of the wind generator, and the output of the power inverter.

Performance

Unfortunately, before Norton could finish with the project he left Nondalton. Although the wind generator and tower were erected, not much else was done immediately. The batteries for the battery-bank were never charged and were stored over the winter in an unheated building. By spring the cases were ruptured and the batteries useless.

A strong wind shortly after Norton left also caused problems. The automatic brake mechanism failed, causing expensive damage to the internal components of the generator. The blade has since been removed and placed in storage.

As of mid-1984, the project has been mothballed, although the school district is considering restarting the project.

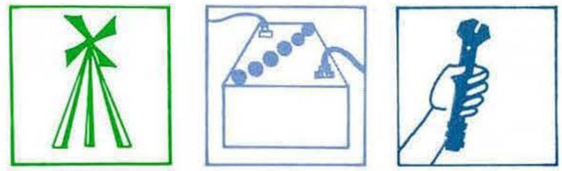
Funding

U.S. Department of Energy	$3,660
State of Alaska	8,540

Grantee

Lake and Peninsula School District
Nondalton High School
Nondalton, Alaska 99640

Students learn from wind project



About 450 miles due west of Anchorage, where the Eek River meets the Kuskokwim and both meet the Bering Sea, is the small Yupik Eskimo village of Eek, population 200. The wind blows constantly here, a scant six miles of open tundra from the sea. Even on calm days, the wind averages almost 10 miles per hour and the flat delta offers little terrain to stop it.

In remote villages such as Eek, subsistence hunting and fishing remain as a cultural lifestyle and economic necessity. And in many cases, low-cost fuel is a thing of the past.

Harnessing wind power is not a new idea for Eek. Between 1930 and 1960, there were three or four wind generators operating. This was before the village power plant operated by the Alaska Village Electric Cooperative was installed. The wind generators faded from the Eek skyline soon after the diesels arrived.

Eek is in an area of Alaska that offers little opportunities for the younger citizens. Tom McIntyre and the Lower Kuskokwim School District were determined to change part of that.

The Lower Kuskokwim School District is one of 21 Rural Education Attendance Areas (REAAs) in Alaska. (The Northwest Arctic and Lake and Peninsula School Districts' experiences with their projects also are described in this book.) The REAAs were formed in 1974, to allow local control of education and to eventually take over rural education responsibilities from the federal Bureau of Indian Affairs. Increasingly in recent years, these REAAs have recognized the value of vocational education in assisting students in making a smooth transition to rapid changes in Alaska; Native culture and language programs also are common, as well.

The district figured that having the vocational students construct and operate a small wind generator would teach practical, new skills with a locally available energy source. The project also was conceived as part of a visible symbol of what can be done when a village cooperates together.

The 1980 grant project involved selecting the wind generator and support tower, voltage regulator and battery-bank, back-up generator system, and developing a record keeping system to monitor the results of the project. Throughout the course of development, the education of the students would be kept in the forefront.

Design and Construction

Shortly after the project began, the village was informed that the old school was being replaced with a new building. It was decided to mount the wind generator on the roof of the Traditional Council building instead of the school and to move it when the new school was completed. The wind generator chosen had to have the following qualities; it had to be able to withstand extreme cold, high winds, a salty environment, and it had to be affordable. A WINCO 1222 wind generator and support tower was chosen because it was thought to match these parameters and was readily available.

The output tower cables from the roof-mounted wind system are connected through a voltage regulator to two T-16, six-volt batteries connected in series. The wind gen-

The Council building (above left) where the wind generator is mounted. A view of the village of Eek (above right).

erator is manufactured so that its propeller blades must be manually braked when the wind velocity is too high (around 30 miles per hour). With the tower also designed to keep the generator from turning a full 360 degrees, the system seemed suitable for the type of wind conditions found in Eek.

The battery output is connected to a 120-volt alternating current inverter which changes the 12-volt direct current to the standard 120-volt alternating current used by most modern appliances and televisions.

A small, gasoline powered, 120-volt AC 440 watt generator is used to keep the batteries charged during long periods of no wind, or in high wind when the wind generator is shut down.

Performance

The WINCO operated without any major problems until the late fall of 1982, when a storm slammed into the coast with 70 mph winds. The wind generator's brake malfunctioned and within seconds the propeller blades were splintered. Luckily, the local television station, KYUK-TV in Bethel, had already featured a story about the windmill at Eek and how the proud students had performed the major work on the project. The generator stands idle today because the village lacks the funds to replace the damaged parts.

While it ran, the wind generator lived up to its original design parameters. It operated during the first winter, spring, and summer without a flaw. The second part of the project was also successful. The students were instructed on construction and operating techniques, wind system monitoring, and project management.

Conclusions and Problems

The only major problem encountered with this project was the failure of the wind generator during the storm. The other problems were relatively minor and typical of rural areas.

Coordinating skilled craftsmen with classroom hours was difficult, especially when the craftsmen were due at another project. Over time, however, the system was completed.

Funding

U.S. Department of Energy	$4,500
State of Alaska	$4,500

Grantee

Lower Kuskokwim School District
Eek High School
Eek, Alaska 99578

Windmill pumps hatchery water

"The aquaculture industry should set an example of utilizing pollution-free techniques and work toward energy self-sufficiency since its welfare and production depends largely upon clean water. Simple economics makes energy self-sufficiency a necessary reality," says Jack M. Van Hyning, aquaculturist and president of Nerka, Inc. a nonprofit private fish hatchery located on remote Perry Island in Prince William Sound.

Van Hyning believes that the periodic peaks and dips in salmon production can be moderated by farming salmon much like cattle ranchers farm beef in the western states. The same problems are common to both industries' energy costs and water.

One major problem facing salmon hatcheries in general is the ability to supply a constant flow of clean, clear water over eggs and young fry. Periodic flushes with seawater also are necessary. In a remote subarctic location without access to a year-round clear stream, supplying this water is extremely difficult and expensive. Van Hyning has initiated a method that may reduce both dependence on petroleum-based fuels and possibly eliminate the need for a year-round fast flowing stream. His answer is wind pumps.

Philosophically, Van Hyning chose wind energy because it's a renewable resource that can be used to increase a renewable biological resource (salmon). It also helps conserve a non-renewable resource (oil). In addition, wind pumps are easy to install and require minimal maintenance and training to operate.

Van Hyning's 1980 grant was to research and develop a wind powered water supply system for the Perry Island salmon hatchery. The project involved researching available literature and consulting wind energy experts, studying wind patterns at Perry Island, purchasing a suitable wind pump as a result of the research, field testing the system, and publishing the results of the project.

Design and Construction

The operational requirements for the Perry Island hatchery would be similar to those of other remote locations in Prince William Sound. Both seawater and fresh water would have to be transported from a low water site up to the hatchery. The seawater would be needed on a daily basis for about two hours per day. Fresh water would need to be pumped in an "on demand" situation, usually when the flow from the fresh water stream dried up or lowered during winter. The fresh water would have to be delivered at a rate fast enough to compensate for the reduced stream flow. In each case, the need to replace standard petroleum-based energy sources would be necessary to make the hatchery economical.

After consultation and research, Nerka, Inc. decided that a small Savonious rotor windmill connected to a diaphragm pump would be sufficient for pumping the seawater to the hatchery. A Dempster windmill, like the ones dotting the American West, would be used to supply fresh water. Each of these pumps were chosen because they promised simplicity, low maintenance, and ease of operation.

Seawater is added once per day to the hatchery trays to reduce fungus infestations and, being several degrees warmer than fresh water, to enhance growth and production. Because the seawater is not needed in large quantities, the simple Savonious windpump was chosen for this purpose. The Savonious windpump was constructed in Fairbanks from two halves of a 55-gallon drum. Initial tests indicated that it functioned well; however, when it was moved to Perry Island and attached to a diaphragm pump, the results were marginal at best. A piston pump substituted for the diaphragm pump helped a little, but only during a high tide and high wind combination.

The water transfer lines for this pump were flexible one inch pipes, one extending down to the mid-water line on the beach and another to the hatchery trays 10 feet above the pump. Calculations showed that this combination with a submersible diaphragm bilge pump would produce an output of about four gallons per minute with a 10 mph wind.

A traditional farm-type, multibladed Dempster windmill would supply the fresh water. This windpump was chosen because of availability of parts, minimal maintenance, reputation for durability, automatic "furl-out" for high winds, manual braking, documented pumping rates and ease of interface with a mechanical pump for windless periods. After attending a seminar at New Mexico State University on installation and operation of this type of system, Van Hyning purchased one and moved it to the hatchery site. In addition to the 10-foot-diameter windpump, a 35-foot tower and six-inch brass well pump were ordered.

The final location of the Dempster was a compromise. The poor performance of the Savonious and low wind measurements convinced the builders that another location should be used. It was decided to move the tower and windmill to pilings in the fresh water reservoir near the hatchery. Construction was as easy as "putting up an erector set," according to Van Hyning. Anemometer measurements taken earlier indicated that adequate wind existed in this new location to pump sufficient water for the hatchery needs. A two-inch pipe carried the water from the windpump to the hatchery.

Unfortunately, during shipping, the wind vane was lost. Creative cutting of some old scrap metal rectified this situation and by the spring of 1981 the windmill was ready for testing.

Performance

The performance of this project was not as initially projected. The Savonious windpump never produced an adequate supply of seawater and was soon abandoned. Even the larger capacity piston pump did not help. Seawater is still supplied by a petroleum-fueled water pump.

The larger Dempster windpump was also a disappointment. It was determined after installation that although the anemometer showed adequate wind speed, it did not show the wind turbulence in the area. The north ridges surrounding the hatchery site produced a "wind shadow" that caused the Dempster to gyrate instead of face the wind as desired. The small diameter water transfer pipe was also too restrictive, indicating that a three or four-inch pipe was needed.

With all the consultants and literature used to research this project in the beginning, all rules were broken when the actual system was actually installed. The wind direction was never monitored. When the Dempster was installed, it was installed according to convenience and necessity instead of measured results. The farm windmill ended up in a protected location, a "wind shadow." As Van Hyning put it, "the systems worked in the sense that they pumped water, but with the locations chosen, the amount of water would be marginal for even a mom and pop operation." For a commercial venture, the project was not overly successful.

Future plans are to relocate both the hatchery and wind systems. Wind speed and direction measurements will be used to determine the optimum location for the Dempster. The Savonious is still questionable. Other ideas include purchasing a small windgenerator to power an electric pump. This could be used to deliver seawater to the hatchery location and may prove more economical; however, the need to maintain battery banks makes this a questionable approach.

The last aspect of this project, gathering and assimilating information for others was accomplished successfully. A detailed project report was made by Nerka, Inc., which includes a tremendous amount of background on windpower and windpumps.

Tips

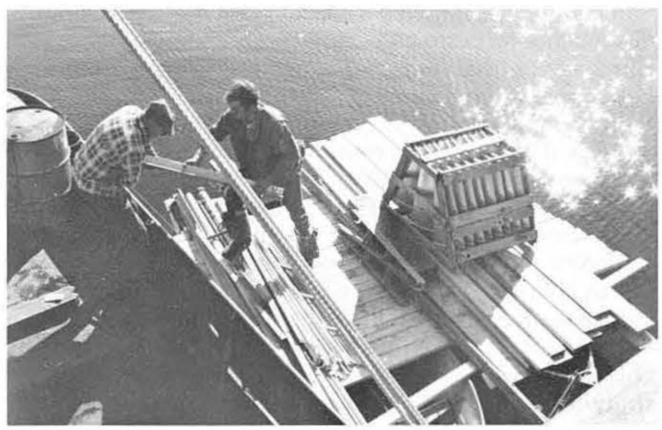
"Place the windmill in an open area, away from trees and out of sheltered valleys," said Van Hyning. "I cannot stress this point enough. Although such areas may not be the best location for the hatchery itself, a suitable compromise must be found if you are to use this energy source."

Funding

U.S. Department of Energy $21,805

Grant Recipient

Nerka, Inc.
Jack M. Van Hyning
P.O. Box 80165
Fairbanks, Alaska 99708



Windmill parts (top right) are unloaded from a makeshift landing craft. (Bottom right), the installation of a firm tower base. The completed installation (left).

Waterwheel made more efficient

Water wheel technology has undergone another revolution in the hands of entrepreneur Robert Nelson.

He's designed a water wheel capable of generating 600 watts of electricity—perhaps twice as much as similar-sized, conventional wheels. That's more than enough power for his remote lodge on Thayer Lake, about 60 miles southwest of Juneau on Admiralty Island in Southeast Alaska.

"Most of the electricity goes for the radio, power tools or for cooking," says Nelson. "The freezer is operated directly off the wheel."

This isn't the first time Nelson has built a water wheel. He built a conventional water wheel at Thayer Lake in 1947 because it was too expensive and too difficult to transport gasoline to the lodge.

So far, Nelson's new water wheel has been working well since he installed it in 1981. Now he and his wife, Edith, do not have to worry about flying in expensive gas to their remote lodge.

"I've got most of the bugs out of it," says Nelson, a retired electrician from Ketchikan who runs the lodge from spring until fall. "It works beautifully. All I have to do is grease it once in a while."

System Design

Conventional water wheels are not very efficient because they carry the water through only about one quarter of the turning radius before releasing it.

By comparison, Nelson improved the efficiency of the conventional water wheel by adding covers to the trough-like buckets that do not dump their load of water until it completes a 180 degree revolution. This means his water wheel is able to add more thrust to the drive shaft.

"In conventional, overshot water wheels the water falls onto the top of the wheel and stays there until it gets about a quarter of the way down," says Nelson. "The one I designed holds the water in until it gets to the bottom of the wheel, doubling the power."

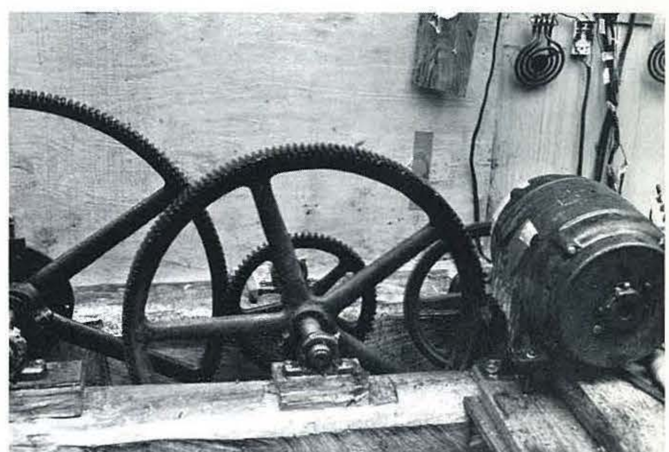
Nelson's seven-foot-diameter water wheel is made of three-sixteenth-inch thick sheet steel. The wheel has 42 cedar buckets held in place by metal slots.

Each bucket is 36 inches long and is fitted along its length with a five-inch-wide wooden cover attached by a slightly off-center nail. With the force of gravity and the weight of the water, each bucket cover will open and close at the appropriate time. At the bottom of the wheel, the weight of the water will shift to the opposite, outer edge of the cover, forcing the cover open and dumping the water out.

At the top of the wheel, cascading water fills the bucket and the wheel begins its downward rotation. The water will force the cover shut. The cover doesn't reopen until it swings to the bottom of the wheel's arc.

"With our modern technology, the steel water wheel is just as easy to construct as a wooden one," said Nelson. "I believe this project could have been built 50 or 75 years ago without too many difficulties provided rolled sheet steel had been available."

Nelson also built a 500-foot-long, polyethylene "pipeline" to channel water from a nearby creek to the water wheel. The flexible material was laid on wooden braces three feet above the ground. The tube would lay flat without any water passing through it, because it is such a



A cedar trestle (left) supports the waterway. A gearing and heating element (above) give overspeed protection. (Next page), buckets close as the wheel rotates.

light material.

Water cascades onto the water wheel at about 100 cubic feet per minute, turning the wheel at three revolutions per minute. This makes a two-phase, 110-volt, 60-cycle generator turn at 450 rpm, producing about 600 watts of electricity.

"By using a two-phase AC generator I was able to run a refrigerator of 3.5 amp capacity directly off the water-wheel generator," Nelson said. Additional power is stored in a bank of Edison batteries.

Other features Nelson has added at his home include a hydraulic ram system that pumps water to a tank located high in a tree. He also uses dried muskeg mixed in plaster as insulation on the freezer and hot water storage tank. Water is heated through pipes placed across the back of the fireplace.

Performance

Overall, Nelson has been very pleased with his water wheel, which took only eight months to build and test at his Ketchikan home.

Afterwards, he dismantled the hydro project, loaded it into a plane, flew to Thayer Lake and reassembled it. So far, his system has worked well.

One problem—flooding of the creek—threatened the project. But Nelson resolved this difficulty by building a small gate that will automatically close off the entrance to his water tube any time the creek floods. This ingenious device uses a block of styrofoam that floats on the water. An old broomstick extends up from the block with a thin rope fastened at the top. When the water level rises, the rope is pulled up, causing a wedge to fall out from under a weighted five-gallon bucket that forces the gate closed.

He also strung an electric wire along portions of the pipeline to prevent bears from clawing into it.

Tips

Nelson discovered a number of small details that improve the wheel's performance. Among them is his advice to:

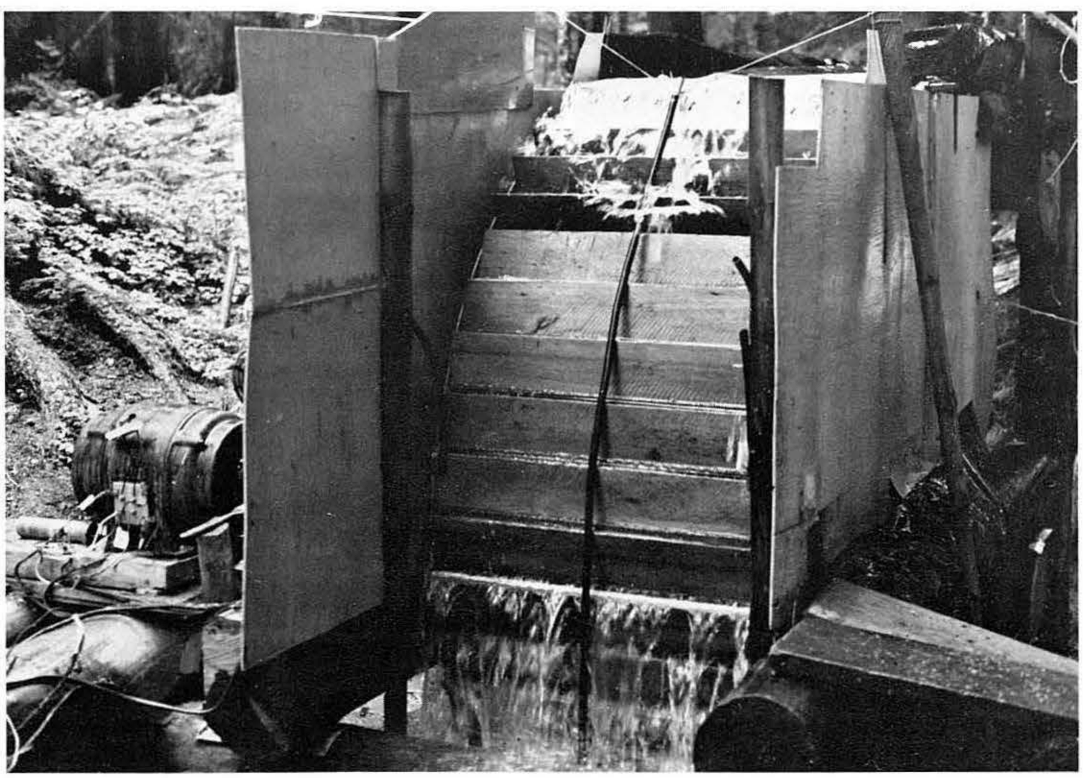
- Soak all wood for at least one week before installing it in the water wheel.
- File the heads of any of the nails used for the bucket covers to get rid of roughness that may hinder their free-swinging motion.
- String a thin monofilament line over the center of the wheel so that the bucket covers gently bounce against the line and ensure the bucket covers close promptly.
- In order to convert an AC motor it must be at least seven horsepower so that its rotor is seven inches in diameter. The rotor must be milled to provide flat spaces to hold permanent magnets. The stator must be rewound with a lightweight enameled wire.
- Direct the power produced by the 450 rpm generator through a 110 volt A.C. battery charger to prevent power surges.
- Consider designing a mechanism that will automatically close when the creek floods. Such a device will reduce the amount of water traversing the pipe, and prevent flooding of the water wheel.

Funding

U.S. Department of Energy	$454
State of Alaska	929

Grant Recipient

Robert Nelson
P.O. Box 5416
Ketchikan, Alaska 99901



Hydro system powers hatchery

Eugene Richards built a hydroelectric system so he wouldn't have to rely on expensive diesel fuel for his salmon hatchery in Southeast Alaska.

A favorite stop of the cruise ship lines because of its Gold Rush heritage, Skagway is also the gateway to Canada's Yukon Territory along the Klondike Highway. Across Taiya Inlet lies Burro Creek and Richards' non-profit hatchery. Access to the site is by boat only. No power, water, electricity or other services are supplied to the remote site by the city.

Richards was committed not only to the hatchery project to replenish local salmon stocks, but to build an energy system and home on the site, as well. In all, these projects took five years to accomplish; the first year, the hatchery took top priority. After being awarded the 1980 AT grant, he built the powerhouse for the hydro system. The Richards used the structure as a temporary home until their log residence was completed in 1982.

"The hydroelectric plant was necessary at Burro Creek Farms to provide inexpensive electrical energy for the operation of a nonprofit salmon hatchery," said Richards.

Diesel oil, he said, was priced at about $1.09 per gallon for No. 1 fuel and 98 cents per gallon for No. 2 fuel during the spring of 1984. Residential power cost from 17 to 20 cents per kwh depending on consumption.

Richards hopes his hydroelectric plant will serve as a model for building similar plants throughout Alaska.

"The project will develop a renewable energy source and the hatchery will provide more salmon for commercial and sport fishermen," he said.

Design and Construction

A 1,400-foot-long, 10-inch PVC pipe channels water from a dam on Burro Creek to two pelton wheels mounted side by side. There are two water jets on each of the two turbines. The two turbines drive a 25 kw generator. The turbine units are commercially made by Peltech.

The 25-kilowatt, three-phase 220-volt Lima-brand brushless alternator produces electricity for refrigerator compressors used to process fish.

The pipeline, which has a 125 psi rating, was laid in sections. Richards uses quarter-inch aircraft cable and cable clips to secure the pipe to expansion bolts, which are anchored in bedrock or large boulders.

At the anchor points, the pipeline is wrapped in building paper, aluminum flashing, and used firehose to secure and protect the pipe from chafing. Downhill ties are used on slopes at 200-to-300-foot intervals to prevent the pipeline from "crawling" down the hill.

Where the pipe changed grade, supporting posts were fabricated from six-by-eight-inch treated wood at 10-foot intervals so that the pipe rests on saddles formed by two-by-10-inch braces.

Special concrete anchors were installed for the last 80 feet of the pipeline to prevent the pipe from excessive movement and strain where it approaches the powerhouse. At the inlet above the dam, a wood filter box and screen also were installed to prevent debris larger than a half-inch in width entering the pipeline and possibly plugging the nozzles at the pelton wheels.

Problems

Overall the system has worked well since its installation, providing the Richards with round-the-clock electricity.

Low winter temperatures, however, caused freezing and icing on the filter box, along sections of the pipe and in the metal discharge pipes. And despite good performance, the governor disengaged from the pelton wheel, causing a bearing burn-out and scored shaft.

Freezing temperatures made it difficult to maintain adequate water flow. Richards says he plans to increase the height of his dam on Burro Creek to boost the depth of its water.

An atmospheric vent also was installed at the top of the pipeline to decrease the possibility of dead water freezing. And he plans to put a manifold in the lower end of the pipe for clean-out and to keep the jets and the main throttle valve free.

Tips

- Make certain the system can shut down easily and will drain automatically. The atmospheric vent at the top of the pipeline is critical to prevent blow-outs and pipe collapse when draining the pipeline.
- Install required valves near heated areas wherever possible to keep them from freezing.
- Avoid bending PVC pipe, especially in the lower sections where pressure is greatest.
- Make sure the pipeline is anchored well.
- Use an open ditch or a wood flume to channel water from the pelton wheel since metal pipes tend to freeze during winter.
- PVC pipe should not be exposed to direct sunlight after installation. It should be painted with a water-base synthetic latex paint or wrapped with tape when installed in sunlight.

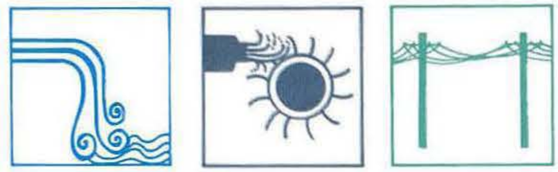
Funding

U.S. Department of Energy	$5,675
State of Alaska	5,675

Grant Recipient

Eugene Richards
Burro Creek Farms, Inc.
Box 455
Skagway, Alaska 99840

Micro-hydro project generates interest



Noted for eagles and rugged mountain peaks, at the head of the Lynn Canal sits Haines, one of the historic embarkation points for trails leading to the interior goldfields and last stop for most tourists traveling the Alaska Marine Highway. From here, it's up the Chilkat River Valley, over the backbone of the Saint Elias Mountains to Haines Junction and the Alaska Highway, passing many small picturesque streams along the way.

To the tourists, these streams make beautiful snapshots for the folks back home. To Roy Lawrence, these same streams make excellent locations for micro-hydroelectric projects. In an area of high electrical bills, limited solar and wind power potential, hydro power and steam generators are about the only alternatives. Lawrence chose hydro power because in addition to long life and low maintenance costs, "there are no emissions from hydro units and even the sound is at a minimum."

Lawrence had visions of a small hydroelectric system when he first bought his 43-acre farm in the early 1970s. Electricity was expensive then and after the oil crisis, it became almost out of reach for many of the 1,700 residents in the Haines area. Lawrence figured that if he could successfully demonstrate the benefits of hydroelectric power, he could generate enough interest to develop and market his own energy systems. "This will not be something just on paper or in a book, but a real live entity actually producing power and not theorizing about it," he said. With this project, Lawrence would have a running demonstration unit, plus practical experience. If his vision were proven true, he would also have a successful business sometime in the future.

In April 1981, Lawrence received a grant to build a micro-hydroelectric power generation system on his property at mile 37 of the Haines Highway. The project involved building an impoundment dam, water transfer system, power generation system, and transmission line.

Design and Construction

Lawrence decided that his demonstration unit should be large enough to supply the power needs of a small house, yet within the economics of area citizens. He chose a small 1.5 kilowatt, 120 volt, 60 Hertz, alternating current generator from Hydro-Watt of Oregon. This generator uses a Pelton-type turbine to turn it. The solid state controls keep voltage level and frequency within three per cent of its rated value. Automatic load control and other safety features were also incorporated into the design. For instance, a special safety solenoid is provided for complete system shut-down in case something were to go wrong. The solenoid must also be manually reset, ensuring that the problem must be corrected before the system can be restarted.

The impoundment dam is located about 310 feet above the power unit. Four-inch PVC pipe transports water from an impound box located behind the small dam. The earth/rock filled dam has a two-inch-thick wooden retaining wall backed by a 28-gauge galvanized metal "L" shaped seal. Additional bracing is provided by galvanized pipe pounded into the ground in front of the dam. Galvanized cable from these pipes to deadman beams imbedded in the pond's floor behind the dam provide additional safety.

A movable 18-by-six-inch spillway keeps leaves and other floating debris from clogging the screened opening in the water impound box. The four-inch, schedule 40 PVC water transfer pipe is fitted to the bottom of the impound box, below the theoretical seasonal low water limit. The spillway is designed to allow periodic removal for cleaning and maintenance.

The water transfer pipe carries the water to the power unit located about 130 feet below the dam. Located in a six foot-by-six foot uninsulated building, the pipe can deliver water at about 56 to 60 pounds per square inch pressure at almost 100 gallons per minute, more than enough to produce 1,300 watts under full load.

Freeze protection for the generator is provided by an insulated 30-by-16-inch enclosure made of two-inch-thick polystyrene bead board. Only the turbine and generator are insulated during the winter. As long as water is flowing in the stream, freeze protection is not needed for the water transfer pipe. When the system is shut down, the impound pond is simply drained along with the water pipe.

Power from the generator is transported to the house through approximately 650 feet of 1/0 size cable. Lawrence originally planned to use tripods made from 12-foot-long four-by-fours to support the cable, but during brushing the transmission line path, it was found that enough tall, straight trees existed to forgo the tripods.

Performance

The small 1.5-kilowatt generator has successfully provided enough electricity to run both house lights, a small refrigerator and a chest-type freezer. Heavy usage items such as shop tools or electric heaters obviously require a larger system.

Even during the late summer, when the water level is at its lowest, the generator has been able to produce power. If it had not been for a small leak in the face of the dam and one extremely dry summer, Lawrence's hydro project could have supplied a full 1,300 watts at all times of its operation. As it was, the leak combined with the low streambed water level dropped head pressure to about 35 to 40 pounds per square inch. The generator's output also dropped to about 100 watts at 110 volts. During this time, a small diesel generator supplied household power.

The small size of the generator required continual energy conservation. A volt meter was plugged into a wall socket to monitor line voltage. Any sudden unexplained drop usually meant that the screen on the water impound box was clogged. This did not happen often and periodic monthly cleaning usually prevented this problem.

Although the system was fairly easy to install, Lawrence recommends using a more flexible water transfer pipe. The rigid PVC required special bends to be made at an added cost. The original design also has the pipe placed a couple of feet off the ground. Burying a flexible pipe would reduce both freeze damage and the chance of a falling tree destroying the water transfer system.

Problems and Conclusions

Lawrence has experienced very few problems with this project. This can be attributed directly to the excellent planning he did in the beginning stages. The solid state controls and simplicity of the system eliminated many problems experienced by other micro-hydroelectric developers.

Although some time was lost due to personal illness at the start of the project and the fact that the generator ran backwards at first, Lawrence was able to overcome these delays and finish the project. The small leak in the dam was repaired during a routine scheduled maintenance period.

Lawrence has been interviewed by KHNS, a local radio station, and there seems to be a lot of local interest in his system. Since this was one of the project's original intentions, it can be considered a complete success. Whether Lawrence can develop a market for his idea depends on his continued enthusiasm for this renewable, non-polluting power generating system. Since his total energy costs for 1983 were only $68, there is no reason to believe his enthusiasm will wane.

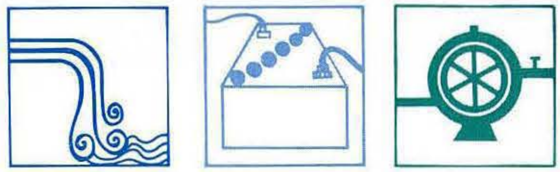
Funding

U.S. Department of Energy	$3,370
State of Alaska	7,862

Grant Recipient

Roy Lawrence
Mile 37 Haines Highway
Box 644
Haines, Alaska 99827

Willie Nelson regulates power output



Energy independence is a dream many Alaskans have, including Chester Johnson. When he first homesteaded at Mile 49 of the Richardson highway in 1968, he would often look at the waterfall behind his house and wonder how he could tap its energy. In 1969, he found his answer. While on a trip to Chitina, he found an old Francis turbine in the city dump. Although it had lain there for some years, the hydro turbine wheel was still in workable shape. Later that same year, Johnson recovered an old 2.2 kilowatt generator from a burned-out building. Now all he needed was something for the penstock. The Valdez city dump supplied that. He salvaged the aluminum pipe that served as Valdez's emergency water main after the 1964 earthquake.

Using a lot of creativity, sweat, and a few new words, Chester Johnson soon made himself a makeshift microhydroelectric power plant, using the energy of his backyard waterfall and all that "junk" he found. After initial adjustments, the crude system put out one kilowatt of energy, enough for his small house. Unfortunately, he had to "regulate" his system manually. A volt meter was plugged into one of the house sockets. When the meter indicated that too much power was available, Johnson simply switched on another light. He kept switching on lights until either the meter indicated the proper voltage and power values, or until "Willie (Nelson) sounded right on the phonograph." If his phonograph played a little slow, Johnson simply turned off lights until power increased. This simple "load control" worked for almost 10 years and would have worked much longer, except Johnson had bigger plans for his waterfall.

In 1979, he received a grant to upgrade his small one-kilowatt generator to a five-kilowatt system. His new system was to include automatic load control and would be able to supply his house and two others with power from May through October. The project involved modifying the turbine/generator, installing a new water gate and new penstock, and laying transmission lines to his neighbors' homes.

Design and Construction

The upgraded system would essentially follow the same design as his older system with a few enhancements, unfortunately, load control wouldn't be one of them. No one could remember how the old turbine was governed. Johnson decided to continue his meter monitoring until a load control could be designed.

By midsummer, work began on the penstock. Johnson and several friends hand carried 30 foot sections of the new four-inch aluminum pipe up the steep cliff and strung them along the side of the waterfall. Although each section only weighed 20 pounds, the steep, heavily timbered mountainside and thick underbrush made it seem doubly hard.

The most difficult part of the whole project was winching a huge cast iron, 10-inch gate valve up the mountain. This valve would be used to shut off the water during the winter months. The half-ton valve, mounted on a skid, had to be slowly lifted up the cliff with a 12-volt (direct current) winch. A portable gasoline powered generator was also moved up the mountain. The generator was used to recharge the large "CAT" batteries powering the winch. Moving the gate was a long slow process, taking two complete summers to finish. The

Chester Johnson (above left) brings new life to abandoned equipment. Johnson's open air hydroelectric system (above right).

final resting place for the gate valve was about 1,000 feet from the turbine up a 45 degree grade. The water delivery pipe is reduced to a one-inch nozzle at the turbine.

Problems and Conclusions

Very few problems were encountered during system construction. A few sections of penstock had to be replaced when an early freeze broke two sections. There was also a continuing problem of birch leaves clogging the inlet screen of the penstock.

Load control was a continuing problem with both the older system and the new five-kilowatt model. Johnson is still awaiting assistance here. An experimental magnetized aluminum disk "Eddy Current Brake" will be attempted at a later date, but it is unsure if this device will really work.

All-in-all, Johnson succeeded in developing a micro-hydroelectric system from mostly salvaged parts that could supply enough power to run three households.

An automatic load control in the future would enhance this system a little more, but "as long as Willie sounds right," power is under control.

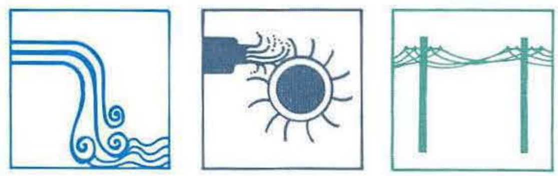
Funding

U.S. Department of Energy $6,280

Grantee

Chester Johnson
Mile 49 Richardson Highway
Valdez, Alaska 99686

Water beats wind for reliability



There's a history of pioneers relying on water wheels to generate power in Southeastern Alaska. And Ken Cassell is adding to that heritage in a modern way.

Cassell is building a hydroelectric system on two creeks that tumble by his home in Juneau. Students from the Juneau-Douglas High School are assisting him.

"Water is more reliable than wind power and you can get more power out of it," says Cassell, a high school teacher who studied the project's Pelton wheel technology during graduate school. "I'm interested in mechanics and how you can corner the water's power."

The project has been an invaluable educational tool. High school students in such classes as surveying, physics, drafting, photography and metal shop have worked on various stages of the project.

The physics students also will continue to monitor the system's efficiency after it begins producing electricity in the fall of 1984. Power from the system will be sold for up to 9¢ per kwh to the Juneau electric utility. He expects his system will generate 10 kwh.

Cassell, who's entering his fourth and final year on the project, is optimistic about finishing it shortly.

"I'm in the final stages," says Cassell, who also owns his own business and is in the U.S. Navy Reserves. "I worked with students and I built everything from scratch. Even the switch panel. It's been a good learning experience." And he sees no reason why the system will not perform well.

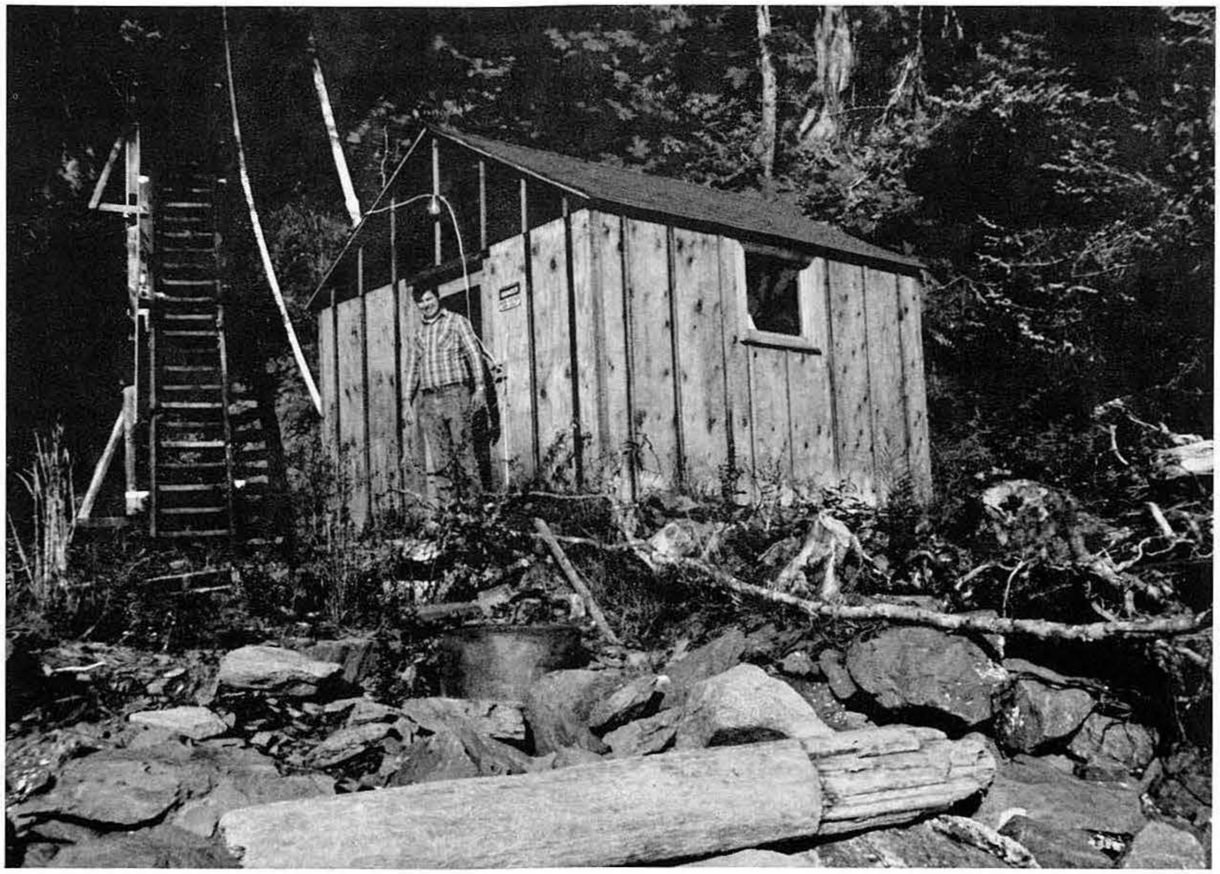
System Design

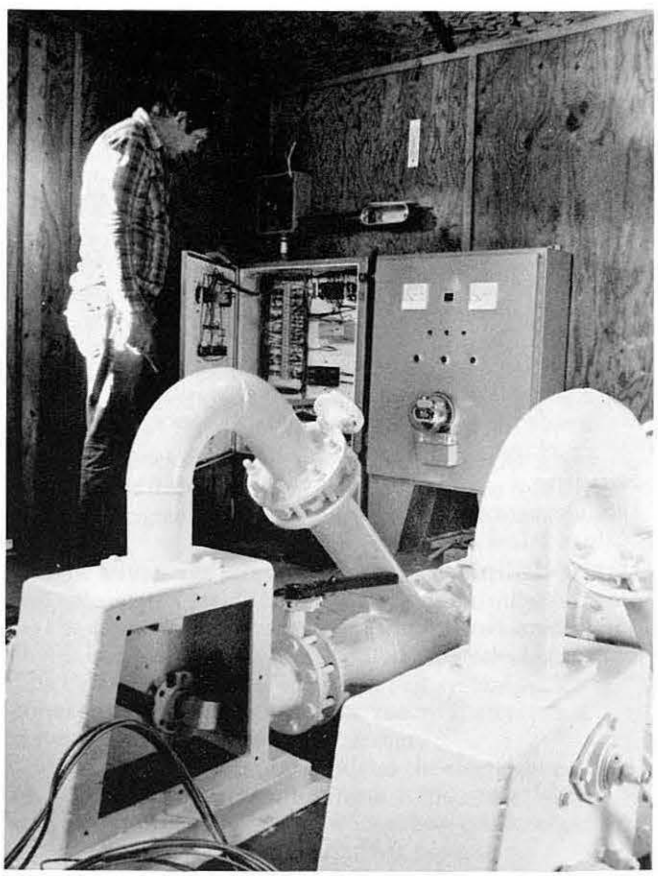
Water from the two streams is piped in two pipelines down a steep hillside to a powerhouse with two six-inch Peltech turbines and two GE induction generators. The rushing water turns the Peltech turbines, producing electricity.

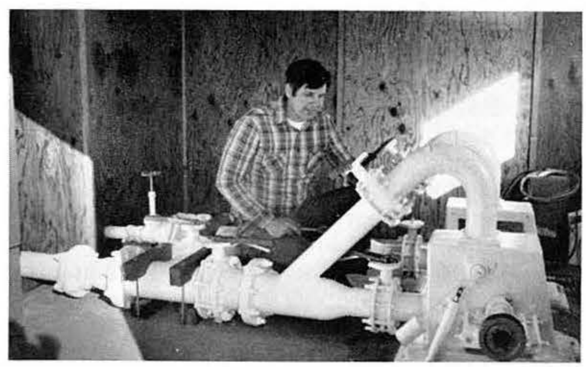
Ken measured his two streams every other day for a year, except during the winter when he measured them just once a week. To measure the smaller stream, he used a five-gallon bucket with a stop watch to measure the flow. Because of the size of the larger stream, he had to use the weir method. Even with the weir, he was not satisfied with the results, so he went to the U.S. Weather Bureau and obtained monthly rainfall data for the previous seven years. Then, he calculated a theoretical average month and watched the Weather Bureau data for the month that was closest to the theoretical average. He measured the larger stream during that month to determine the turbine size he would need for his system.

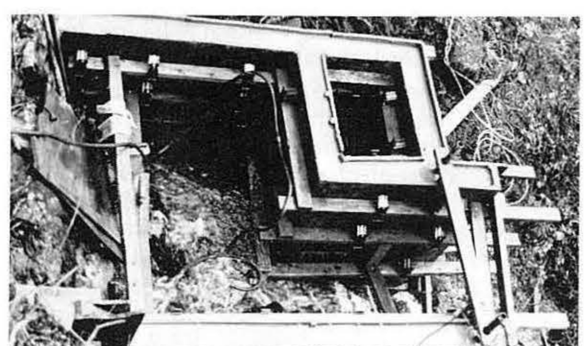
The water is initially held in concrete catch basins which were placed in each stream. The basins are designed to release water into pipes leading downhill to the powerhouse when there is enough water to operate the turbines.

By the summer of 1982 all the materials needed for the powerhouse, penstock, and access stairs were on site and ready for construction. It took the rest of the summer, three athletic high school helpers, and an excavator brought in on a Navy-type landing craft to complete this









Ken Cassell (top) stands beside his powerhouse at the tideline. Installing (middle right) the hydroelectric unit. A concrete form (bottom right) works as a catch basin. (Left), Cassell inspects his control panel.

stage of the project. The project could have been done in less time had Cassell not had to drag everything either down the steep bluff, or up the beach.

Building the catch basins was a major problem. The steep angle of the hillside made climbing difficult and climbing with equipment and materials virtually impossible. It was decided to use the services of a helicopter and cement pumper for these structures.

The catch basin for the smaller stream, which was closer to Thane Road, used a six-sack mix of cement delivered by a cement truck and pumped 120 feet uphill to the basin's location. Fourteen inch deep holes had previously been drilled a foot apart into the bedrock, to pin the structure to the rock face.

The catch basin for the larger stream is located in a high and remote site. A generator was packed up the mountain for power during the form-making and drilling process. Four yards of concrete were finally poured into the forms in October using a helicopter.

The penstocks are two plastic PVC pipelines, each rated at 200 pounds per square inch pressure. The pipe, manufactured by Johns-Manville Company, comes in 20-foot lengths with bell and socket joints that do not require cementing. The socket has a rubber gasket which must be clean during installation to prevent leaking.

One pipe is four inches in diameter and is 1,300 feet long. It drops 437 feet in elevation to provide 200 pounds per square-inch pressure at the turbine. The stream flow is 13 cubic feet per second (cfs).

Similarly, a second, parallel pipe extends 800 feet, dropping 200 feet in elevation. This pipe has a four-inch diameter which narrows to 2.5-inches. Stream flow is 3.5 cfs.

Both lines are buried to protect them from bears and falling trees. However, the pipes are above ground where they extend down a bluff to the powerhouse. The pipe is supported every 10 feet and held off the bluff face by cables anchored by rockbolts. The cable is fastened to clamps at the pipe fitting joints.

Each pipe channels the tumbling water to nozzles which spray onto each of the six-inch-diameter Peltech turbines. The turbines turn fast enough to achieve 1,800 rpm.

In the winter, when water flow is low, there is a manifold between the two turbines so that the small generator can be switched to the highest head stream for greatest efficiency.

The brass Pelton wheels for the turbines were made by Bill Ketchings in Kent, Washington. Rough castings were shipped to Juneau where the high school machine shop students ground off the burrs and polished the buckets.

Using electrical controls designed in the U.S. and manufactured in Denmark, the power plant monitors over/under voltage and frequency conditions, over current, reverse or out-of-phase power, and low water level in the catch basins. The controls are plugged into tube sockets on a control strip and activate water deflectors in the turbines when a problem is detected. These water deflectors rotate 90 degrees into the spray from the water jets, shutting down the turbines. When this happens, the control valve in the catch basin is closed and the penstock pipe is allowed to drain. To restart the seven-kilowatt generator, this problem has to be rectified and the generator restarted manually; with the smaller generator, restarting is automatic.

This system uses two induction generators, one rated at 7.5 kilowatts and the other at 5 kilowatts. An induction generator is used for safety reasons. These power plants require an outside signal before they produce any power. Since the object of this power plant is to supply power to the local utility grid, a method of shutting down the generators automatically when the power company experiences problems is essential for safety reasons. Whenever the utility company loses power, for whatever reason, the reference signal is also lost and Cassell's hydroelectric power plant also shuts down.

Problems

Receiving equipment on time was one of the biggest obstacles Cassell had to overcome.

"By the time one researches the equipment to find what is best suited, finds the vendors, orders and waits for shipped merchandise—one year is gone," Cassell says. "The items needed to build a hydro generation system are industrial equipment and are not found in mail-order catalogs."

The project also has taken more time than he anticipated. He suggests ordering pre-assembled units whenever possible.

"This was partly due to the fact that the whole project was put together in bits and pieces, each little item was ordered separately," Cassell says.

Tips

After spending four years on the project, Cassell has several suggestions to make:

- Plan ahead. Obtain as much information as possible about stream flows, elevations, and where to place the power house, catch basins and pipeline.
- Set aside at least a year's time to find, order and obtain necessary equipment.
- Make sure gaskets in the pipelines are clean to prevent leaks from developing.
- Use bell and socket joints that do not require cementing for the pipeline. In rainy climates, like Juneau, it is hard to keep the fittings clean, or obtain a good seal with glue. Also, if glue forms a ridge inside the pipe, the resultant turbulence could cause cracking.

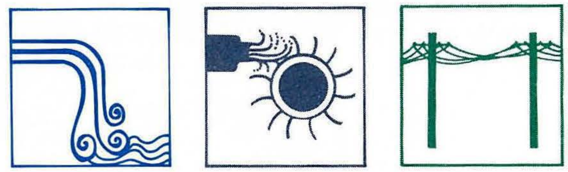
Funding

U.S. Department of Energy	$ 4,850
State of Alaska	25,080

Grant Recipient

Ken Cassell
5680 Thane Road
Juneau, Alaska 99801

"...care involved when you become your own power crew"



When Louis Butera first saw the sparkling creek tumbling through the woods, he knew that's where he wanted to build his hydroelectric dam.

So he bought a creek-side lot and built a home and a hydroelectric system in Eagle River, about 16 miles north of Anchorage.

"I got interested in hydro first," says Butera. "And, then I went out and looked for a creek property. And I found this particular place."

The project is a success, generating between 1,000 and 3,000 watts year-round, despite sub-zero temperatures. Butera uses the power to operate his refrigerator and heat his 1,600-square-foot home. He says it's saving him $15 a month on his electric bill.

"It's working great," says Butera, a civil engineer and consultant who owns Alaska Hydro Systems. "I haven't had any serious problems.

"I've also installed other similar hydroelectric systems for homeowners in the Eagle River area," he says. "They like them. But there is a lot of care involved when you become your own power crew."

System Design

Butera built a two-foot-high dam using two-by-six lumber across the five-foot-wide creek. The boards of the dam can be easily removed to lower the water level for cleaning the screened intake.

Water diverted by the dam flows through the screen into a six-inch-diameter, 408-foot-long, polyethylene tube. The 40-foot sections of the polyethylene pipe were joined together with bolted clamps that secure rubber gaskets on the ends of the pipe. The pipe lays exposed directly on the ground. The pipe, anchored with pilings, channels the water to a Pelton wheel turbine. A gate valve at the dam allows the water flowing to the turbine to be shut off.

The Pelton turbine is housed in an eight-foot-by-12-foot wood shed. The shed has wood siding to match Butera's house.

Butera redesigned the Pelton wheel and built a new housing for it that's six inches wider and two feet longer than the original. He also made it round instead of square.

"The advantage is less resistance to water flow, and less splashback inside the Pelton wheelhousing," he says.

The creek water is funnelled through two nozzles so that it hits the Pelton wheel at 35 pounds per square inch. The Pelton wheel spins, turning a belt system which is connected to a five-kilowatt alternator. The system generates a 120 volt, 60 cycle current.

An electronic governor regulates the electrical current by keeping the turbine spinning at 1,800 rpms. Water flows out of the turbine into a 55-gallon drum, and then back to the creek via a six-inch PVC pipe.

Performance

Butera says he's pleased with the hydroelectric system. It works well, performing better than his expectations. Its simple design makes it easy to build and cost-effective.

But like any new system he's had to spend some time fine-tuning it. A defective governor had to be replaced, and a back-up governor was added to shut the turbine down if the voltage exceeded 140 volts.

A few other tie-ups occurred. The creek's water flow has occasionally dropped too low to run the turbine. Trees also have toppled on top of his pipeline, but he says the polyethylene pipe was not damaged. He's also had to contend with a bearing failure in his turbine two years after he installed the system.

Each year a critical time is just before freeze-up. The stream temperature will drop below 32 degrees. When the stream forms an ice layer on top, the water temperature rises a couple degrees. So far this critical period has not caused a freeze-up problem in the intake, pipeline or turbine, but the possibility exists. "But the turbine has performed as expected," Butera says.

Tips

Butera has several suggestions to make regarding his system, including:

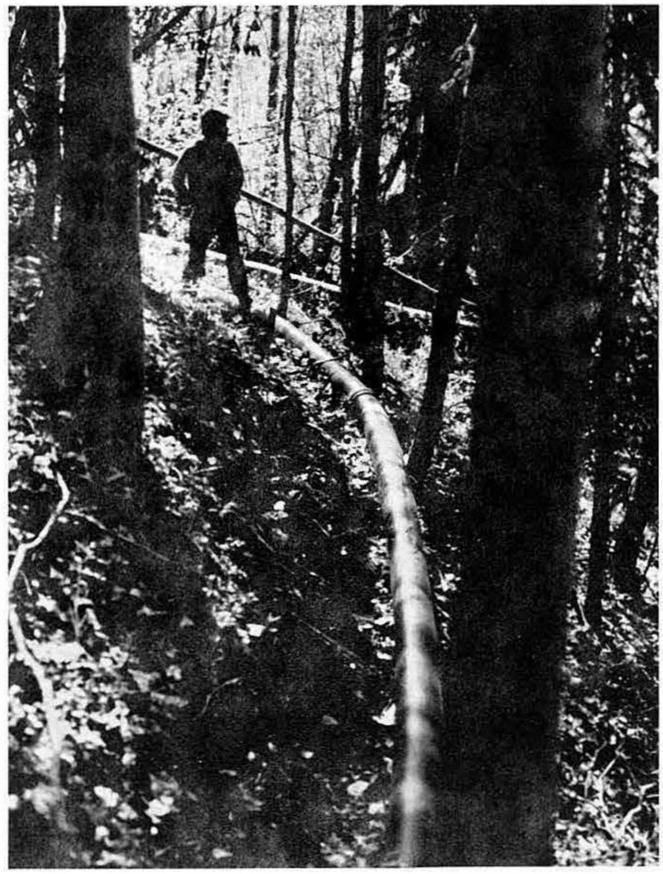
- Order equipment early as it can take three to six months to receive items such as the turbine and governor.
- Use polyethylene pipe. It's expensive, but durable and flexible.
- The powerhouse should be well built and have a south-facing window for solar heat. The floor should be made of marine plywood.
- Place the screen so that the creek's flow will help keep debris from building up on it.
- Make sure all wire connections are secure. A loose wire could damage the governor, alternator, or generator. Split bolts should be used for all connections.
- Allow some slack when routing any wires between trees to allow for tree swaying.
- Use flange fitting for all hydro installations to prevent leaks at the joints. Silicone seal makes a good gasket.

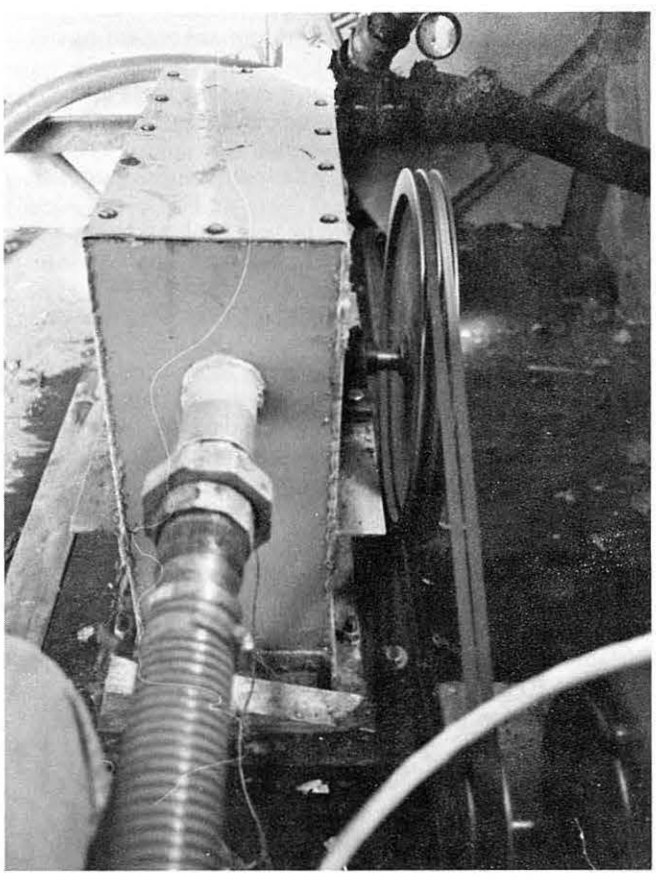
Funding

U.S. Department of Energy	$4,251
State of Alaska	2,811

Grant Recipient

Louis A. Butera
SR Box 1667-ER
Eagle River, Alaska 99577





Louis Butera (top left) rests beside the dam inlet of his micro-hydroelectric project. The water pipeline (top right) snakes its way through the woods. The Pelton system (left) shown inside the powerhouse. (Above), Butera cleans debris from the screen intake.

Hydro success requires careful planning

"After living for three years without electrical power, we are very excited and happy to have electricity anytime we need it. The inside of our house is now bright with both flourescent and incandescent lights; modern appliances grace the kitchen counter tops; and a stereo plays softly in the background. Best of all, those long trips to Ketchikan for fuel and propane are now few and far between—meaning boat fuel also lasts a lot longer."

All-in-all, the Gohrs, James and Maureen, are happy with their new microhydroelectric power plant.

When the Gohrs first moved to Saltery Cove, a small sheltered harbor on the eastern side of Prince of Wales Island, everything was run by propane or gasoline engines. This included the clothes washer and dryer, refrigerator, and even house lights. However, during the 1930's, the Straits Packing Company operated a small cannery in the cove and made electricity from a small stream near the Gohrs residence. The remains of the dam and parts of the wooden penstock can still be seen along the creek. James Gohr figured that if electricity could be produced then, it could be produced now, especially using modern, high output generators.

In 1980, James and Maureen Gohr applied for a water use permit from the U.S. Forest Service. Soon after, they were awarded grants from the AT program to build a microhydroelectric (less than 10 kilowatts) plant on a stream known as Saltery Cove Right. Their project involved building a new dam on the stream, installing a penstock from the dam to a new powerhouse where the turbine and generator would be, and laying underground transmission line from the powerhouse to the family dwelling and shop areas.

Design and Construction

The Gohrs planned to dam the small stream and transport water through an eight-inch penstock about 500 feet, with a 50 foot head, to a Pelton wheel impulse turbine. The turbine's output belt drives a 10-kilowatt, brushless generator. The pulley ratio for the belt drive would be adjusted after installation so that the generator shaft turns at a constant 1800 rpm (revolutions per minute). The generator's output would be 120 Volts AC (alternating current) at 60 cycles per second. Although the generator could produce up to 10 kilowatts, stream flow calculations indicated an actual output potential in the neighborhood of two to three kilowatts.

The dam was made from a large beach-logged cedar that was cut to size and dragged up to the dam site. The wood and rock filled dam, built upstream from the Straits Packing Company site, was calculated to hold back almost 500,000 cubic feet of water. A gate valve and the inlet for the penstock were placed an additional 40 feet upstream. The gate valve is surrounded by a wood and galvanized screen "trash bin". Gohr also installed a short catwalk to the trash bin and valve for periodic inspection and cleaning.

The rigid trestle-mounted penstock hugs the right stream bank. A small slide area had to be blasted clear and a protective covering made during this installation. The penstock enters the powerhouse through a metal reduction tube narrowing its diameter from eight inches to about four inches. The four-inch pipe then splits into two flexible 1¾-inch pipes feeding the Pelton wheel jets. Two jets are used presently, a 1-3/8 and a 9/16-inch (inner diameter) jet. The turbine housing has facilities for

The old dam (above left) which produced electricity in the 1930's. (Above right), Jim and Maureen Gohr arriving home at Saltery Cove.

additional jets if needed later.

The output of the turbine is connected through a belt drive to a Lima-brand 10-kilowatt generator. The Lima was chosen because the Gohrs believed that it is virtually maintenance-free and extremely durable. Both the turbine and the generator are mounted on a hand-poured concrete slab within the powerhouse structure. The output of the generator is transported about 400 feet through 2/0 size underground cable to the house and shop.

System control is through water deflectors and a full load governor. The full load governor is used to evenly distribute the load between a heat sink (electric baseboard heater) and other demands, such as the electric stove or refrigerator. As the electric devices demand power, the load is removed from the heat sink. This works well because the Gohrs ensure that no appliance uses over 1,000 watts and the available power is constantly monitored. A volt meter is mounted with the full load governor in the house for this purpose.

Over/under voltage conditions are also regulated within a range of 110 to 140 volts. Whenever an over/under voltage condition is encountered, a water deflector solenoid is activated, dropping deflectors in front of the water jets, shutting down the system. The loss of power then causes a shunt trip circuit breaker to disconnect power from the transmission line.

Performance

"The system appears to be fail safe," said Gohr. Although they are somewhat disappointed that the generator produces less than half the calculated output (1,300 watts), it produces enough for their needs. A third jet may be added later to bring power output to 1.5 kilowatts.

During initial shakedown, a few small water leaks were encountered, but they were minor and easily corrected. Gohr was very methodical in his shakedown. First, he checked the penstock for leaks and, then ran the turbine for one week to seat the bearings and ensure everything was in order. Finally, the alternator was installed on an adjustable frame, the pulleys and belt installed and the alternator run for a week, with all power going into the heat sink. The result is a very stable microhydroelectric power plant that is getting a lot of interest from others in the area.

Problems and Conclusions

Other than the small water leaks encountered during system shakedown, the Gohrs have had no problems with their power plant. This can be attributed to thorough planning in the beginning phases, selection of a good hydro-engineer, and not taking shortcuts after construction began. Although the lower output was dissappointing at first, it did provide enough power for their needs, in addition to a little extra so that their neighbors could charge batteries or run small power tools.

Other land owners have also begun to show interest in hydropower. One has already obtained a 12-inch Pelton turbine and is planning to build a water-powered battery charger. The Gohrs have also been asked to consult for other similar hydro projects in the area.

Tips

"Check and recheck your available water system and install a system compatible to the available water," says Gohr. Also, great care must be taken at the dam so that small face leaks do not enlarge and cause water losses. But, above all, remember what Francis Soltis, their hydro engineer told them, Gohr said: "When you turn it on, you find out how much power you will have—each system performs differently." Don't get frustrated if things don't turn out exactly as planned.

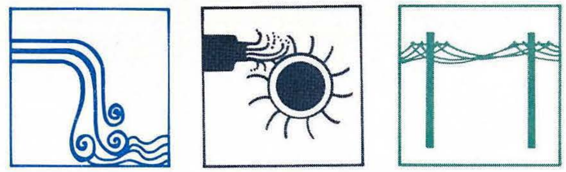
Funding

U.S. Department of Energy	$5,300
State of Alaska	5,300

Grantee

James and Maureen Gohr
Box 6077
Ketchikan, Alaska 99901

What a difference a hot bath makes



Sixty miles south of Sitka, near the tip of Baranof Island, is Port Armstrong. Once a shore station for the U.S. Whaling Company and later a herring reduction plant, a few residences and a hatchery now nestle among the few remaining signs of the former facilities. The once profitable salmon fisheries are reduced to a third of their former levels and the herring catch is limited to seasons measured in hours.

However, today's residents of Port Armstrong are looking beyond the ruins. A commercial 10 million-egg chum salmon hatchery is now in operation. This hatchery will bolster the reduced salmon fishery. Other plans include a 20-ton cold storage plant to support a new bottom fishing industry; and a small commercial greenhouse that will supply fresh produce.

The only drawback when the initial plans were being made was the lack of electrical power. Commercial diesel units were available, but the residents weren't sure if they wanted a noisy, foul-smelling, fuel-gulping diesel in the midst of their town.

During the time that Port Armstrong hosted a herring reduction plant, power was supplied by generators driven by no less than 11 Pelton wheel generators.

Richard Mathews, a veteran commercial fisherman and Harvard graduate, figured that what worked once could work again. Next to the small community is a year-round stream draining a small mountain lake. This stream was used to power those generators before, and its 285 foot drop from the lake to the sea was more than enough to drive a modern, high-efficiency microhydroelectric power plant.

In order to be sure that hydropower would be a good choice, Mathews compared the price of a 50 kilowatt diesel generator plus one year's supply of fuel with the cost of a complete microhydroelectric power plant. To his surprise, there was not much difference. Hydropower had to be the answer to Port Armstrong's power problem. In addition to being cost effective, it would save over 35,000 gallons of fuel oil yearly.

In 1980, Mathews obtained an AT grant to build a hydroelectric project in Port Armstrong. The project involved installing a penstock from the headwaters of the small stream outflowing from Jetty Lake, building a power house and installing the turbine/generator, and installing an underground power grid to the various end users. Dreams of long baths, fresh vegetables, and other comforts soon filled the three-house village.

Design and Construction

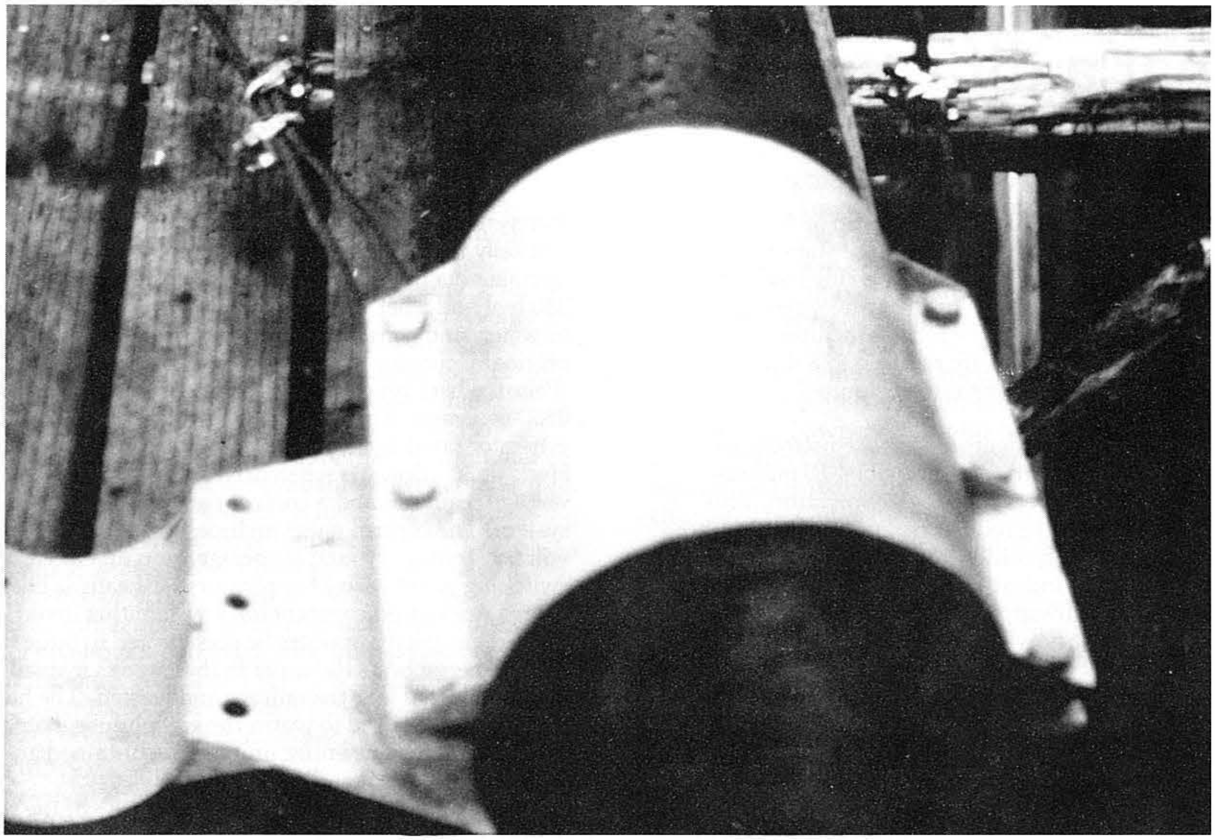
The hydroelectric plant had to be able to supply the needs of the planned commercial hatchery, greenhouse, cold storage unit, and the three local residences, plus a small wood shop/boathouse. The penstock would have to be more than 1,300 feet long with a 285 foot drop, all over rough terrain. In places the penstock could be secured directly to the bedrock; in other areas, heavy cement weights would have to be used. Because Port Armstrong is a fishing-oriented community, the generator system would also have to be easy to operate and virtually maintenance free. The unit also would have to operate on a net head after friction loss in the pipe of 230 feet and a net flow of 3.5 cfs (cubic feet per second of water) and generate at least 48 kilowatts. Mathews originally chose a Peltech Model 975 impulse turbine (Pelton wheel-type) connected directly to a Kato #6P2-0850 generator. This was changed to a Lima belt driven generator rated at 440 volts, alternating current, and 60 Hertz at 50 kilowatts when driven at 1,200 rpm. A Basler voltage regulator and a control panel completed the system. The control panel includes full metering for voltage, frequency, and amperage, plus an electronic switching panel with 24 contactors for heaters. These form a prioritized constant load system that diverts unused electricity to water heaters located in large tanks. Excess energy heats the water in these tanks instead of being deflected into the tailrace and wasted. The heated water in turn is used to warm the greenhouse, hatchery, and residences. The entire unit is self-contained and skid-mounted making installation relatively easy.

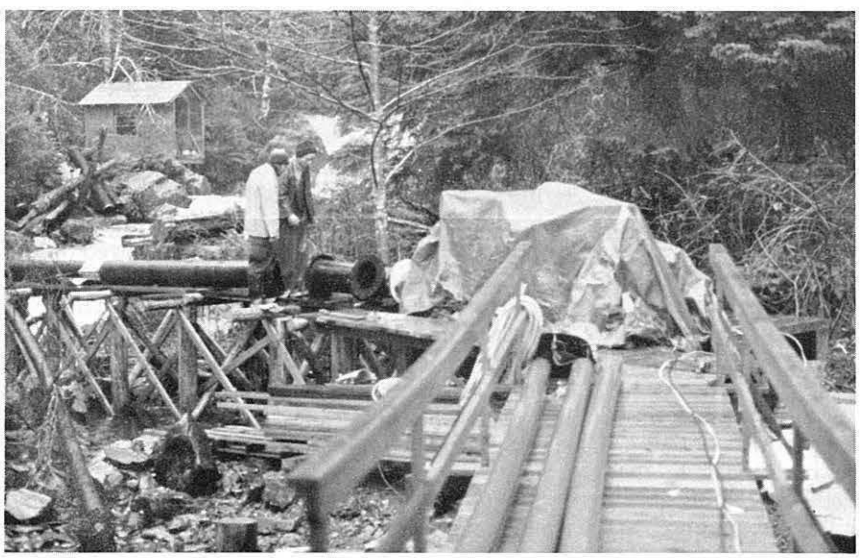
The penstock was another story. Because of the rough terrain and lack of room for a trestle, a flexible but strong polyethylene pipe was used. The pipe material, trade name "Driscopipe 8600," is heat fused to form one continuous piece with a single flanged joint fused to the penstock where it attached to the turbine. This pipe was chosen because it is tough and flexible, has low friction, and can freeze solid without rupturing. More important, Mathews obtained more than 900 feet of it at discount from the dormant Starrigavan hatchery in Sitka.

Installation of the pipe was accomplished by helicoptering sections to the edge of Jetty Lake along with a special machine to heat fuse them into the one continuous piece. The heavy, black pipe was shoved out into the lake as sections were added; then, the 1,300 feet length was towed down the hill as a single piece. There were a few side bets on the success or failure of this scheme. Someone in town even predicted that the whole mess would end up at the bottom of the grade looking like huge coils of licorice. Luckily, there were no problems when the pipe was pulled down the hill.

The penstock is supported in the lake with 210 pound pre-cast concrete blocks. A weighted crib of treated timbers with a stainless steel screen was used to weight down the open end of the pipe and keep debris from entering it. Between the lake outflow waterfall and the powerhouse, rock anchors, galvanized steel cable, and restraining collars were used to keep the pipe from slipping.

The 10-by-12-foot frame powerhouse shields the turbine and generator from the Southeast's perennial rains. The penstock, after a 285 foot drop, enters the powerhouse and is attached to the two-nozzle Peltech turbine. A Woodward hydraulic governor keeps the output frequency at 60 Hertz.





A metal saddle (above) clamps the pipeline. Richard Mathews and an assistant (left) prepare to install the 300 lb. gate valve.

From the powerhouse, underground wires lead to the newly constructed salmon hatchery, the cabins, shop building, and cold storage facility. Underground cables were chosen to keep the aesthetic beauty of Port Armstrong intact.

Performance

At 4:30 p.m. Christmas Eve in 1981, Richard Mathews threw the switch and the Port Armstrong hydro system went on line. For the first time in more than 20 years, electric lights glowed in the winter night. In celebration, a large roast was cooked in an electric range for a special Christmas dinner. Two other residents eagerly waited their Christmas present, long baths in water heated by "electric" water heaters. Baths in the "old days" required heating big awkward pots of rainwater and lugging them out to a bathhouse. While they soak in the laps of luxury, their clothes will be drying in an electric dryer.

From all indications, the power plant is a resounding technical and social success. There is enough power available for the hatchery, shop, cold storage, cabins, and grow lights in a greenhouse. The unit produced consistent power throughout the year, never experiencing freeze up, or lower output during the winter months when stream flow was minimum.

Conclusions and Problems

There were very few problems with this project other than the design changes in the power house. The original Kato generator and control panel were replaced by a less expensive, but equivalent Lima generator. The Lima's belt drive mechanism posed no problems to Mathews as the turbine/generator was purchased as a complete unit. All modifications were done by the manufacturer.

Mathews' method of developing this project successfully shows that with proper planning it is easy to install hydroelectric systems in remote locations. The almost forgotten technology has tremendous potential in this area of Alaska and the modern self-contained units which are assembled, aligned, and tested in manufacturing centers makes the power plants relatively simple to install, operate, and maintain. Another point Mathews likes to make is that the system is environmentally sound, does not pollute; operates quietly; and has an extremely long life in relation to other electrical power generators.

Funding

U.S. Department of Energy	$22,084
State of Alaska	26,325

Grant Recipient

Richard Mathews
Box 538
Douglas, Alaska 99824

Hydraulic ram ensures reliable water supply

An innovative pump powered by water from a nearby creek works "fine" as it provides a continuous supply of fresh water from the same stream for most of the year to the home of Don and Kathryn Chaney.

In fact, adds Don, it was Kathryn who designed the hydraulic ram system that is driven by a small amount of the water tapped from the creek.

The water drops three feet as it flows through a two-inch pipe from the creek to the hydraulic ram.

This vertical drop provides adequate force to drive the pump, which lifts the rest of the tapped water through a one-inch pipe to a 500 gallon storage tank 23 feet above ground.

Don, a retired telephone construction and maintenance worker, says the pump also provides water for a nearby greenhouse. He describes the enclosed storage facility as a "mini-city water tank."

As long as the water behind a small diversion dam in the creek maintains its three-foot level, and the temperature remains above 21 degrees, Chaney says their domestic water supply source is "reliable."

A gasoline-powered pump is used to lift water to the insulated tank for one to two months each winter.

Otherwise, the only interruption in the operation of the hydraulic ram-driven pump is "an occasional cleaning that takes about 10 minutes. It's really simple," he says.

The system has been operating since 1980.

The hydraulic ram, a type that has been manufactured since 1894, operates silently, and pumps water continuously with only the energy of a portion of the tapped creek water.

It has eliminated the year-round operation of a 7,000-watt gasoline powered generator that used about six gallons of fuel a day to run a one-half horsepower electric water pump and electric water heater.

A wood-burning water heater now supplies the Chaney's domestic hot water needs.

Part of the system's success is its location. The Chaneys live near Petersburg in Southeast Alaska, where the climate is comparatively mild and water is abundant. The town lies along the Alaska Marine Highway (ferry system) Inside Passage and is resplendent with spruce and tumbling waterfalls.

Don says there is "certainly" enough water in the creek (excess water pumped into the tank is returned to the stream) to support similar systems in the area—if more people lived near the water.

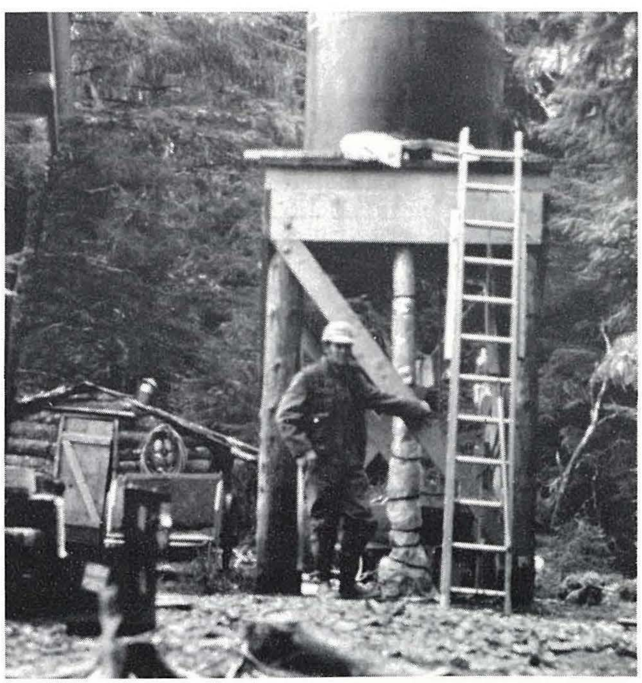
The system also is practical for widespread use where climate and water conditions are favorable, he adds.

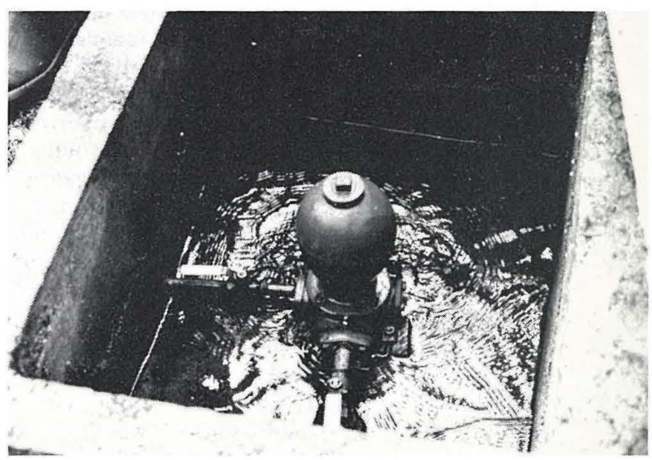
Funding

U.S. Department of Energy $1,535

Grant Recipient

Don Chaney
P.O. Box 1276
Petersburg, Alaska 99833





Freon steam propels turbine

Sometimes an idea comes along that's so simple but so unique that nobody believes in it. Arthur Manning had that problem when he first proposed his novel power generation idea. He even asked a professor from the University of Alaska—Fairbanks' Geophysical Institute for a professional opinion—"It won't work because you can't build a perpetual motion machine," he was told.

It's to our benefit that people like Manning aren't deterred by "experts." He knew his idea for generating electrical power would work and could benefit groups needing power in remote locations.

Conventional methods of generating electrical power have either a fossil fueled motor turning a generator or water or steam turning a turbine, which in turn turns the generator. What Manning proposed was not really much different from a conventional steam-powered electrical generator. However, instead of boiling water, he wanted to boil Freon and use the Freon steam to propel a turbine. Because Freon typically boils at -20 degrees, the colder it got outside, the more efficient his system would get.

In 1980, Manning was granted funds to build his Freon powered electrical generator. He proposed to develop a device that could tap hydrothermal sources, a previously untapped energy source. The project involved building, operating, and monitoring a hydrothermal Freon electric power plant.

Design and Construction

Manning wanted to prove that you could use the temperature difference between warm, running water and outside ambient air temperatures (especially in the winter) to develop electrical energy. His prototype system would produce 2.25 kilowatts of power at 115 volts, alternating current. The energy used to boil the Freon comes from the relative warmth of a lake or moving water. The Alaskan winter will be used to enhance that warmth, producing more electricity during the winter when the demand is the greatest. The system could also be used in geothermal areas that do not have enough steam pressure to drive a turbine or ice island research stations where energy sources are limited at best.

Manning's design closely paralleled the construction and operation of a low pressure, closed loop steam plant. His Freon plant would have a heat exchanger; low pressure, high expansion turbine; governor; condensor/expansion chamber; feed pump; electrical generator; and the necessary system controls and monitoring devices.

The four-by-five-by-six inch heat exchanger is made from ½-inch O.D. (outside diameter) hydraulic tubing arranged in three rows on two-inch centers with a total surface area of 53.7 square feet. Steam-type pressure flanges rated at 600 psi (pounds per square inch) connect the pipes carrying hot Freon from the heat exchanger to the jet harness on the turbine unit. These connections provide great strength while allowing a slight amount of movement. Valves placed in both the supply and return lines enable manual shutdown and complete isolation of the heat exchanger from the rest of the system.

One-inch I.D. (inner diameter) stainless hydraulic tubing runs from the heat exchanger to the jet harness. The jet harness feeds 16 jets up to ¼-inch diameter. The size used depends on the outside temperature conditions, load factor, and type of Freon used. A butterfly valve in the pressure feed line controls pressure input to the turbine. A governor built as an integral part of the turbine assembly controls speed fluctuations.

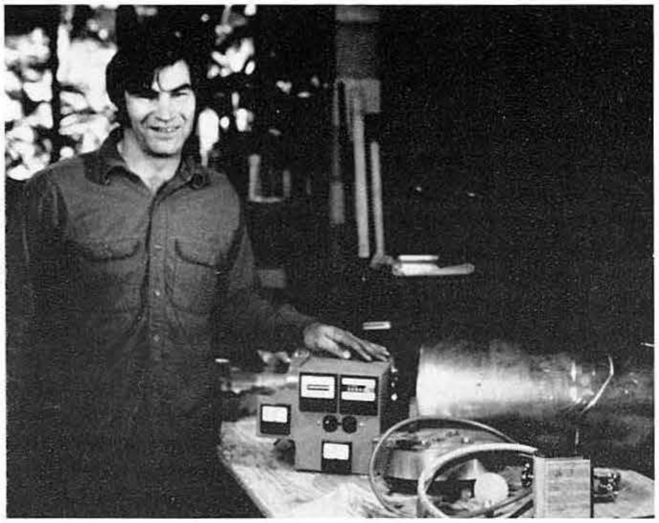
The low pressure, high expansion turbine consists of a sliding rotor, governor mechanism, and evacuated housing. The self-throttling feature Manning used is important because the Freon gas pressure will change with the ambient temperature change. The governor mechanism is a flyball arrangement that physically moves the rotor as speed increases. Turbine fins are cut so that as the rotor slides with the increase in speed, they restrict the amount of Freon gas allowed to enter the rotor area. When resistance causes the rotor to slow, the governor action causes more gas to enter the rotor chamber producing more thrust, overcoming the resistance. This action keeps rotor speed relatively constant under varying load conditions.

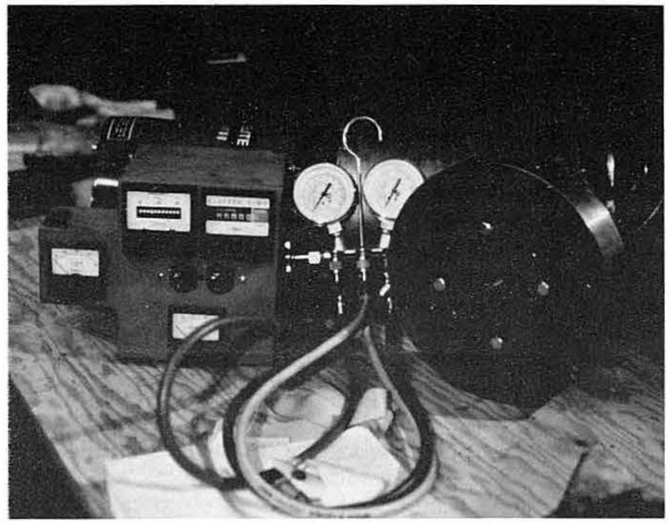
The 10-by-24-inch expansion chamber has a two-by-seven-inch deep liquid collector at the far end. A pressure/vacuum seal between the chamber and the turbine housing ensures that this joint will be both pressure and vacuum tight. The housing is designed to operate at pressures up to 26 psi and temperatures exceeding -40 degrees. Although this may seem like a bit of overdesigning, the prototype system experienced even colder temperatures during actual operation. "I have no idea what the max was," says Manning, "the temperature went clean off the scale, maybe -80 or more."

A magnetic, impulse-activated solenoid drives a spring powered feed pump to return liquid Freon to the heat exchanger. As the level of liquid Freon in the bottom of the expansion chamber rises to a predetermined level, a magnetic float/reed switch operates, activating the pump. Freon is drawn through a one-way valve into the heat exchanger feed line. Liquid Freon will flow until liquid level in the collector area of the expansion chamber falls enough for the reed switch to open.

The generator is a Homelite, singlephase, 2.25 kilowatt, 110-volt, 60 Hertz unit operating at 3,600 rpm. This generator was chosen because Manning knew it to be well made, dependable, and requiring very little maintenance. Also, it has a taper-drawbolt type of connection that allowed true concentric coupling of the turbine to the generator. Manning modified it so that monitoring instruments could be attached to the outer housing.

The instrument monitoring panel has a frequency, voltage, and amp meter. Additional monitoring devices include temperature probes placed in the heat exchanger, warm water supply, turbine housing, expansion chamber, plus a temperature probe placed in the atmosphere





Arthur Manning (above left) explains the unique design of his system. (Right), shown here are electrical gauges and the unmachined turbine used in the design

near the expansion chamber and outside the test building. This configuration allowed monitoring of the heat exchanger, the effect of high and low load conditions on the expansion chamber, and the effect of ambient air temperature on the efficiency of the system.

A pressure gauge is also located on the pressure line between the heat exchanger and throttle valve, between the throttle valve and the jet harness, and on the turbine housing directly over the turbine fins.

Performance

The prototype unit was housed in an eight-foot square building on skids placed over a hole in the ice of the Chena River. The building shields the equipment from the elements and allowed for artificial heat for greater experimental control of the ambient air temperature.

Start-up of this system requires the operator to generate an artificial vacuum in the expansion chamber and to prechill the condensor walls. As the system is turned on, the expanding Freon gas chills the expansion chamber below the condensing point of the Freon, causing a partial vacuum. Because the feed pump creates a pressure of 18 psi on one side of the turbine, and the expanding Freon itself creates a vacuum on the other side (about eight psi) a pressure difference of approximately 26 psi is actually created within the system during normal operation.

After initial start-up, the prototype was allowed to operate continuously for a week with 12-hour checks. Then the unit was shut down and dismantled for inspection. A second five hundred hour test was then run. After the long test, the system was again shut down for inspection. Prior to breakup, the test building, prototype unit, and heat exchanger were removed and test results tabulated.

Manning found that although his device did produce electricity, system control was more difficult than originally expected. The non-linearity of the expansion of the Freon made speed control difficult using only the simple spring/flyball arrangement and sliding rotor. "The system either tries to run away with itself, or shuts down," said Manning, who feels that a more sensitive control system may help solve this problem.

It was also found that the heat exchanger configuration did not allow optimum heating of the Freon; but, because the Chena River supplied more than enough "warm" water, the original design was adequate. In other situations, the design may need to be modified.

Problems and Conclusions

"You've got to be kidding."

This just about sums up the technical assistance Manning got throughout this project. Relying on personal creativity, many hours of research, and belief in his own ideas was what Manning used to prove his theory. Although his Freon powered generator is not cheap and cannot compete with today's fuel prices, it did work. In making it work, Manning had to overcome funding problems, extreme temperature effects on metal and gaskets, speed control at those varying temperatures, and a lack of supporting information. He was essentially on his own.

Early in the project, funding delays by the federal and state agencies caused costly project delays. The U.S. Department of Energy reduced the requested funding for the project by 30 percent. The funding reduction and delay caused Manning to change the expansion chamber design as the original model was no longer available by the time funds were received.

With little support from the university, turbine design was based on the hope that the extreme cold temperature would not critically affect the metal. As it was, the metal held up fairly well; only one of the flyballs used in the governor cracked from the cold. Although the temperature extremes were greater than originally calculated, increasing system efficiency, it pressed the seals and gaskets in the prototype to their limits. The temperatures of the lubricants decreased their effectiveness, which increased friction. Further developments in these areas will probably have to be done before a suitable material or lubricant is found.

"In small scale operations, it's almost impossible to control speed accurately without costly electronics or computer controls," Manning adds, "large scale units would be more efficient because they wouldn't be as touchy." However, when Manning approached developers for additional support in this project (a proven concept), the common response was: "You've got to be kidding." It now sits in boxes in Manning's machine shop, waiting for another chance.

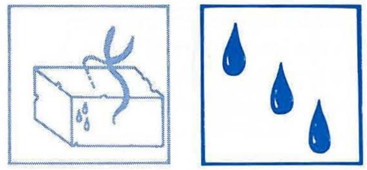
Funding

U.S. Department of Energy	$4,547
State of Alaska	4,547

Grantee

Arthur Manning
P.O. Box 10013
Fairbanks, Alaska 99701

A water-powered refrigerator



Don Bailey is keeping his food chilled by circulating cold well water through an innovative refrigerator that doesn't use electricity.

It's also saving him about $3 to $5 monthly on his fuel bill.

But there are a few drawbacks.

Bailey cannot keep ice cream frozen, make ice cubes or keep his milk very cold because the refrigerator never gets colder than about 43 degrees.

"Our refrigerator keeps liquids at about 43 to 45 degrees—a little warm," said Bailey, who lives in Anchor Point on the Kenai Peninsula in Southcentral Alaska.

"As long as the water flows, the refrigerator works great. When no one is at home, the system doesn't work," he said.

Design

Bailey modified a used upright freezer and installed more than 40 feet of coiled, three-quarter-inch fin tubing on its interior walls. Almost all of the interior surface of the freezer was covered to increase the amount of water flowing through the system.

Bailey also said he selected a freezer because it is better insulated than a refrigerator and doesn't have a separate freezer compartment, making the fin tubing installation easier. All fin tubing was soldered securely to the refrigerator's interior walls so that vibrations didn't break the fittings loose.

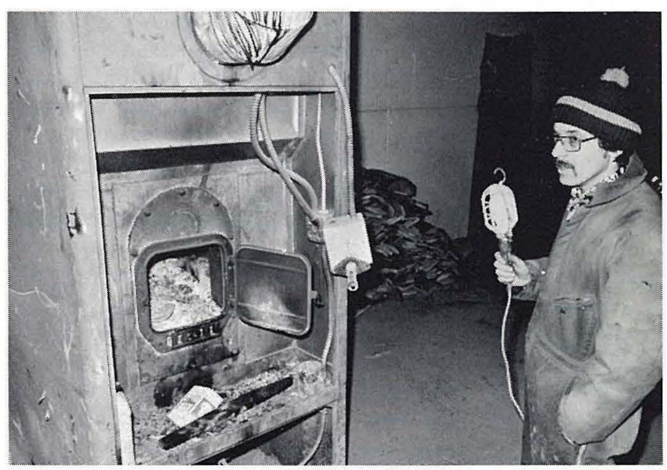
The fin tubing is linked with Bailey's water supply from his well. The pipe from the well's holding tank was insulated to keep the water temperature as low as possible. The water temperature ranges between 34 to 40 degrees.

The water, however, only circulates through the refrigerator when someone in the house turns a faucet on, because the water flows through the refrigerator on its way to the faucet.

"Everytime someone flushed the toilet, took a bath, did the wash or did dishes—cold water would circulate through our refrigerator, cooling the interior and its contents," Bailey said.

Before installing the system, Bailey flushed water through the used fin tubing for over a day and used Clorox to disinfect the inside of the tubing.

Fin tubing that has been used in a heating system should not be used later for a domestic water system because you can never be sure what may have contaminated the pipe. For example, had toxic antifreeze once been used in the fin tubing, water circulated through the system could not be used for drinking or cooking. Where national plumbing codes are in force, this practice is not allowed.



The interior (left) of Don Bailey's water-powered refrigerator. Bailey shows the oil furnace he converted to wood (above).

Two valves were installed in the water line so that Bailey has the option of having water bypass the refrigerator. The second valve, placed in the lower part of the pipes, enables him to drain water from the coils for repairs or cold weather shutdown.

Performance

Bailey is generally pleased with his refrigerator. It was simple to build and has been almost maintenance-free. Also, it's helping him reduce his electric bill.

"All items, except milk, keep well in our refrigerator," Bailey said.

The major drawback is that there is no way to keep the refrigerator cool when there is no one at home for a day or two to run water. One solution is to leave a faucet dripping, but then the well pump has to run unnecessarily when no one is at home.

Bailey also had to increase the well pump's pressure to provide the desired pressure at the faucets. The extra piping through the refrigerator causes a greater pressure drop between the pump tank and the faucets.

Funding

U.S. Department of Energy	$200
State of Alaska	$200

Grant Recipient

Don Bailey
Box 79
Anchor Point, Alaska 99556

Bush refrigerator an unqualified success

Out near Trapper Creek, going to the store can be a bit more involved than walking to the end of the block or driving to market. First, you stoke the trusty wood stove, tossing in a couple of extra logs for good measure; then, move all the water containers closer to the stove so they won't freeze when the fire burns low; finally, high-tail it three miles through deep snow to the nearest store. Don't stay long, because you have to be back at the cabin before the houseplants freeze.

Trapper Creek is a small community near the Parks Highway some 100 miles north from Anchorage. This small homesteading and gold mining community has about 200 year-round residents sprinkled among dense stands of spruce and birch. For these people, the area offers natural beauty and seclusion, yet easy access to one of Alaska's major highways, and on clear days a spectacular view of North America's largest mountain, Mt. McKinley (Denali).

Perry Hilleary was building a house on his property near Trapper Creek early in 1980 and thought that it would be nice to be able to leave home for a couple of days without fear of freeze damage. While he was at it, he figured to tackle "Bush refrigeration" too.

In the fall of 1980, Hilleary received an AT grant to build both the heat storage and refrigeration systems, plus record data illustrating the success of the project.

Design and Construction

Each section of this two-part project had the same development criteria: materials had to be easy to install, maintain, and operate; they had to be inexpensive; and they had to be energy efficient. In return, the two systems would provide some of the comforts that urban folk take for granted and rural dwellers dream about.

The heat storage system begins with a seven-foot-eight-inch by twelve-foot-eight-inch by fifty-four-inch deep concrete block structure built in the basement of the cabin. Four-inch Thermax brand Polyisocyanurate insulation was used to line the inner surface of the box and the leveled box floor. After a layer of sand is applied to the bottom, a horizontal three-pipe grid of four-inch ventilated tubing was placed across the short axis of the heat sink. Each horizontal tube has three, four-inch ventilated pipes rising vertically from them. Above this is another grid of one-inch copper tubing. The copper tubing is looped along both sides of the vertical risers, crossing the horizontal tubes at right angles and the entire structure is backfilled with a compacted clay/sand/pea gravel mixture. Hilleary believes that this design distributed heat better within the heat sink. Another four inches of Thermax tops off the heat sink.

The copper tubing feeds through the concrete block wall of the thermal mass into a furnace/control area. Here, they connect to an expansion tank, pressure relief valve, and heat coils from the 55-gallon drum/barrel stove. Originally, a small battery-driven pump was used to push the antifreeze solution through the heat sink. The battery was kept charged by a small portable generator. However, this pump was quickly discarded when Hilleary found that the liquid was flowing too fast through the heat sink to give up heat. Thermoconvection now propels the antifreeze through the system.

The second part of this project involved building a semi-passive "Bush refrigerator." By using a drawer-type of refrigerator instead of the standard door refrigerator, Hilleary hoped to decrease the cooling energy enough to make a simple, but effective system.

The refrigeration chamber is located under a U-shaped kitchen countertop. A wood cook stove is at one end of the "U" and a propane stove at the other. The cooling box is insulated by a two-inch thick rigid Thermax. Attached to the back wall of this box is a serpentine loop of ½-inch copper pipe. One end of this tubing exits the cooling cabinet and runs along the underside of the countertop to the wood cook stove. It rises along the backside of the cookstove fluepipe, held on with metal straps, and exits the cabin near the ceiling. The pipe then drops into the ground in a long 60-foot loop beside the house and returns through the log wall to the lower end of the serpentine loop in the cooling cabinet. An antifreeze solution fills the copper pipe.

When the woodstove is being used the antifreeze is heated slightly, causing a convection flow up through the pipe. The liquid flows down through the ground, cools, and then returns to the refrigerator. When the woodstove is not in use, a small battery-powered, 12-volt pump provides the needed circulation. Through experimentation, Hilleary discovered that a continuously running pump pushed too much liquid. A switch from a car windshield wiper is used for intermittent operation. The pump runs for one second, then rests for 13.

The drawers are also customized for different food container sizes. One has an egg tray. The bottoms of the drawers are made of wood slats for better circulation.

Performance

The first part of the project (the heat sink) worked even better than expected. Hilleary originally calculated that the thermal mass could store up to one million BTUs of heat. Even with the small pump removed, however, it was determined that the mass could store enough heat to supply the house with about 465,000 BTUs of heat per day for up to three days without additional heat input. The ability to selectively uncover only the amount of thermal mass needed to keep the house above freezing greatly enhanced the effectiveness of the system.

Storing heat in the heat sink also saved on fuel requirements because it allowed a more efficient, hotter fire to be burned in the barrel stove.

The "Bush refrigerator" was an unqualified success. The R-8 Thermax, combined with the simplicity of the system, resulted in an easy to install, relatively energy free system. Outside energy is required only during the summer when the wood stove is not used. Then only periodic charging of the battery is required. The addition of a small solar powered pump would reduce this power requirement to zero. Measurements indicate that the refrigerator effectively cools foods to about 40 degrees with a ground temperature variation from 39 to 44 degrees.

Problems and Conclusions

Hilleary encountered few problems building either system. He has successfully shown others that a heat storage and heating system and a "Bush refrigerator" can both be built with less than $1,000 in materials. Now, whenever Hilleary goes out to the store, he can stay and chat for a while.

Funding

U.S. Department of Energy	$432
State of Alaska	432

Grantee

Perry E. Hilleary
Box 21
Trapper Creek, Alaska 99688

In Perry Hilleary's home (above) near Trapper Creek, the kitchen drawers are refrigerated.

Kenai City Hall saves energy

Since 1981 an air-to-air heat exchanger has helped the City of Kenai save energy by pre-heating air circulated through City Hall. The prewarmed air for the ventilation system has meant less demand on the building's oil-fired heating system.

The exchanger recaptures heat from exhaust air and uses it to preheat fresh air as it's drawn into the 12,000-square-foot government building from outside. The south wall of the building also is made of triple-glazing for solar heat absorption.

Howard Hackney, city building inspector for Kenai, said the system is working well and has not malfunctioned. He said it works at about 66 percent efficiency.

And architect Carmen Gintoli estimates the exchanger has reduced the city's annual oil consumption by about 3,279 gallons.

"It's always on," Hackney said. "It picks up the heat from the exhaust air and tempers the incoming air."

System Design

The heat exchanger, manufactured by the Q-Dot Corporation, was installed in a duct on top of the city hall roof.

The duct, which is about eight feet square, is partitioned into two sections; one for incoming air and the other for exhaust air. Fans continuously expel exhaust air from the building and replace it with fresh air.

The air-to-air heat exchanger, which is about five feet wide by 10 feet long, was installed inside of the big duct. The heat exchanger has a center assembly with rows of protruding aluminum fins that span across both the duct for incoming air and the duct for exhaust air. (The system is partitioned so that the exhaust air does not mix with incoming air.)

The heat exchanger is mounted on a tiltable axis to control the flow of the Freon that is used to conduct heat to the fin assemblies.

When the heat exchanger is tilted toward the exhaust duct, liquid Freon flows into the fins bathed by the hot air. As the Freon absorbs the heat, it converts to a gas which rises upward into fins spanning the cooler incoming air duct.

As the cold air absorbs the heat from the fins, the gas converts back into a liquid and flows back down to the exhaust side to be heated up again.

In summer, the heat exchanger can either be shut down or used to cool incoming hot air by tilting it so that the liquid Freon flows into the fins spanning the incoming air duct.

During mid-winter, a hot-water boiler also is used to provide supplemental heat for the building.

Performance

City officials say they are pleased with the heat exchanger. They say it has been working well and has required little maintenance. Architect Carmen V. Gintoli estimates that the system saves about 365,719 BTUs per hour, conserving about 3,279 gallons of fuel over the year.

Funding

U.S. Department of Energy	$4,225
State of Alaska	4,225

Grant Recipient

City of Kenai
P.O. Box 3504
Kenai, Alaska 99611

A wastewater heat exchange system

Every time someone takes a shower, runs a dishwasher or washes clothes—precious heat is lost as the water swirls down the drain.

But Mark Gudschinsky has designed a compact, virtually maintenance free system to help homeowners recover heat from wastewater.

It's called a greywater heat recovery system.

"It definitely works real well," says Gudschinsky, a plumber and apartment owner in Fairbanks, Alaska. "And I'm going to put it in the other buildings I own."

Before installing the system, however, Gudschinsky suggests that homeowners make sure that they produce enough wastewater—at least 3,000 gallons monthly—to make the system cost effective. Also, he advises against installing the system if it will require major plumbing changes.

Gudschinsky's system preheats the domestic water by as much as 40 to 50 degrees before it enters the hot water heater. And it's helping him save some $300 annually on his hot water heating bills.

Better yet, the system is compact and virtually maintenance free.

"I put mine in the laundry room corner," Gudschinsky said. "My goal was to make this so it would be out of sight and out of mind. I didn't want pumps and stuff. I wanted absolute simplicity."

System Design

The greywater heat recovery system consists of a three-to-four gallon sealed, steel tank, with three-sixteenths-inch walls. It is 24 inches long, 16 inches high and 6 inches wide.

Wastewater from the showers and dishwasher flows directly to and through the tank before being discharged into the city sewer lines.

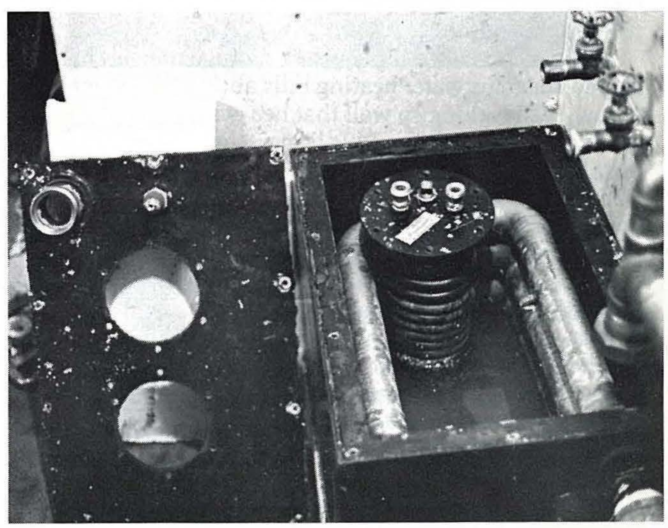
Cold, incoming domestic water is piped through the tank through two Crane finned copper coils, which are immersed in the warm wastewater tank. The system raises the temperature of the domestic water by as much as 40-to-50 degrees, before it flows into the oil-fired hot water heater for warming to household use temperature (110 to 120 degrees).

Small thermometers measure the temperature of the greywater and of the domestic water as it enters and exits the sealed tank.

Gudschinsky also experimented with two variations, but found that they were not cost-effective.

One variation consisted of segregating dishwasher and washing machine water by moving it through the tank in a copper pipe enroute to the sewer system. This was to prevent contamination of the greywater (from sinks and showers) with food and dirt sediments.

Gudschinsky, however, does not recommend install-



Mark Gudschinsky (above left) explains the details of his invention. (Above right), a manufactured coil collects heat from wastewater.

ing a separate copper pipe for dishwater and washing machine wastewater because it increased the cost of the system by $300 and because tank contamination is not a problem.

Gudschinsky also tested a waterjacket arrangement, which consisted of installing a small pipe inside of a wider tube. The greywater flows through the inner pipe, heating the domestic water which encases it.

This design, however, did not work out because a homeowner would have to install a waterjacket about 60-to-70 feet long to obtain satisfactory temperature increases, he estimated.

Performance

Gudschinsky's greywater heat recovery system is performing better than he expected.

It boosts the temperature of his domestic water from about 42 degrees to 80-90 degrees before it enters the hot water heater.

This saves at least 168 to 336 BTUs per gallon of hot water used, he calculates. For a 15-minute shower using 30 gallons of hot water, 5,000 to 10,000 BTUs will be saved, which is about one-twentieth to one-tenth of a gallon of oil for a heater firing at 80 percent efficiency, Gudschinsky said.

In Fairbanks, this means a 6 to 14 cents in savings per shower, no small cost reduction for apartment managers or tenants.

Tips

Gudschinsky says he's learned several things from his project:

- Homeowners should make sure that they can recycle the heat from enough hot wastewater to make the project feasible. As noted previously, Gudschinsky considers 3,000 gallons of water monthly usage a minimum.
- Do not install the system if it will require major—and expensive—changes in the plumbing.
- Consider insulating the house first and other conservation measures, before installing the wastewater heat exchanger system.

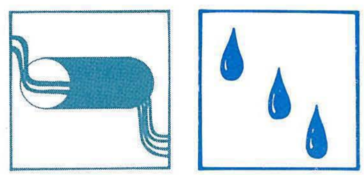
Funding

U.S. Department of Energy	$3,495
State of Alaska	3,495

Grant Recipient

Mark Gudschinsky
1608 Laurene St.
Fairbanks, Alaska 99701

Heat exchanger cuts fuel bills



Instead of tossing out hot water used for bathing, cleaning and washing, Richard Runser is recycling it to pre-heat his domestic water.

The system, called a greywater heat exchanger, has helped slash his water heating bills about 40 percent. In fact, it's working so well that he's even designed a more compact version of his heat exchanger that could be installed in new homes.

"I think it's wonderful—it's one of the few successes I've had," says Runser, who has dabbled in solar energy, heat extractors and other alternative energy devices. "I really believe this would save a lot of energy for homeowners, commercial users, and industries."

Runser, a science teacher at East High School in Anchorage, says the high costs of energy make it desirable to conserve wasted heat. This philosophy of energy conservation also is practiced by his family on their five-acre farm in the heart of the Matanuska Valley north of Anchorage. They built their own house and raise goats, pigs and sheep, not unlike the colonists who came to the Valley in 1935 under the New Deal. The government program gave the colonists 160 acres to clear, farm and live upon. Today, the Valley remains as Alaska's rural agricultural center.

Moreover, the greywater heat exchanger is simple to build and install in a home, apartment building or commercial enterprise, he says.

"This project is intended to develop and test a heat exchanger system which will remove much of the wasted heat and recycle it to the domestic hot water heater," he says. "Some of the recovered heat may be diverted to the toilets where it is needed to prevent condensation around the toilet and the resulting damage from the moisture."

System Design

Runser's heat exchanger is based on piping cold water through a larger tube filled with hot waste water from the sinks and showers (known as greywater). Heat from the wastewater warms the domestic cold water as it flows to the hot water tank. The wastewater passes out of the heat exchanger to the sewer.

The heat exchanger, installed in Runser's basement, is formed of four, six-inch PVC plastic pipes. The pipes are linked to form two upright U sections. He sealed the four tops of the vertical PVC sections with urethane foam.

Hot wastewater flows down and up one U-section before flowing through the second U-section. These two U-sections segregate the greywater into four different temperature zones.

Domestic cold water flows through three-quarter-inch copper pipe in the heat exchanger. It moves in the opposite direction as the wastewater.

The domestic water flows through the two U-sections, gradually moving from colder to warmer wastewater. The temperature of the cold water can be increased by over 40 degrees.

Runser also installed gas vents at the top of each U-section. The gas vents are connected to the home's sewer system. There also is a clean-out plug at the bottom of each U-section to allow for any cleaning of sediment or sludge build-up.

Performance

Overall, the heat exchanger has functioned without any problems since it was installed in the winter of 1980.

Incoming and outgoing greywater and cold water temperatures have been measured with thermometers to evaluate the system's effectiveness.

Runser discovered that the cold water temperature has been increased by as much as 46 degrees. He estimated that his heat exchanger is helping him save between 30 to 50 percent on his hot water fuel bills.

Moreover, Runser's heat exchanger is compact enough to be installed in almost any new home with only a minimal increase in cost.

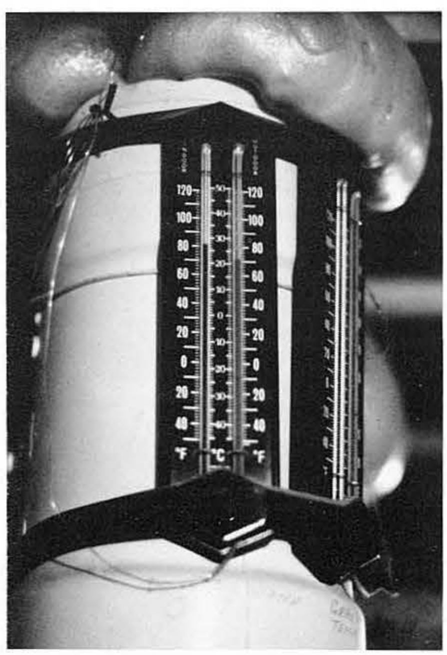
"It could be adapted for any home," Runser says. "It would be extremely simple to build. And I'm really convinced it is an energy-conserver. It extracts heat out of the wastewater before it goes down the drain."

Funding

U.S. Department of Energy	$971
State of Alaska	971

Grant Recipient

Richard Runser
SRA 6289 Yadon Drive
Palmer, Alaska 99645



Appropriate technology is second nature to the Runser family (above). Richard Runser (far left) discusses the details of his system design. (Left), an indoor/outdoor thermometer is used to measure incoming and outgoing water temperatures.

Computer prioritizes wind energy use

A microcomputer was installed in Stanley Baltzo's home in Kodiak, Alaska to regulate electricity produced by a wind generator.

"The computer related demand to supply on a priority basis," says Baltzo, a product manager for Prudhoe Bay Supply who now lives in Wasilla, north of Anchorage.

"It was a sensing device that would determine where the need was and reroute the electricity to meet that need."

First, electricity was used to light the house. Once that demand was met it was used for the hot water tank and home heating. Any additional power was sold back to the Kodiak Electric Association for about 7 to 9 cents a kilowatt.

Overall, Baltzo said the computer-monitored wind generation system worked well, reducing his monthly electric bills from $3 to $150 depending on how much the wind blew.

The biggest setback he faced was making his wind generator work properly. He had to replace the governor, put shorter blades on the machine, and reset the angle of the gear head to increase the distance between the whirling blades and the tower.

But once the wind generator was repaired for free by Jacobs, the manufacturer, everything worked well.

"It definitely worked after the bugs were removed from the Jacobs wind generator," Baltzo said. "It required normal watching. I was absolutely pleased with it. If I had to do it all over again, I wouldn't hesitate if I lived in an area with viable wind energy."

System Design

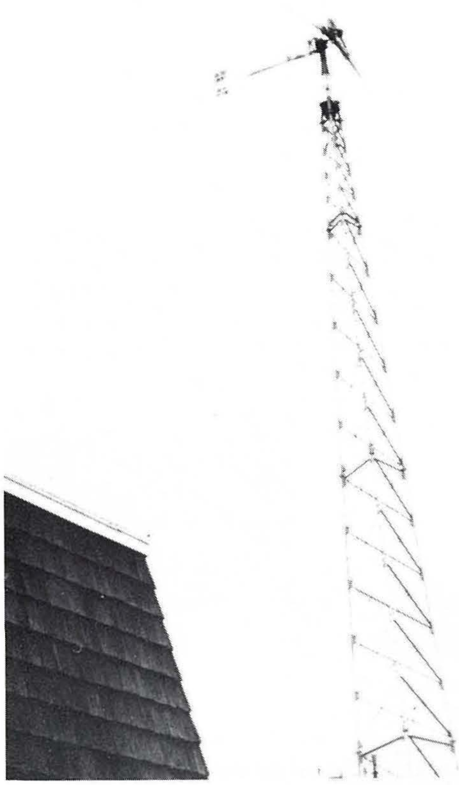
The commercially-built microcomputer panel, about eight inches by 12 inches, regulated electricity produced by a wind generator.

The microcomputer was an Ohio Scientific C-2 OEM-NET. Its components consisted of a 6502 processor chip with 32 bytes of dynamic random access memory, a CA-15 universal telephone interface board, CA-20 time clock with battery back up, a CA-12 96-line parallel I/O board and an OSI 538 Eprom board with 32 K of erasable, programmable memory.

Every tenth of a second the computer monitored heat demand and the domestic hot water temperature, and stored all the data in its memory.

Meanwhile, electricity was produced by a 10 kilowatt Jacobs wind generator, which is intertied with the Kodiak Electric power.

The generator was placed atop a self-supporting, 80-foot-high tower. Each leg of the tri-pod tower was



A wind system (left) on the Kodiak shoreline catches sea breezes.

anchored six feet in bedrock with cement.

The blades, originally 12-feet long, were replaced with 11-foot-long laminated spruce blades to reduce the chances of the blade hitting the tower as winds shifted.

Power from the generator was channeled through a commercially built "mastermind" Jacobs control panel.

Since Baltzo was tied into the local electric company, he did not use batteries or other back-up energy systems. He purchased power from the local power utility only occasionally when his wind generator failed to produce enough power.

Performance

Baltzo was very pleased with his energy system after he was able to "get all the bugs" out of the wind generator. He said it required little maintenance, and it helped him lower his electric bills substantially.

He says the problems with the generator were likely caused because it was the first Jacobs 10 kw wind system to be installed in Alaska.

The blades of the machine, for example, smashed against the tower within the first 30 minutes of its operation. He doesn't know what caused the accident, but said the spruce blades have solved the problem. Increasing the angle of the gear box from 9 degrees to 13 degrees also prevented the blades from hitting the tower.

Overall, he says he was very pleased with the system.

In fact, he says that if there were enough wind around his new home in Wasilla—he'd install a similar system there too.

Funding

U.S. Department of Energy	$3,076
State of Alaska	5,175

Grant Recipient

Stanley A. Baltzo
SR Box 5232
Wasilla, Alaska 99687

Automatic stack dampers installed

It was an article reviewing automatic stack dampers in the January 1980 *Consumer Reports* that motivated Thomas Busch, general manager of radio station KNOM, to see if these devices could help reduce high yearly fuel costs.

The nonprofit Nome station nestles in a town known for its Gold Rush beginnings, brutal winter cold, vicious ocean storms and Front Street finish for the 1,049-mile Iditarod Sled Dog Race.

The article indicated that stack dampers (devices that keep heat from escaping up the chimney when the furnace is off) could give up to 23% fuel savings. In Nome, on the southern shore of the Seward Peninsula and only three blocks from Norton Sound, the possibility of 23% savings bore investigation.

Busch started checking with others in the area and found that very few people, if any, had ever heard of a stack damper, let alone had installed one. Even the Cooperative Extension Service could offer no hard facts. If these devices could save him money, and since nonprofit KNOM was "more desperate than most to save money," Busch decided that it was time for the small station to do its own research.

Fuel savings could be calculated easily. KNOM had already been hauling its own fuel since late 1980 and had records for its non-damper consumption. Recording fuel consumption during the same period after damper installation would allow an easy comparison.

In 1981, KNOM and Busch received a grant to install stack dampers in five furnaces and monitor the results. The results would then be compared to a corresponding period without the dampers and fuel savings calculated.

Design and Construction

Furnaces in five buildings used by KNOM were fitted with motorized Flair brand stack dampers. The stack dampers were installed above the customary barometric damper. Theoretically, the stack dampers would dramatically improve the efficiency of the furnace by closing the chimney when the burner was off, preventing heat loss from the fire chamber and from the area where the furnace is located. The damper must open before the burner can start. A built in safety feature also opens the damper if there is a motor or power failure.

The furnaces included both water boilers and hot air furnaces. The buildings ranged in size from 640 square feet to more than 4600 square feet. Although two of the furnaces also provide hot domestic water to the buildings, the fuel savings would still be interesting, Busch reasoned.

Performance

"The analysis was a surprise, indicating quite varied results—results that appeared to be in variance from subjective impressions," said Busch. "I lived in one of the buildings and it was clear to me that after the stack dampers were installed, the furnace ran less often. Yet, the data indicated a 6.5 per cent increase in fuel consumption," in his building, he said. Some of the other buildings showed no gain, others showed only a slight savings. "Clearly, something was wrong," said Busch. Different theories suggested fuel theft or leakage, but Busch feels that the poorly insulated buildings were affected by heat loss from wind. One reason that the data may be inaccurate is that the oil consumption analysis did not determine a gallon per degree day, but rather a gallon per year figure, for the before and after data.

Buildings in Nome are not known for thick insulation. This, combined with the fact that Nome is a very transient town means that upkeep may not be up to professional standards, either. Busch's house also had a settling problem. "I've used about a half dozen tubes of caulk this year alone, just sealing the cracks," said Busch, "and I can feel drafts again." This indicates that the settling problem and air infiltration may be the most probable culprits.

The dampers themselves, however, are virtually maintenance free. Only one had to be replaced, and that was because of incorrect installation and not due to a faulty mechanism.

Conclusions and Problems

The only real problem with this project was that no one in Nome had ever installed a stack damper before. After learning on the first one, the remainder were a snap, Busch said.

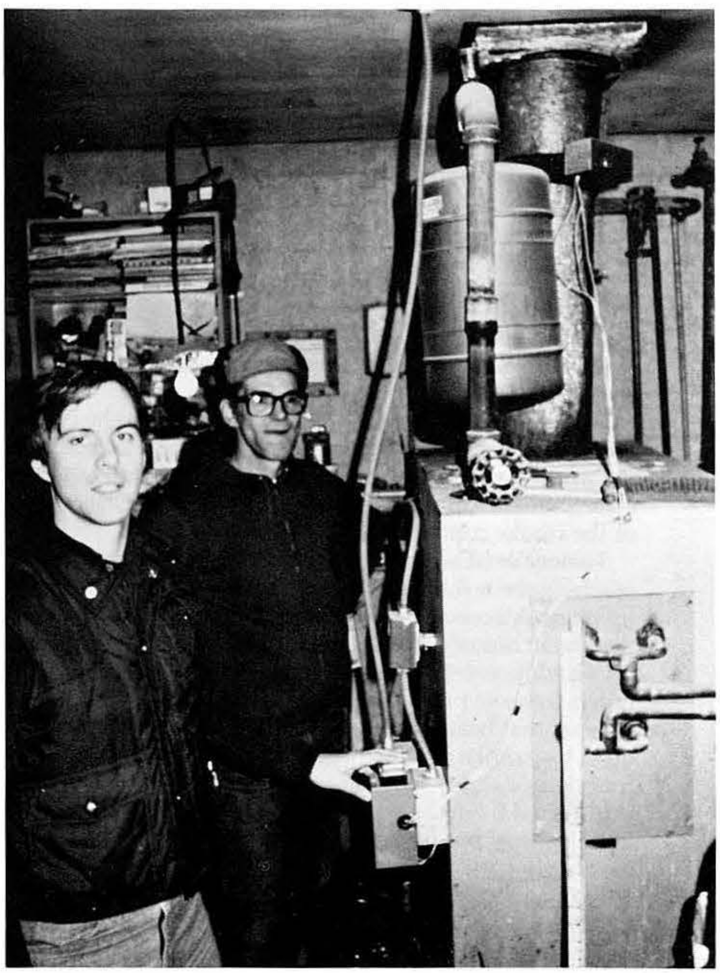
The project itself stimulated a little interest, but little success in getting others to install the devices. Better results might have changed this, but Nome is affected by other problems. One of them was transience; a common remark to Busch was "sure it will save a couple percent (fuel usage) but I'll only be here for two years . . ." Busch also found some resistance to the dampers from "the old timers and contractors." He feels that this attitude is changing, and that the future may find more of these devices in Nome.

Funding

U.S. Department of Energy $1,150

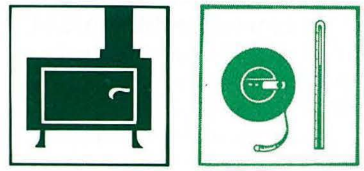
Grantee

KNOM Radio
Thomas Busch, General Manager
P.O. Box 988
Nome, Alaska 99762



Tom Busch (left) initiated the use of stack dampers as an energy-saving device in the town of Nome.

Building a fire-proof chimney



Several years ago, an apparent creosote build-up caused a fire in David Norton's chimney. Fortunately, no one was hurt and his home was not damaged.

But the incident prompted Norton to design a more fire-proof chimney for his home in Fairbanks, Alaska.

"I thought there must be a better way to build a chimney than to endanger the structural part of the dwelling," said Norton, a biologist at the University of Alaska-Fairbanks. "An engineering friend of mine had an idea: why not build it (the chimney stack) exterior to the home? So we did it, and it's working quite well."

System Design

The chimney system is comprised of three parts: a wood stove, a buried steel trap that collects creosote, and an 18-foot-high chimney stack. Hot gases flow through a pipe from the wood stove to the underground steel trap before swirling out of the chimney stack.

A six-foot-long, by six-inch-diameter steel pipe connects the wood stove in the basement with a five-foot-deep by 18-inch-diameter steel trap, which was buried outside the basement wall. The chimney stack, which rises above the creosote trap, was built three feet away from the outer wall of Norton's house.

"The original intent was to put enough distance between the chimney and combustible structural materials of the dwelling, so that, if creosote accumulations in the chimney did ignite—there would be no threat to letting the stack fire burn itself out," Norton said.

The chimney also was designed to withstand high temperatures. Stack fires can burn at 2,000 degrees—hot enough for thin-walled smoke conductors to melt or oxidize.

Therefore, Norton chose steel well casing with an internal diameter of six inches and a wall thickness of three-eighths-inch for the smoke conductor. It was insulated with sections of asbestos-lined, double-walled steel chimney made for use with Heatilator brand fireplaces. These sections have an inner diameter of nine inches and an outer diameter of 13.5 inches.

Moreover, the 1.25-inch-wide space between the outer and inner walls was filled with clean dry sand. The sand annulus was tamped to prevent settling.

Norton also fitted the chimney system with two thermocouples that register temperature on a digital readout display. A stack fire warning instrument with analog readout and a variable setpoint readout also was purchased. It was installed in the pipe that connects the wood stove with the creosote trap, to sample flue gas temperatures under normal operations.

Performance

The chimney system worked well from mid-October through March for several years. Mixtures of birch, aspen, poplar, willow and spruce were normally combined in a 2:1 ratio by volume with coal for each loading of the stove.

When Norton gets ready to fire up the stove for the first time each fall, he connects the blower side of an industrial vacuum cleaner to the air intake of the stove. This prevents a reverse draft problem that could fill the house with smoke.

Creosote does build up in the chimney's smoke conductor, but not as fast as Norton originally feared. Reduced draft is an indicator that creosote has built up; this occurs two or three times per heating season for Norton's system. The pipe connecting the wood stove with the steel trap can be cleared of this flammable residue with a conventional six-inch chimney brush on a rigid pole.

It's a little harder to clean the vertical smoke stack however. Norton lowers an old screw jack base (5.75 inches in diameter) into the chimney and jigs it up and down. If the jig becomes stuck, he drops a second roped weight on top of the jack and jiggles it until both are free.

Norton, however, has not determined how much heat transfer to the dwelling is sacrificed by externalizing the chimney or what the life expectancy of the present system may be.

Deliberate Ignition of the Creosote

Norton said he could not cause a creosote stack fire just by building a roaring blaze in the stove and operating it with all dampers open. By the time sufficient creosote accumulates to sustain a stack fire, the draft in the chimney is so weak that it cannot transfer sufficient heat from the wood stove to start a stack fire.

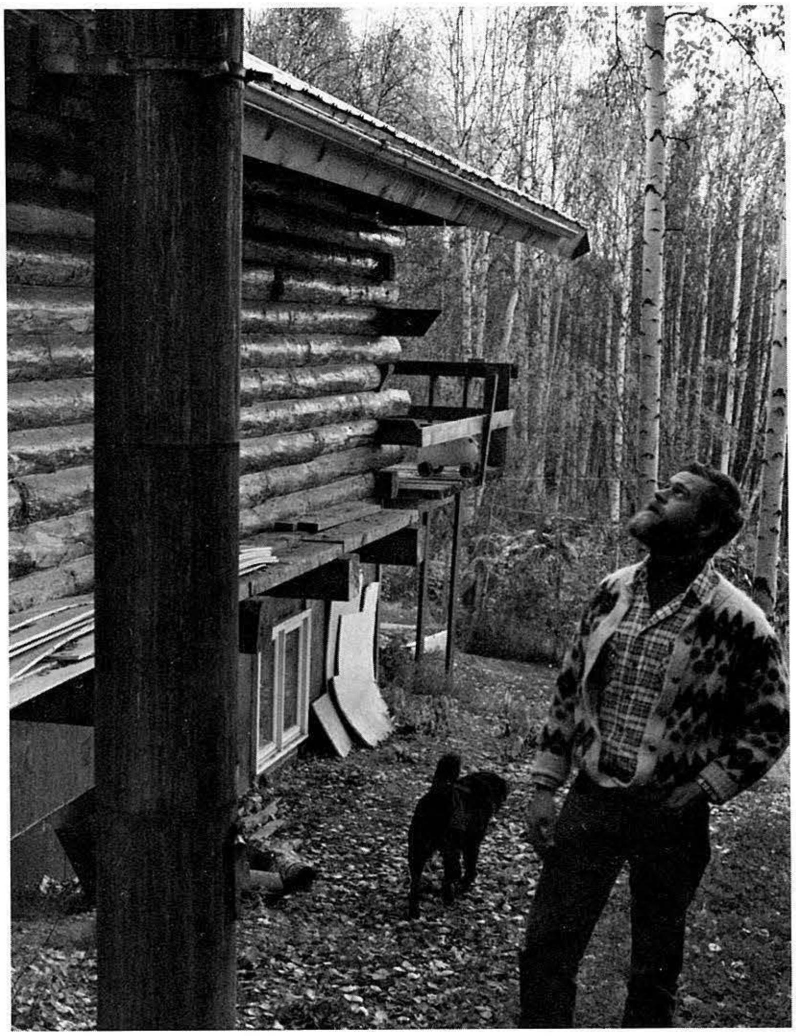
On March 7, 1984, the University of Alaska Fire Department assisted in a controlled burn-out experiment when most of the season's creosote accumulation was in the chimney system.

A pile of wadded newspapers was ignited in the underground creosote trap after it had been disconnected from the wood stove. It took 15 minutes after ignition to generate a self-sustaining creosote fire in the vertical section of the smoke conductor.

The combustion climbed slowly up the chimney, reaching the level of the top sensor 120 minutes after ignition. All creosote had burned, melted or fallen off the inner chimney walls. The entire system began cooling off steadily, except in the trap where glowing embers of fallen creosote produced heat for about 24 hours.

Fears that heat from burning creosote would build up in the smoke conductor and melt the steel were unfounded. Meltdown did not occur because heat was transferred from the smoke conductor to the sand annulus, and out of the double-walled Heatilator sections.

No significant problems arose from the burn-out experiment, but it is a dangerous undertaking. There is always a risk of backflashing during oxygen regulation. A backflash did occur when oxygen was restored after starving the fire of air. Such backflashes can fill the house with smoke, cover an unwary observer with soot, singe eyebrows, or damage property and injure nearby people if sparks are shot outward.



David Norton and his dog (left) inspect the chimney of their Fairbanks home.

Overall, the experiment was successful and showed that the chimney could be cleaned by starting a two-hour stack fire far easier than a six-hour vacuuming project.

Norton said that experts advise against letting creosote fires burn in standard chimney installations. Besides backflashing, he said, the stack fire causes considerable noise and a ghastly pall of foul smoke. He said neighbors downwind of the experiment would have been justified in complaining.

Tips

Since most people may have little experience with a chimney configuration such as his, Norton has several tips:

- The pipe linking the woodstove with the buried steel trap should be exactly level, rather than slightly descending as it was inadvertently installed. This may prevent a creosote fire from working its way backward toward the furnace from the trap.
- Do not be alarmed by a "rainshower" sound in the chimney trap when you start up the fire for the very first time. The sound is caused by the condensation of water from combusted materials on the walls of the vertical portion of the smoke conductor. Eventually, the water evaporates.
- The chimney heats the soil surrounding the underground trap. The area could be an ideal location for a greenhouse, or the base of an attached solarium. The heat also could be used for year-round composting next to the chimney.
- Be sure to seal off the sand annulus from moisture and creosote. Sheet metal collars corrode in less than a season; two masonry collars also have cracked and disintegrated. Consider welding a three-eighth-inch steel collar to the smoke conductor.
- Use a masonry jacket for the smoke conductor core, and retain a sand annulus to allow for expansion and contraction of the steel in the smoke conductor.

Funding

U.S. Department of Energy $1,460

Grant Recipient

David Norton
SR 20787
Fairbanks, Alaska 99701

Monitoring system collects useful data

"I realized that the project was going to be slightly more complicated when I stood beside my pregnant wife and watched the snow drift down onto the cabin. The cabin itself was slightly tipped to one side, and its foundations were sinking into the hole I had just excavated for the greenhouse rockbed."

Jeremy and Linda Weld were building an attached passive solar greenhouse and rockbed thermal mass for heat storage on the east side of their small log cabin. The cabin is located on the crest of a hill, about 200 feet above the Gulkana River, and 14 miles north of Glennallen. Temperatures in the area range from a blistering 90 above to 60 below. Seasons change with a snap.

The greenhouse was an integral part of the Welds plan to make their little homestead self-sufficient. In addition to providing fresh vegetables, the greenhouse would also supplement the cabin's heating system during the spring, summer, and fall. During the winter, the greenhouse would be closed down and the below ground thermal mass placed in "hibernation."

Being a park ranger, Weld certainly knew about animals and hibernation, but little about arctic construction techniques. When he began asking questions, he found that he was not alone. Weld found that most construction in the area was at the builder's convenience rather than to maximize environmental benefits. For instance, "a new development near the Richardson (Highway) has every house facing the road," says Weld, "if the builder would have turned the houses slightly to take advantage of the sun, those homeowners would have considerably lower heating bills." Weld also found that most written information was "wrapped up in the technical aspects of construction and offered little practical information for the inexperienced owner-builder."

The greenhouse that the Weld's were building was made possible by a grant from the Alaska Council on Science and Technology. Jeremy and Linda felt that if they could monitor the greenhouse and include performance data with construction information, a practical example of passive solar construction for the Copper River Basin would be available for others. In 1980, they received a grant from the Appropriate Technology program to install a monitoring system in the attached greenhouse and also in a free-standing control greenhouse.

Design and Construction

The original design called for a one-story, east facing structure with a small below-grade rockbed thermal mass. But as Weld was repairing his damaged cabin foundation, the project grew "like a snowball rolling downhill." The small one-story affair grew to a two-story "heating center." His greenhouse monitoring idea also grew to a study of arctic building techniques and materials.

In addition to his automatic temperature monitoring, Weld planned to include the results of visual observation in his final report. He felt that this would be more beneficial to others attempting the same type of project.

The new greenhouse/heating center would have a 15-by-20 foot first floor with a 9-by-20 foot upstairs bedroom. The newly repaired and reinforced house foundation was extended to support the addition. A three foot deep, 12-by-16 foot depression below the main floor houses the rockbed. Two layers of four inch-urethane foam (salvaged from the Alaska Pipeline) line the depression to prevent heat seepage from harming the permafrost eight feet below. Although the experts recommended two-inch river rock for the thermal mass, all that was available in the area was coarse sewer rock.

Embedded in the sewer rock are two perforated pipes. These pipes are connected to a solid pipe that ends above the ceiling separating the first and second floors. On top of the sewer gravel, Weld layed a six-mil plastic vapor barrier and then a layer of pea gravel. Finally, the floor area is covered with a 3½ inch cement slab with narrow slots cut in it above the thermal mass area to allow heat to escape.

Post-and-beam construction using logs and rough cut dimension lumber frames the addition. Discussions with others who have built greenhouses before convinced Weld not to use the traditional angled windows because they're difficult to seal. At the last minute, Weld decided to put in two angled windows, to allow comparisons on building techniques.

An insulated wall and door sealed the greenhouse from the cabin and six inches of fiberglass and waterproof sheetrock isolated it from the second story bedroom. The ceiling, backwall, and door are painted white to ensure a bright interior, while all other walls are covered with cedar. The insulated wall and ceiling was to keep with "common wisdom that says the best thing to do with a solar project in the winter is to isolate it from the house." By the end of February, a new plan was brewing, and Weld was determined to find a way to use the greenhouse throughout the winter.

The purchase of a small multi-fuel hot air heater was the final step in the greenhouse's evolution. Using flourescent lights during the winter, removable thermal shutters and a removable 3½ inch insulated floor, Weld figured he could minimize heat loss and almost double the size of his house during the long cold winter. The insulated floor would still let his thermal mass "hibernate" during the winter.

The thermal shutters are made from two-inch, aluminum-clad urethane foam boards with a vapor barrier stapled to the outside and decorative burlap attached to the inside making an attractive and efficient barrier. Both the shutters and the floor insulation are removed in the spring and stored until late fall.

A medium volume, squirrel-cage blower mounted atop a three legged two-by-four tower blows air into the thermal mass inlet pipe. Another large, reversible fan is mounted on the side of the greenhouse. Rated at 3,300 cfm (cubic feet per minute), this fan could quickly evacuate the greenhouse, but was found to be very expensive to run. Two smaller, low wattage fans help move warm air from the ceiling to the floor reducing stratification problems.

To ensure a complete picture of the solar environment was recorded, Weld used two automatic thermometers, a strip-chart recorder, visual observations of cloud cover, and temperature sensors placed at various locations throughout the attached and free-standing greenhouses and thermal rockbed. The results of these measurements would be graphed and made available to various state and local agencies.

The rockbed in the attached greenhouse and the internal area of the smaller free-standing control greenhouse were monitored on a daily and sometimes hourly basis. At the end of the year's study, Weld collected his data and discovered that the rockbed was coolest from November through January, never getting beyond 40 degrees, then losing warmth quickly after the sun went down. From February on, the rockbed increased both in temperature and thermal capacity, reaching a peak in early July.

Since Weld's original plan was to let the rockbed "hibernate" during the winter, he wasn't disappointed when it wouldn't supply heat during the first winter's use. Future plans are to draw heat directly from the multi-fuel furnace instead of the ceiling area between the first and second floor. This heat would be injected directly into the thermal mass. Although this would mean higher internal temperatures for the rockbed, Weld doesn't expect permafrost damage, but he's "real worried about it."

Another interesting thing that was discovered during this project was the debunking of the "closed-building rule." This rule infers that all solar structures should be closed off and sealed from the rest of the home during the winter months. Jeremy Weld discovered that by defying this rule, heating performance actually improved. "Closed, it not only looked terrible, it simply didn't work." His real problem wasn't isolation, but rather infiltration. "If I were to build this structure again, I would use a version of double-studded wall," he said. It was virtually impossible to seal the corners of the post-and-beam walls. The only place that remained sealed was the sloped windows. This, by the way, was also the only part of the structure that worked well as a greenhouse, the original purpose of the addition, and was probably due more to the increased light from the sloped windows than anything else.

Weld also found that although post-and-beam construction is very attractive, it is virtually impossible to seal. Normal wood expansion/contraction caused by the Copper River Basin climate would leave small cracks around the support beams. He tried many different commercially available caulks and concluded that about the only way to actually seal them from the outside was to cover them up.

Tips

After building a number of experimental walls, testing insulation materials and techniques, and caulking compounds, Weld offers the following tips for the amateur owner-builder:

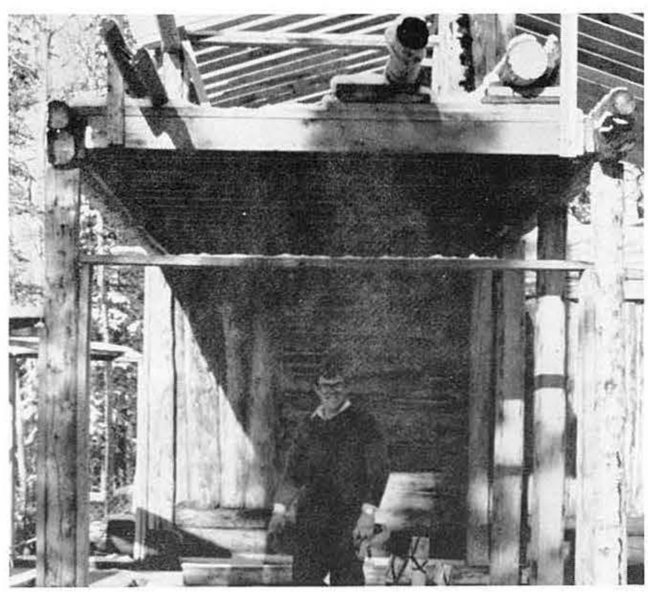
- Don't get wrapped up in the technical aspects of construction, remember practical is better.
- The ability to ventilate moisture out of a wall is as important as keeping moisture from entering it.
- When conflict arises between keeping out the winter chill and letting in as much light as possible, better to err on the side of more glass.
- Although proper insulation is important, air infiltration will destroy any benefits of the insulation.
- Build to make maximum use of the environment, *i.e.*, solar gain, wind protection, etc.
- Finally, have a definite idea of what you want and like before you pick up a hammer. Keep in mind that the most important result of the building is not the structure itself, but the improvement you feel in your quality of life.

Funding

U.S. Department of Energy	$ 408
State of Alaska	408
State of Alaska (Greenhouse)	5,000

Grant Recipient

Jeremy and Linda Weld
Box 224
Gakona, Alaska 99586



Jeremy and Linda Weld's greenhouse (right) was under construction during 1981.

Demonstration project a success

Once the site of the world's most profitable low-grade gold mine, Juneau now hosts politicians, tourists, fishermen, and determined gardeners. Located at the base of Mount Juneau and Mount Roberts, Juneau is a short drive south from the great Mendenhall Glacier Valley.

Its location places Juneau almost directly in the path of every storm crossing the Gulf of Alaska; consequently, the area does not exhibit the most hospitable gardening climate. This means that those sun loving, high temperature vegetables either have to be imported, given-up, or grown in a climate-controlled greenhouse. Unfortunately, these greenhouses are usually so expensive to build and operate, that the owners cannot afford to grow those items that the greenhouse was built to handle.

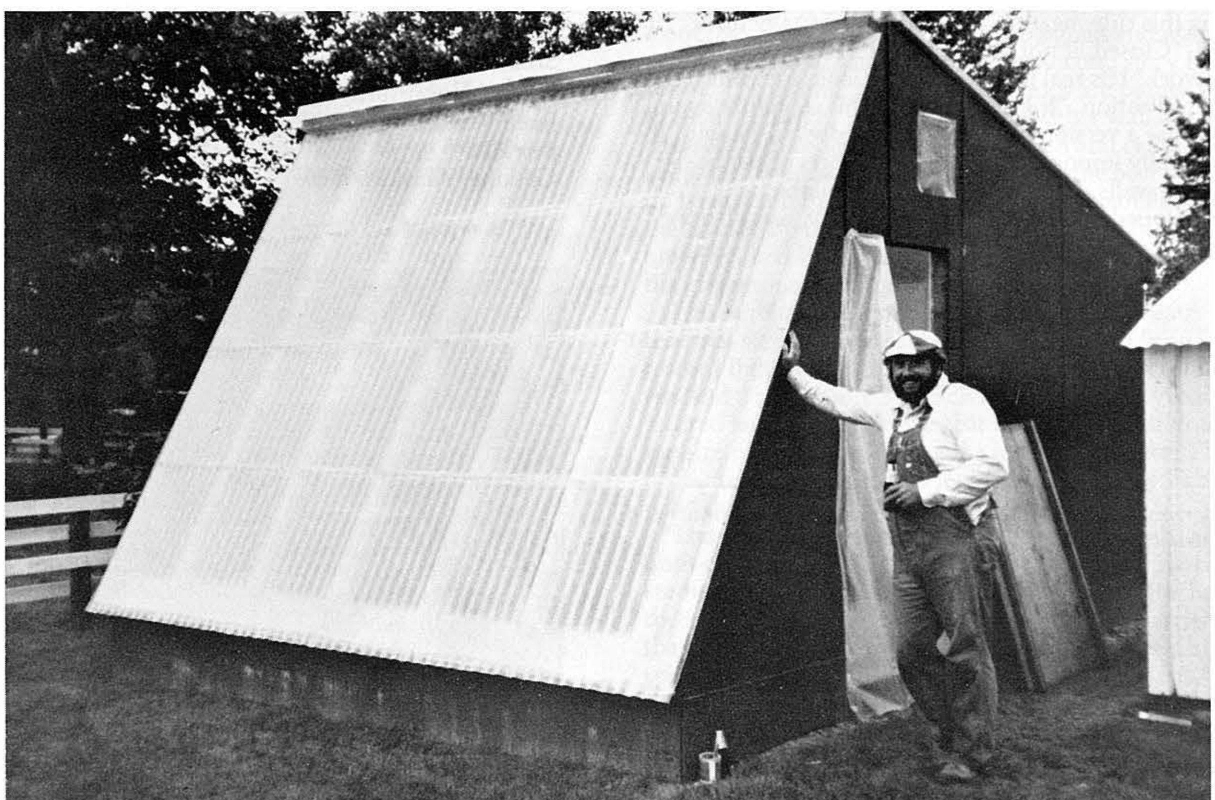
Stan Moberly felt otherwise. By using passive solar principles, he thought he could successfully extend the growing season and improve the climate for those special vegetables without mortgaging his soul to the energy companies. In 1979, Moberly built his solar greenhouse and is amazed at how well it was working. After a cursory canvassing, he found that "this solar greenhouse is the only known solar greenhouse in this area of Alaska that is utilizing stored solar energy to grow vegetables and flowers," and that it could "serve as a demonstration project if careful records are kept."

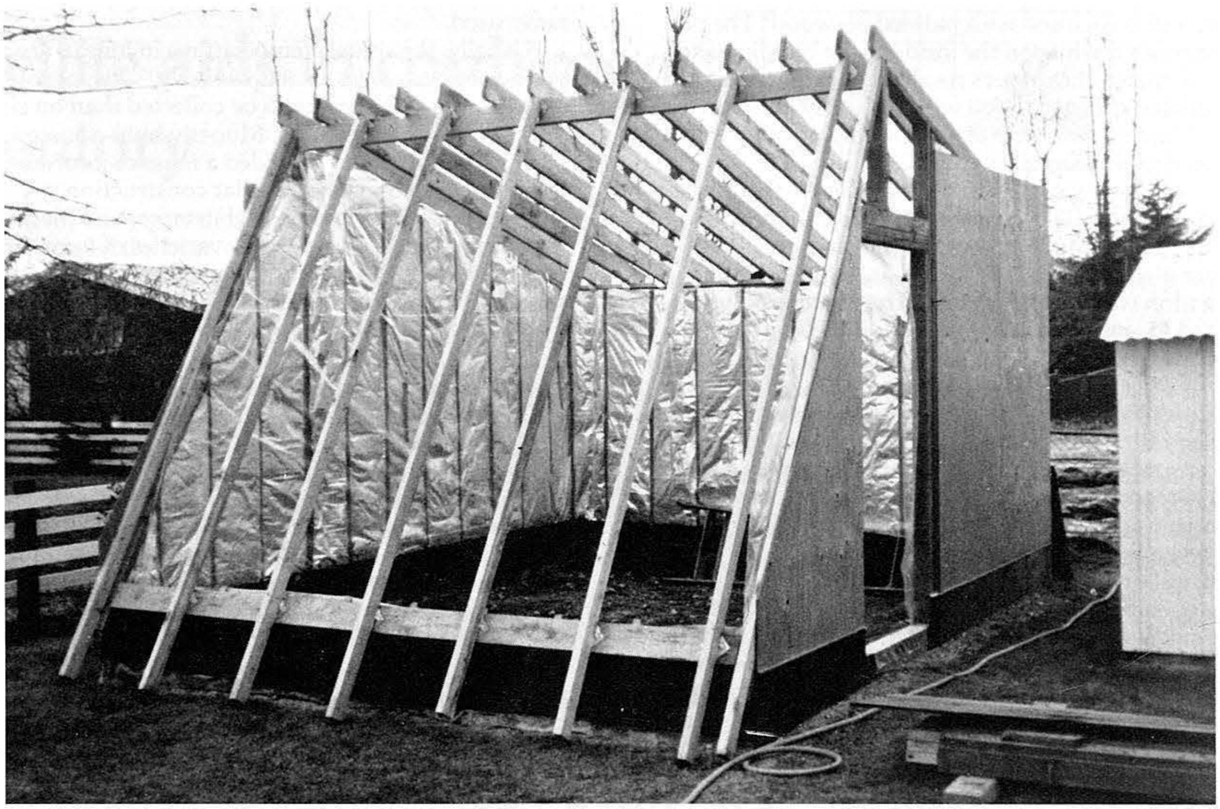
In 1980, Moberly was awarded a grant to develop a monitoring system to keep those records. The project would involve monitoring the climate both inside and outside the greenhouse, recording the sun's daily intensity, and keeping track of any supplemental electrical energy usage. The monitoring project would last one year and the results would be tabulated for public interpretation.

Design and Construction

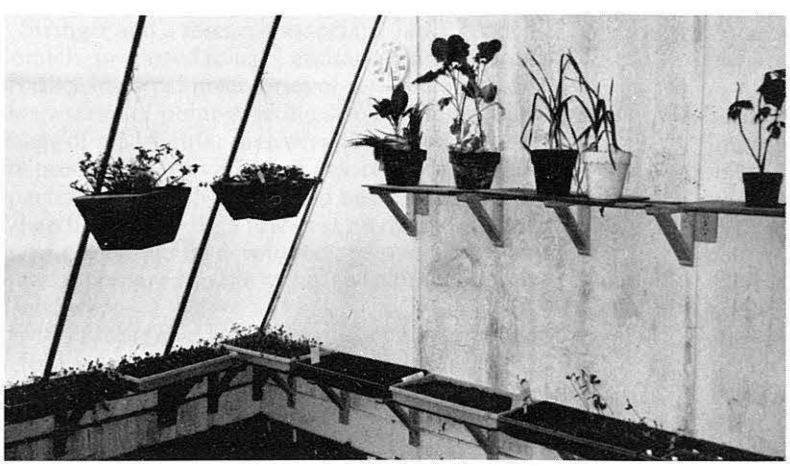
The 12-foot-eight-inch-by-16-foot south-facing structure sits in the rear of the owner's residence where the garden used to be. Supported by a treated wood foundation, the building is 11 feet high at grade and is sunk another 14 inches in the ground to reduce air infiltration and to enclose a 235 cubic foot sand and gravel heat sink.

The two sides, rear, and short front wall are framed with treated two-by-four studs. The bottom two feet of the sides and rear wall are insulated with styrofoam, sheathed with treated plywood and have a vapor barrier both inside the sheathing and stapled outside around the bottom of each wall. Metal flashing caps the treated plywood. The remaining wall area is insulated with fiber-





Stan Moberley (previous page) takes a break during the construction of his greenhouse. (Above and middle left), two phases in the construction of the greenhouse. A view (bottom left) of the structure's interior with plants and seedlings.



glass, with a plastic vapor barrier attached to the inner surface, and is enclosed with painted plywood. The plywood is painted white on the inside of the building and brown, to match the owner's residence, on the exterior. The insulated roof is covered with white plywood on the inside, insulated with fiberglass, and then covered with corrugated green fiberglass sheets.

The south facing solar glazing is angled so that the sun strikes it at exactly 90 degrees on March 21. The solar energy passing through the corrugated clear fiberglass and clear plastic inside is absorbed and stored by a 1,000-gallon water thermal mass. The water is stored in discarded 55-gallon drums, five-gallon fuel cans, and plastic storage bottles that are stacked across the north wall.

A time-activated oscillating fan is turned on for one hour every three hours to prevent thermal stratification and to ensure equal temperatures throughout the greenhouse. A thermostatically controlled wall fan and louvered opening on the opposing wall purge the greenhouse when inside temperatures get extreme.

Electrical outlets are located about half way up in the middle of each wall for convenience. Other nice features are the small sink and potting bench near the split dutch entry door. The split door allows more ventilation in the summer. Growing benches along the side walls and a lattice in front of the thermal mass for climbing plants complete the structure.

Performance

Although the location of the greenhouse resulted in solar interference from both Moberly's and his neighbor's house, the structure's design was so good that the interference never has caused any problems. Even during the coldest months, the solar mass never went below 32 degrees. Because of this, and because electrical usage was minimal, the power meter and solar intensity meter were never used.

"Usually, the coldest temperatures in Juneau are during periods of clear skies," states Moberly, "this, of course, allows more solar energy to be collected than on cloudy days." From all indications, Moberly built a successful solar greenhouse and provided a mass of information for others interested in passive solar construction.

As for those sun loving, high temperature plants, "experimentation with various varieties of tomatoes was tried" and "the variety that performed the best was selected for growing thereafter."

Conclusions and Problems

About the only real problem Moberly had building this structure was accidently mounting the front and back walls outside of the end walls instead of butted against the end wall as designed. This added eight more inches to the structure and added material costs.

"The greenhouse provided the opportunity to garden over two months earlier than could have been accomplished outside, and the risk of late freezing temperatures was eliminated," writes Stan Moberly. For a serious hobby gardener, a greenhouse full of flowers and vegetables is the true mark of success.

Funding

U.S. Department of Energy	$1,415
State of Alaska	1,415

Grant Recipient

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Satellite aids in cordwood inventory

During the early part of the century, before the Alaska Railroad opened the Interior to the vast Matanuska and Healy coal fields, the main fuel source for the Fairbanks area was cordwood. Vast stands were slashed to fuel the boats plying the Yukon and Tanana Rivers, after gold-seekers created this 1903—incorporated city.

Today, most of the remaining timber is either in private ownership or in the hands of the state. Unfortunately, the rising use of woodstoves as an alternative energy source is putting stress on this remaining resource. This pressure has made resources inventory important to determine what the sustainable yield is for a particular area. Arbitrary cutting beyond this limit may do irreparable damage to the resource and reduce its availability to support future generations.

"Timber inventories, and those of other natural resources, are usually managed by separate government agencies. This type of management may or may not reflect the actual availability of a resource to the local community," says Dr. William Stringer, associate professor of geophysics at the University of Alaska—Fairbanks Geophysical Institute. The main impediment to inventorying cordwood potential is the cost of surveying large, remote areas. Even using airplanes is costly.

Stringer's solution would have amazed those rugged Fairbanksans of 80 years ago—the use of satellite technology that has been pioneered by Alaskans of another age.

The need for a cordwood inventory was early recognized in a February, 1980 meeting of the Tanana Valley Development Council, which identified the need for a cordwood inventory as essential for "future cordwood use in the Fairbanks North Star Borough." Without this knowledge it is virtually impossible to monitor this resource for the benefit of future citizens and self-reliance, said the council.

In 1980, Stringer and the Geophysical Institute obtained an AT grant to develop a low-cost method for inventorying cordwood. Stringer proposed to use high-resolution satellite images and remote sensing techniques for this purpose.

Project Description

Stringer and a research associate, Janis Zender-Romick, proposed to use Landsat satellite imagery to produce low-cost inventories of selected areas. Landsat uses a series of polar-orbiting satellites to produce an image of a particular area every 18 days. These images are produced by a variety of devices; one, a Multi-Spectral Scanner (MSS) would be used for this project. When finished, both a low-cost method of cordwood inventory would be developed and a cordwood mapping manual prepared so the technique could be replicated elsewhere.

MSS is obtained both separately and simultaneously in four wavelengths. It is also possible to obtain black and white images representing the amount of light reflected from the earth in each of these wavelengths. Since different types of vegetation reflect different wavelengths of light and higher densities reflect more of that wavelength, using both color and black-and-white images, it is possible to roughly estimate the types and densities of ground cover.

It was decided that the cordwood inventory process would be developed in stages. First, satellite images of the selected area would be obtained for both the summer and winter. This would help determine both the types and densities of ground cover.

Stringer and Zender-Romick chose Viereck and Little's description of interior Alaska forests as a base for their study. Viereck and Little's book, *Alaska's Trees and Shrubs*, Agricultural Handbook Number 410, divides Alaska's ground cover into six categories. These are:

- Closed Forests, consisting of white spruce, aspen, birch, and poplar
- Open Forests, consisting of black spruce, small birch, and tamarack
- Recent Burns, consisting of willows, saplings, and scrub
- Treeless Bogs, consisting of willow, berries, dwarf trees, and no cordwood
- Shrub Thickets, consisting of flood plain thickets and elevated thickets
- Alpine Tundra

The next step was to determine which color in the satellite photographs corresponds to a particular ground cover type. This was done by using high-altitude aerial photos in color infrared. Field observations were used to classify the color blocks in the satellite photographs.

Analysis

The first stage in data analysis was to trace the color boundaries from the summer satellite photographs. Four main color scale classes were used: bright red; mostly red with some mottling of blue-grey; dark reddish-purple; and dark blue-grey to black. The winter photograph also was divided into four categories: very bright; light grey or brown; medium to dense brown; and dark black-brown. These classes were subsequently traced onto a topographical map and copies of that map were taken to the field to determine the composition of each category base on the information presented in Table 1. This was done by direct observation or, if direct observation was not possible, binoculars and aerial observation.

The information gathered from the field caused some adjustments of the maps. It was found that it was almost impossible to separate pure birch and pure aspen stands in the satellite photographs and that extremely dense undergrowth may indicate a different type of vegetation than actually exists. During map interpretation it was also found that the blurry nature of these extreme enlargements made it difficult to determine actual boundary lines between vegetation types. It was determined that the final maps for this project would have to be larger to be of any value.

After this table was prepared, 10 sample units were selected at random for quantitative sampling. Each sample was superimposed on a high-altitude aerial photograph and species composition and density estimated. This final analysis resulted in a more accurate description of vegetation indicated by the two Landsat photographs and are illustrated in Table 2.

By relating average cordwood per acre to the type of vegetation present, it is possible using this method to estimate the cordwood available in selected locations throughout the state at an extremely low cost. In all, Stringer and his staff mapped over 962,000 acres and actually inventoried 120,000 acres. The total cost for this inventory was 16 cents per acre.

Conclusion

The method developed by Stringer is indeed a low-cost cordwood inventory process; however, it cannot be deemed totally accurate. Because of the difficulty determining borders between vegetation groups, a 30% variation should be anticipated. This variation may mask the locations of highly significant stands of mature hardwoods, but "it should be stressed that the technique described here is largely a reconnaissance process aimed at exploring a wide region quickly in order to locate areas for closer investigation. Before consideration of a potential cordwood area progresses very far, a site should be visited," said Stringer.

Funding

U.S. Department of Energy	$9,500
State of Alaska	9,500

Grant Recipient

Dr. William Stringer
Geophysical Institute, University of Alaska
Fairbanks, Alaska 99701

Table 1

FINAL DESIGNATION OF COLOR - GRAY SCALE UNITS IN TERMS OF VEGETATION DESCRIPTIONS

	SUMMER IMAGE - COLOR				
WINTER IMAGE - GRAY SCALE	Bright Red A	Red with Some Blue Mottling B	Some Mottled Red-Blue, Maroon Purple, Lavender C	Blue-Gray, Very Few Red Patches D	Blue-Black E
0 White	Low-lying deciduous vegetation. Open crown cover, grassy fields, recent burns, urban areas. Sapling size trees.	Low-lying deciduous vegetation with some spruce. Some urban areas. Sapling size trees.	Alpine tundra with some black spruce.	Largely bog.	Not observed.
1 Lt. Blue-Gray Lt. Brown-Gray	Largely closed deciduous forest with~10% shrub, little spruce. Sapling to pole size trees.	Largely closed deciduous forest with 20% spruce and 10% shrub. Sapling to pole size trees.	Open crown cover shrub thicket and treeless bog, 60% shrub, 30% black spruce, 10% deciduous trees.	Medium crown cover shrub thicket, 65% shrub, 35% spruce. Sapling size trees.	Not observed.
2 Brown-Gray to Deep Brown	Completely closed deciduous forest with little spruce or shrub. Pole to commercial size trees.	Completely closed deciduous forest with 20% spruce, no shrub. Pole to commercial size trees.	Largely closed crown cover. 50% deciduous, 35% spruce, 15% shrub. Pole to commercial size trees.	Largely closed crown cover spruce forest, 70% spruce, 20% shrub, 10% deciduous. Pole to commercial size trees.	Largely closed crown cover, 80% spruce, 10% deciduous, 10% shrub. Pole to commercial size trees.
3 Black Deep Shadow	Not observed.	Largely closed crown cover. 75% deciduous (very likely largely birch), 17% spruce, 18% shrub. Pole to commercial size trees.	Largely closed crown cover. 50% deciduous, 25% spruce, 25% shrub. Commercial size trees.	Largely closed crown cover, spruce forest, 80% spruce, 10% deciduous, 10% shrub. Commercial size trees.	Moderate crown cover, 50% shrub, 50% spruce (largely black spruce). Sapling to pole size trees.

Source: *The Northern Engineer*, Vol. 15, No. 4

Table 2

WINTER IMAGE - GRAY SCALE	SUMMER IMAGE - COLOR: Bright Red Scarlet, Magenta A	Red with Some Blue Mottling B	Some Mottled Red-Blue, Maroon Purple, Lavender C	Blue-Gray, Very Few Red Patches D	Blue-Black E
0 White	deciduous young trees or saplings, grassy fields, tundra, recent burns, urban areas	deciduous forest; some spruce, urban areas	tundra with black spruce, urban areas		
1 lt. blue-gray lt. brown-gray	deciduous forest; small to medium trees	deciduous forest with some spruce; small to medium trees	shrub, alder/willow, black spruce; small trees	black spruce, some shrubs; small trees	
2 brown-gray to deep brown	deciduous forest; medium to large trees	deciduous forest with some spruce; medium to large trees	mixed forest, climax stage; medium to large trees	spruce; medium to large trees	spruce forest; medium to large trees
3 black deep shadow			mixed forest	spruce forest	spruce forest

Notes: For the mostly deciduous A and B categories, moving from a 1 to a 2 indicates older trees as well as a higher proportion of conifers.

C1 areas, usually found in drainages and floodplains, are not useful sources of cordwood; C2 areas on a slope are likely to be good cordwood sources.

D1 areas of black spruce appear as a light-bluish-gray in winter images; deciduous vegetation appears light-brownish-gray in the winter color infrared image.

An E2 category is often a forest of tall white spruce in a sunlit location. The E3 category is not well defined, but probably has a low cordwood potential.

Source: *The Northern Engineer*, Vol. 15, No. 4

Ethanol production requires large amounts of energy

Most alternative energy systems need some means of heat storage as part of their overall design. This is due to the often interruptive nature of specific power sources. Solar cells generate electricity only when the sun is out; likewise, wind generators need wind, and solar collectors store heat only during the daytime.

Other than conventional batteries, there are few long-term energy storage devices available for these systems. One device that is gaining a following is the hydrogen fuel cell, but hydrogen is highly explosive and hard to control.

Neldon Wagner, a former teacher in Kodiak, thought that ethanol, a form of alcohol, would be a perfect energy storage medium. Ethanol can be burned in car and truck engines, home space heaters, water heaters, cooking appliances, and so on. It has a long, stable "shelf life," and it's not explosive like hydrogen.

In 1980, Neldon Wagner obtained a grant to study the economic feasibility of ethanol production. His project would use electrical power to generate ethanol from water (H_2O) and carbon dioxide (CO_2). The experiments would take place at a local Kodiak High School.

Project Design

Wagner purposely designed a project that was too small for large scale energy production; however, his concepts and findings could be upgraded to a full production system easily. The main thrust of his experiments was to execute four independent but serially connected chemical reactions that would convert water and carbon dioxide through methane and acetylene to ethanal and finally to ethanol. The reactions were chosen because:

- They were environmentally safe and produced no unmanageable or toxic by-products.
- They were technically simple, and
- They were low cost and used no exotic metals or apparatus.

Each reaction in the synthesis series was independently conducted to achieve maximum efficiency, simple construction, and technical feasibility. The final results of these reactions would give Wagner an idea of the economics of ethanol production.

Two glass reaction chambers were manufactured for these experiments. Reaction Chamber A, used for reactions one and two, is a 36 cm long, 12 mm diameter quartz tube with a Nichrome heating element supported down the center of the tube with mica spacers. The mica spacers provide mechanical support and also help interrupt gas flow for better contact between the gas and the Nichrome wire.

Reaction Chamber B is a necked-down (12 mm to three mm) quartz tube with a 200-watt tungsten filament inserted in the narrowed section. Although it was originally planned to insulate the two reaction chambers, no insulation was used during the course of these experiments. This is because temperature was visually controlled with a crude SCR (Silicon Controlled Rectifier) light dimmer circuit.

The four chemical reactions Wagner would use to convert the water and carbon dioxide were: 1) combining carbon dioxide with hydrogen to produce methane, 2) converting the methane at 1400 degrees to acetylene, 3) combining the acetylene with water to make acetaldehyde (ethanal), and finally 4) combining the ethanal with hydrogen to make ethanol.

Wagner decided to perform the experiments out of order since the reactants for reaction Number 3 were readily available. This reaction converted acetylene to ethanal. Ethanal is needed for the last reaction. As he was converting the acetylene to ethanal, Wagner found that simply bubbling the gas through an aqueous solution was very inefficient. He improved the process by "squirting" the gas through a pinched off glass tube and baffling the container with small pieces of plastic. Actual efficiency was determined visually. Acetylene by itself burns in an open flame and produces a lot of particulate matter (pure carbon), ethanal burns with a clean, slightly yellow flame. Wagner simply adjusted the amount of acetylene introduced to the reaction chamber until he could produce an ethanal flame.

This same type of attitude was taken performing the three remaining reactions. Visual observation was used as the final test to determine the quality of the reactions. During each reaction, the flow rates of the raw ingredients were monitored and compared to the gas produced. This, Wagner decided, would give an accurate efficiency value for ethanol production.

Results

Wagner found that although ethanol is a safe, long-lasting fuel source, it required much energy to produce. Starting with 100% energy, a full 99.8% would be consumed just to store 0.2%. Very few situations would justify that type of energy loss.

Minimizing the number of reactions, or creating larger, more efficient production units may reduce the energy loss somewhat, but the ability to make this process economically feasible seems highly unlikely.

Another problem with this process is the relative sophistication of the components and processes as they would relate to remote locations. More urban locations would not have the type of storage problems this project envisions because of more uniform usage.

Funding

U.S. Department of Energy	$1,639
State of Alaska	1,639

Grantee

Neldon Wagner
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Troutdale, Oregon 97060

Energy-efficient salmon drying facility studied

Two Native village corporations conducted a study to see if they could start up a commercial salmon processing plant powered with solar panels, wind generators, hydroelectric or some other local energy source.

Unfortunately, the Iguigig Native Corporation and the Levelock Natives Ltd. did not build the plant, and there is no data about whether solar and wind power is applicable.

The two village corporations had intended to build the plant about 20 miles north of the mouth of the Kvichak River which flows into Bristol Bay near Naknek and King Salmon. The region is the world's largest commercial salmon spawning area. There are no roads into Levelock, so everything must be flown or shipped to this small village of 100 residents.

Commercial fishing, trapping and subsistence hunting and fishing are the principal economic activities of Levelock. During summer, salmon are dried and smoked, many on open-air drying racks.

Purpose

The feasibility study was to develop ideas for an energy-efficient solar-heated, wind-powered commercial salmon drying facility. In addition, a videotape was planned to illustrate how innovative technology could be used for a commercial salmon operation in a small community.

All Alaska Services, Inc., of Kodiak, Alaska, conducted the study. The consultants compiled information on fishery resources, marketing, smoking procedures, plant facilities, staffing, transportation and financing.

But the evaluation of alternative energy options was given only a cursory review in a one-third-page discussion of solar and wind energy. Instead, the report spotlighted the potential use of diesel generation with waste heat recovery for providing the fish processing heat requirements.

Study Findings

The consultants proposed a $1.64 million plant which would process about 4,000 pounds of smoked salmon daily during a 10-week period, for an annual production of 240,000 pounds of smoked fish with a price of $7.20 per pound in Seattle, Washington. The consultants also said an additional $1.5 million would be needed for operating expenditures.

The village corporations, however, decided not to pursue a project of this size after reviewing the study.

Project Evaluation

The feasibility study was approached from the standpoint of high technology production equipment, requiring significant amounts of energy and minimal manpower.

State AT evaluators have indicated that a more appropriate approach would have been to analyze the available and potential alternative energy sources. These would have included active solar water heating, photovoltaics and wind generation among other options. The issue of using local labor and importing hired help also should have been analyzed, in the State's view.

By assessing all these resources and their alternatives, the parameters for plant design could have been identified under all potential scenarios, something the report did not do.

Funding

U.S. Department of Energy	$5,000
State of Alaska	$5,000

Grant Recipients

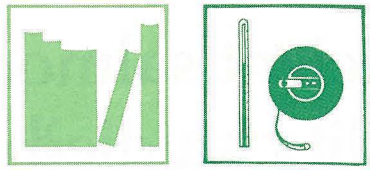
Iguigig Natives, Ltd.
General Delivery
Iguigig, Alaska 99613

Levelock Natives, Ltd.
General Delivery
Levelock, Alaska 99625

Available Materials

All Alaska Services, Inc., *A Study of the Feasibility of Establishing A Commercially Smoked Salmon Processing Facility*, 1981, 70pp.

Salmon waste study shows good result



Most fishermen do not think twice when they clean a fish and let the fast moving stream or tidal action carry away the refuse; but when the total amount of that viscera is over 130 million tons, you begin to understand the problem facing Alaska's cannery industry.

Alaska's lucrative commercial fisheries produce upwards of 500 million pounds annually, often yielding catches close to one billion pounds. The salmon catch, alone (representing about half of all species landed) is some 87% of the total U.S. catch. And depending upon how the fish are processed once they are landed, from 15 to 33% of the catch becomes processing waste. For every pound of salmon stuffed in a can, significant waste gets tossed in a landfill or in marine disposal areas.

A background in both the seafood processing industry and waste disposal convinced Dr. Leroy Reid that this problem needed further investigation. The present practice of disposing more than 50% of each fish is both wasteful and unnecessary; "in many parts of the world, processing wastes are routinely channeled into a variety of by-products. What scientific insights and what technology does Alaska need to properly manage this waste resource and to use it well?" asked Reid.

In an effort to find answers to these questions, Reid, president of Alaska Environmental Control Services, was granted funds to study methods that would make maximum use of each salmon caught in Alaska waters.

His project would involve investigating and testing the feasibility of digesting fish wastes from fish processing plants to recover usable oils, solids, and liquids. The project would be performed in two phases. First, a literature search of anaerobic and enzymatic digestive systems would be performed. Then, a bench-scale test of the most effective method would be done and the results presented in a formal report. Reid acted as advisor to two assistants who would do the actual work.

Testing and Analysis

The first part of the project, the library search, was carried out by a graduate student, Roy Timmreck. Timmreck began with a computer search of the University of Alaska Resource Library and the Department of Interior's Alaska Resource Library, followed by a trip to the University of Washington's Fisheries Resource Library and School of Fisheries. The literature study was to determine the resource potential of cannery wastes and identify processing methods to extract those resources. Reid hoped that by identifying the resources available in those wastes, the fishing industry would begin to seek ways to develop it instead of dump it.

The literature study would look at oil content, liquid/solid fertilizer potential, or other resources such as combustible gases and heat. After the library search was complete, Gwen Turner would perform a bench-study of anaerobic digestion of various salmon samples to determine gas content and quality and heat potential. The results of both the literature search and the bench-study would be drafted into reports available to the seafood industry and other interested parties. This study assumed that some useful by-products, such as the oils high in vitamins, had already been extracted. The only wastes digested would be those that had no other uses.

Turner used ground salmon wastes "donated" by area canneries. These wastes were placed in 2,000-millimeter glass flasks and immersed in a water bath to control digesting temperature and allow the recording of heat production. Although the water bath was originally to be kept at 55 degrees centigrade, further literature research determined that 33 degrees would produce a faster and more stable digestion.

The two researchers monitored each sample until gas production ceased, between 30 and 45 days, and then analyzed both the gas produced and the spent flask contents.

Conclusions

Roy Timmreck's final report on the literature study is a comprehensive dissertation on the resources available in fish wastes. Beginning with a description of the fish processing industry including types of fish processed, catch size, and typical fish wastes and waste treatments, Timmreck then undertakes a thorough discussion of the fish processing technology and practices including methods of extracting valuable nutritional and other beneficial products from the wastes. His report ends with a list of the available vitamins and minerals in the fish wastes and a list of all the certified Seafood Operators in Alaska from 1977 to 1980.

Gwen Turner's report was based on the results of the anaerobic digestion study. Although digestion was not complete at the end of the experiment, the study did provide information on gas content and quality and the heat potential in fish wastes. The digested products were also analyzed for fertilizer potential and the results included in the report. Whereas Timmreck's report dealt with theoretical potential, Turner's report provided hard data on the potential resources available in the wastes.

Based on the bench tests conducted on the processed salmon wastes, the researchers concluded that it is possible to digest these wastes anaerobically, but that further experimentation needs to be done to find the balance that will fully complete the digestion process. Researchers concluded that the following variables (explained in detail in the report) must be adjusted or monitored to go beyond the partial digestion achieved in this project: chemical oxygen demand; nitrogen and phosphorus ratios; pH levels; carbonate content of wastewater; sodium concentrations; and potassium content of wastes.

Throughout the course of the project, the potential of the resource was stressed and not the development of a workable system for developing the resource. Dr. Reid feels that this is the responsibility of the fish processing industry; his organization was involved only in identifying the resource potentials. Because the fish processing industry traditionally works only with processes that have a fast payback schedule, it is uncertain if the industry will take advantage of this study.

Funding

U.S. Department of Energy	$2,795
State of Alaska	2,795

Grant Recipient

Leroy C. Reid, Jr., Ph.D.
1200 West 33rd Avenue
Anchorage, Alaska 99503

Wood gasification studied by timber mill

The 1980s have brought hard times for Alaska timber companies and Mitkof Lumber Co., a small sawmill located on the Wrangell Narrows three miles south of Petersburg, found its market deteriorating and operating costs rising.

Like many lumber companies, Mitkof had to look for ways to remain profitable. Typically, small firms cut payroll or search for new markets to do this, but in the current business climate, the workforce was already cut to the bone and new markets just weren't there. Another method had to be found.

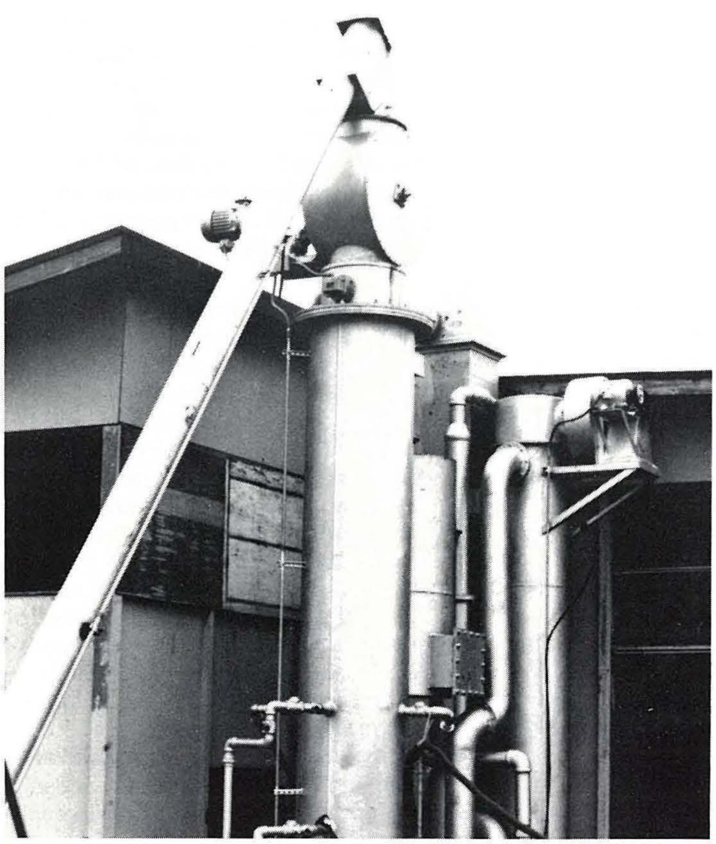
For every two-by-four cut in the world, there is a pile of bark and sawdust left behind. This residue either ends up being dumped, or burned in a giant incinerator. Sawmills in California, Oregon, and Washington are converting a portion of this waste into "manufactured" fireplace logs. Unfortunately in Alaska, there is an abundance of fuel wood and thus a limited market for this type of product.

Wood gasification was becoming popular with other wood product companies. This process was a way to "change a liability to an asset by converting waste wood residue directly into a fuel" that could replace the 211,200 gallons of diesel used every year by the company. Other small and large scale projects had already proven the technology. *The Mother Earth News*, an alternative magazine, outfitted a late model pick-up truck with a wood gasifier and has traveled cross country using salvaged waste wood as fuel. They also modified a small gasoline generator to use wood-gas to generate electricity. After "a world-wide" search, Ed Lapeyri, President of Mitkof Lumber Company, and Gerald Engel, area forester, decided that a wood gasifier may be part of the answer to Mitkof's problems.

In 1980, Mitkof Lumber Company applied for and was awarded grants to research and develop a workable wood-gasification plant. This project would be completed in three steps, with each step dependent upon the results of the previous step. The steps would be to:
(1) test the wood wastes to determine fuel content;
(2) test the wood wastes' ability to produce a usable fuel in a wood gasifier; and (3) develop an operational gasifier. This was modified soon after receiving the award to install a full-size wood gasifier at Mitkof for electrical power generation.

Data Collection and Testing

In April 1981, Engel and Ken Kilborn, a U.S. Forest Service employee, determined that the sawmill produces about 6,800 tons of wood waste each year, calculated by monitoring 100 typical sawlogs as they were processed.



A wood residue sample was tested in this gasifier located in Portland, Oregon.

Later that year, a sample of wood residue was shipped to Hamilton Energy Systems of Portland, Ore., where it was tested for five hours in a gasifier designed by Franz Rotter. Although the output of the gasifier was supposed to run a 175-horsepower Waukesha diesel/generator, the generator section was inoperative. The gas produced did, however, run the internal combustion engine with no load and provided needed momentum to the project.

At the end of the five-hour test, the results showed that almost 42 percent of the heat value in the wood was converted to a low BTU gas. About 10,700 cubic feet of this (95 BTUs per cubic foot) gas was produced, or approximately 26 cubic feet of gas per pound of wood. Further studies indicated that the quality and amount of gas could be increased by pelletizing the fuel, recycling the spent charcoal, and adding a small amount of oil to each burn. Pelletizing the wood before adding it to the gasifier would also keep the wood scraps from periodically clogging the feed hopper.

Final analysis of the wood-gasifier by-products indicated that hazardous wastes were present and additional scrubbing would have to be performed in order to satisfy environmental requirements. For example, water produced as a by-product, was highly acidic, black from soluble tars, and had an awful odor.

However, the test run proved that an acceptable gas can be generated from the wood residues and that with some modification a gasifier could be built to overcome the offensive by-products. Shortly after this stage was completed, Mitkof was informed by the State of Alaska Division of Energy and Power Development that an Anchorage company, Marenco, Inc., also was working on wood-gasification. In fact, they had an experimental system in Anchorage. Mitkof agreed to a contract with the State to install a second generation gasifier manufactured by Marenco. Mitkof sent three workers to train on the completed unit in Anchorage. After three days of trying to get Marenco's gasifier to work, Mitkof management decided that a more reliable system would be needed before installation would be approved. Mitkof "lost interest at that point," according to Engle, and the project was dropped.

Conclusions

Although the prospects of converting waste wood to a usable fuel still sound exciting, the "technology isn't up to snuff," said Engel. "Although one of the guys we contacted had recently won a cross country race in a wood-fired car and is planning a five-megawatt wood-gasification plant in Michigan, we aren't large enough to warrant a large investment in technological research," he said.

The study itself, however, was considered a success. It exposed those grey areas of the technology that dramatically increase costs when going from experimental units to full production facilities. For example, the studies in Oregon indicated that the fuel had to be pelletized prior to use and that additional environmental protection devices were needed to process the by products. These additions raised the price of a working system to almost that of a large wood-fired steam generator system. With present market conditions and an uncertain future, Mitkof decided to maintain its present system of diesel powered generators and equipment, supplemented by utility power.

The future for wood-gasifiers is uncertain, even though the State of Alaska has spent over $1.2 million in wood gasification development since 1978. Problems with fuel consistency, dangerous by-products, etc., makes this energy source questionable.

Funding

U.S. Department of Energy	$6,415
State of Alaska	6,415

Grant Recipient

Mitkof Lumber Company
P.O. Box 89
Petersburg, Alaska 99833

Media and curriculum projects expand energy knowledge

While scores of grantees were inventing new applications for energy technologies, grappling with technical problems, and getting their equipment on-stream, other grantees were participating in a statewide series of grants to spread the word about appropriate technology.

These programs ranged from full-scale video and audio tape programming production to community workshops that taught the basics of energy conservation. Several grants enabled communities to develop their own energy libraries or resource centers (in addition to a series of grants awarded individual libraries statewide to improve their collections; these grants are listed in the Appendices).

The following is a synopsis of each grantee's media and educational project under the AT grant program.

Robert Woolf

A textbook outlining the historical origins of appropriate technology was developed by Robert Woolf, and Paul Helmar of Juneau. Woolf received $7,026 from the U.S. Department of Energy and $39,376 from the state of Alaska for the project, which he developed while teaching in the village of Atmautluak.

The history textbook, a one-semester course, is available through the Alaska Department of Education's vocational education office. The state is publishing some 1,000 copies of the textbook.

In addition, Woolf designed a model home for classroom use. The model, two-feet-by-one-foot-by-two-feet, helps students learn about the concepts of appropriate technology. It also is available through the vocational education office.

Further information may be obtained from Woolf at 749 St. Ann's Ave., Douglas, AK 99824.

Southeast Regional Resource Center

The Southeast Regional Resource Center obtained $35,000 for producing videotapes, slide tapes and lesson materials on the appropriate technology grants. All that was completed was a 30-minute videotape on some of the AT projects. It is available through the State Film Library under the title "Appropriate Energy Modes."

University of Alaska-Fairbanks, School of Agriculture

Belle Michelson and Sue Yerian, with the U of A's Fairbanks School of Agriculture, received $7,769 in funding to create an energy curriculum library at the North Pole Junior-Senior High School. Multi-media teaching materials emphasizing northern energy applications were selected for the library collection. Goals of the program included demonstrating local appropriate technology through multi-media education, boosting the amount of locally available alternative energy literature, and teaching these energy topics in seventh through 12th grade classes.

For more information, contact Yerian at Box 82114, College, AK 99708.

Western Media Concepts, Inc.

Western Media Concepts, Inc., a radio production firm in Anchorage, received a $16,896 grant to research, edit and produce radio broadcast tapes for various alternative energy projects around the state. In all, the company produced 15 five-minute programs, aired on 10 commercial radio station members of the Alaska Radio Network. Three documentaries also were produced, as well as 15 two-minute features. The tapes were offered to and used by radio stations statewide.

Further information on the radio project may be obtained from Western Media at P.O. Box 215, Anchorage, AK 99510.

Northwest Community College

Nome's Northwest Community College used AT grant funds to improve knowledge of appropriate technology's benefits in a number of villages in the Northwest Alaska region, including Unalakleet, Gambell, Savoonga, Shishmaref, Wales, Teller, Stebbins, Diomede, White Mountain, Golovin and Nome. The $26,797 project included workshops, demonstrations, consulting for residents and accumulation of a collection of books for the college library and five learning centers throughout the region.

Further information on the program may be obtained from the Energy Information Center (Library) at the college, Pouch 400, Nome, AK 99762.

Sitka Community College

The Sitka Community College also conducted an energy outreach program in its region with a grant totaling $9,582. Workshops were held in Kake, Angoon, Petersburg and Wrangell by two instructors. The workshops covered lifestyle practices that can reduce energy consumption; conservation measures suitable for (individually audited) homes; applications for renewable resource energy sources; financing and other programs available through the state for energy conservation; federal energy conservation tax credit programs; and retrofitting methods to improve energy efficiency.

Further information on the program may be obtained from the college, P.O. Box 1090, Sitka, AK 99835.

Huslia High School

Huslia High School was awarded a $5,579 grant to develop an Energy Resource (Information) Center in the school. The collection included books, pamphlets, reports, video and audio tapes, and films. The school sought the grant to improve its teaching and educational resources for the community. The library was available to teachers during the day and to the community during after-school hours.

Further information on this Yukon-Koyukuk region project may be obtained from the high school resource center, Huslia, AK 99746.

Steve Smiley

In addition to his wind generator project in Homer, appropriate technology advocate Steve Smiley conducted a workshop at the Seward Training Center under a $5,000 grant from the AT program. In the workshop, Smiley discussed techniques for building and retrofitting for energy efficiency. He covered costs and benefits of energy efficiency (such as tax credits, etc.), general design considerations, specific building techniques, building materials, and selected hardware.

Further information on the workshops may be obtained from Smiley at SRA Box 41-C, Homer, AK 99603.

GLOSSARY & APPENDICES

Glossary

Absorber pipe—The tubing is a solar collector that transfers the heat collected by the absorber plate to the heat transfer fluid, either air or liquid, within it.
Appropriate Energections—A quarterly magazine published by the State of Alaska, Department of Commerce and Economic Development, Division of Energy and Power Development until June, 1983.
BTU—British Thermal Unit. A measurement of heat, or more specifically, the amount of heat required to raise one pound of water one degree Fahrenheit when the temperature of the water is initially at 39.2 degrees.
Clerestory—A window, or windows, placed high on a wall near the eaves, used for light, heat gain, and ventilation.
Cooperative Extension Service—A cooperative education program between the University of Alaska and the U.S. Department of Agriculture. The purpose of this service is to provide information to Alaskans to help identify and solve problems in order to improve business, homes, and communities.
Deadman beams—Long poles or beams buried in the ground like a dead man to provide strong anchors for winching or guy wires. Deadman beams are buried at right angles to the line of pull in order to provide maximum resistance.
Domestic water supply—Standard household water system connected either to the municipal water system, a well, or another source like a cistern collecting rainwater.
Double-glazed thermal window—A double-paned window that has an air gap between the panes, giving increased thermal insulating qualities almost double the insulating value of a single-pane window.
Earth-sheltering—A construction technique which places all or part of a building under ground level. Although construction materials used in earth-sheltered buildings must be heavier than for standard above-ground structures, earth-sheltered homes have the advantage of less air infiltration and sometimes decreased heat loss through the walls.
Float-valve (controlled) alarm—A device used to automatically signal a homeowner when the fluid in a reservoir falls below a predetermined level.
Gin pole—A tall pole used as a portable derrick fulcrum for lifting heavy objects.
Heat exchanger—A device that transfers heat from one fluid to another without the two fluids touching each other. Both air and water are considered fluids.
Heat exchanger coils—Coils of tubing, usually copper, within a heat exchanger assembly. As fluid flows through the heat exchanger coils, the heat is transferred from the fluid outside the coils to the liquid inside the heat exchanger or vice versa. This system is often used to ensure that the liquid on the outside of the coil does not mix with the liquid inside the coil (i.e., one fluid may have antifreeze in it and the other fluid may be drinking water).
Heating degree days—A measure of the need for heat, based on the assumption that when outside temperatures drop below 65 degrees, the heating system will come on to keep the house at 70 degrees. Degree Days (DD) are calculated daily as follows:

65 degrees − average outdoor temp = heating DD

Temperatures above 65 degrees are considered 0 Heating Degree Days. Over the course of a winter, the total annual Heating Degree Days are used to compare the severity of one winter with another.
Parabolic reflector—A bowl-shaped device used to concentrate solar or electromagnetic energy by reflecting the energy to a focal point much smaller than the collector area. This device produces much higher temperatures at the focal point than can be obtained with a flat-plate collector.
Passive system—Passive systems involve energy collection, storage, and distribution by means of natural processes using a minimal amount of power fans or pumps. Passive cooling also includes methods to shade the solar collectors and control ventilation and humidity.
Plastic bubble insulation—A form of insulating material which sandwiches bubble polyethylene (the same material used as packing in shipping boxes) between layers of other materials. This system creates several layers of dead air space for improved insulating abilities.
Photovoltaic cells—Devices which convert sunlight directly into electrical energy (also called solar cells). A grouping of cells may be manufactured as a panel.
R-value—The measure of the ability of a material to resist heat flow. This term is used to compare the heat-saving ability of building insulation and other construction materials and represents how many BTUs per hour will pass through the structure to the outside. The higher the "value" the better the insulating ability; R-20 is twice as good as R-10 and R-50 is five times better than R-10. A single-pane glass is less than R-1 and a common two-by-four wall insulated with fiberglass has an R-13.
Radiant heat system—A heating system that takes advantage of the radiant component of heat transfer. Radiant heat is composed of electromagnetic waves that travel through space, demonstrating warmth only when they strike a solid object, like a wall, or your skin. The warmth felt directly from the sun or a woodstove is radiant heat.
Reflective mylar—A generic term for polyester film with a microthin coating of metal applied to one side, usually aluminum. The metal coating greatly increases the heat reflectivity of the mylar with only a slight reduction in its light transmission qualities.

Sola-Roll Systems—(Also known as Solaroll.) A flexible, black rubber EPDM solar absorption system with six molded tubes for carrying water or other heat transfer fluid. Sola-Roll can be used for solar absorption energy systems or imbedded in concrete for radiant heat applications. The fluid-carrying flat tubing (¼" diameter) is an integral part of the Sola-Roll System. The term applies to the construction which places six tubes in parallel, then seals them in flexible, black rubber EPDM material. The end result is a "flat-tubing" product.

Shotrock—Coarse rubble left over from a blasting operation and which can be used for thermal mass.

Solar gain—A measure of the amount of BTUs received on a particular surface over a given period of time.

Solar greenhouse—A greenhouse that is attached to a house and provides heat storage and heat to the interior of the home.

Solar water heaters—Domestic water heaters that use the energy of the sun to heat the water.

"Space Blanket" curtains—Quilted aluminized-mylar curtains that reflect a large portion of the radiant heat striking them and yet still offer the light transmission reduction of standard curtains. These curtains are also lightweight and extremely thin.

TJIs—A fabricated wooden beam which uses a combination of solid wood and plywood to make a strong, lightweight building material. TJI is an acronym for truss joist/I, or I-shaped truss joists and are manufactured by the Truss Joist Company.

Thermal mass—Building materials that absorb and store heat. Thermal masses can be brick, shotrock, large containers of water, adobe, masses of cement, etc.

Thermax—An isocyanurate foil covered foam sheathing (plastic) used to insulate buildings and manufactured by the Celotex Corporation. Other similar products are called R-MAX, THERMOFAX, TECHNIFOAM, and HIGH-R. Thermax is known for its strength, high R-value, and light weight.

Thermosiphon system—A heating system designed to exploit the natural tendency of hot fluids to rise and cold fluids to fall. It can provide heat distribution without the use of a circulating pump, or fan.

Tracking system—A mechanical system designed to rotate solar collectors so they receive maximum available solar energy.

Utility intertie system—The direct connection through a control box of a wind or hydro electric generation system with the local utility electric power system. This enables the homeowner to almost always have electricity either from the wind or hydro system, or the local utility. Any power not used by the homeowner may be sold to the electric utility.

Vapor barriers—A layer of material used to retard the movement of moisture and air from the warm insulated wall to the cold side. Because warm air can hold more moisture than cold air, a vapor pressure will occur in cold weather on the outside walls and ceilings of a house. The moisture can be forced through openings and permeable materials in the walls and ceilings. The moisture may then condense or freeze in the insulation, reducing the insulating value and causing moisture or water problems which are sometimes severe. Some common vapor barriers are polyethylene film (Visqueen) and aluminum foil.

APPENDIX A

Appropriate technology grants to libraries, 1980–1982

Grantee	Location	Amount*
Cooperative Extension Service	Anchorage	$2,297
West High School Media Center	Anchorage	213
Service Hanshew Resources Center	Anchorage	390
Anchorage Career Center	Anchorage	350
University of Alaska	Anchorage	350
Angoon High School	Angoon	1,244
Yukon Flats School District	Arctic Village	350
BIA Bethel Regional Library	Bethel	391
Cantwell Education Association	Cantwell	550
Anderson Village Library	Clear	350
Cordova Public Schools	Cordova	530
Dillingham Public Library	Dillingham	553
Dillingham City School District	Dillingham	1,685
Eagle Library	Eagle	350
Elim Community Library	Elim	350
Fairbanks North Star Borough	Fairbanks	1,150
University of Alaska, Rasmuson Library	Fairbanks	905
Yukon Flats School District	Fort Yukon	550
Glennallen School Library	Glennallen	350
Copper Valley Community Library	Glennallen	350
Haines Borough School District	Haines	350
Haines Borough Public Library	Haines	198
Tri-Valley School Library	Healy	4,472
Homer Public Library	Homer	374
Hoonah Schools Library	Hoonah	300
Hooper Bay High School	Hooper Bay	350
Alaska Conservation Society, Taku Chapter	Juneau	350
Juneau Borough Library	Juneau	618
Juneau-Douglas High School	Juneau	372
Kake High School Library	Kake	468
Kenai Junior High School	Kenai	284
Kenai Central High School	Kenai	319
Kenai Community Library	Kenai	1,350
Kenny Lake Community Library	Kenny Lake	691
Ketchikan Public Library	Ketchikan	350
McQueen School	Kivalina	320
A. Holmes Johnson Memorial Library	Kodiak	650
Kodiak Island Borough School District	Kodiak	450
City of Kotzebue	Kotzebue	350
McGrath Community Library	McGrath	350
Nenana Public Library	Nenana	350
Kegoayah Kozga Library	Nome	850
Mat-Su Community College	Palmer	1,004
Palmer Public Library	Palmer	350
Petersburg High School	Petersburg	720
Petersburg Public Library	Petersburg	1,050
Port Lions Public Library	Port Lions	650
St. Mary's High School	St. Mary's	175
Susan B. English School	Seldovia	175
Seward High School Library	Seward	670
Kettleson Memorial Library	Sitka	622
Skagway City School District	Skagway	175
Soldotna Public Library	Soldotna	350
Kenai Peninsula Community College	Soldotna	300
Sutton Public Library	Sutton	281
Talkeetna Public Library	Talkeetna	350
Tanana Community Library	Tanana	350
Tenakee Public Library	Tenakee	350
Valdez City Schools	Valdez	350
Valdez Public Library	Valdez	320
Wrangell Public School District	Wrangell	350
Irene Ingle Public Library	Wrangell	1,300
Yakutat City Schools	Yakutat	350

*Most current reported

APPENDIX B

Appropriate technology edited videotape project material

The Alaska State Film Library has available for viewing a number of AT project films, most compiled as news reports by the television media. These projects are listed below.

KTOO-TV

Petersburg Ram	June, 1983
Pt. Baker	June, 1983
Port Armstrong	June, 1983
Thayer Lake	September, 1982
Thayer Lake	September, 1982
Ken Cassell Hydro	September, 1982

KIMO-TV

Dallas Solar, Fairbanks	June, 1983
Don Chaney/Mike Baumgartner	May, June, 1983
Port Armstrong Hydroelectric	June, 1983
McGrath Greenhouse	May, 1983
H. Jack Coutts	June, 1983
John Collette	June, 1983

KYUK-TV

Hooper Bay Wind—3 parts	May, 1982

Alaska Review #46 "Alternative Energy: Alternatives for Alaskans" 29:14, 1982

"Appropriate Energy Modes" 27:30, 1982

"Alternative Energy in Alaska: Everett Drashner's Homestead" 1981

"The Great Alaskan Warm-up" 29:30, 1984
("Retrofit" and "Sunspace" segments)

APPENDIX C

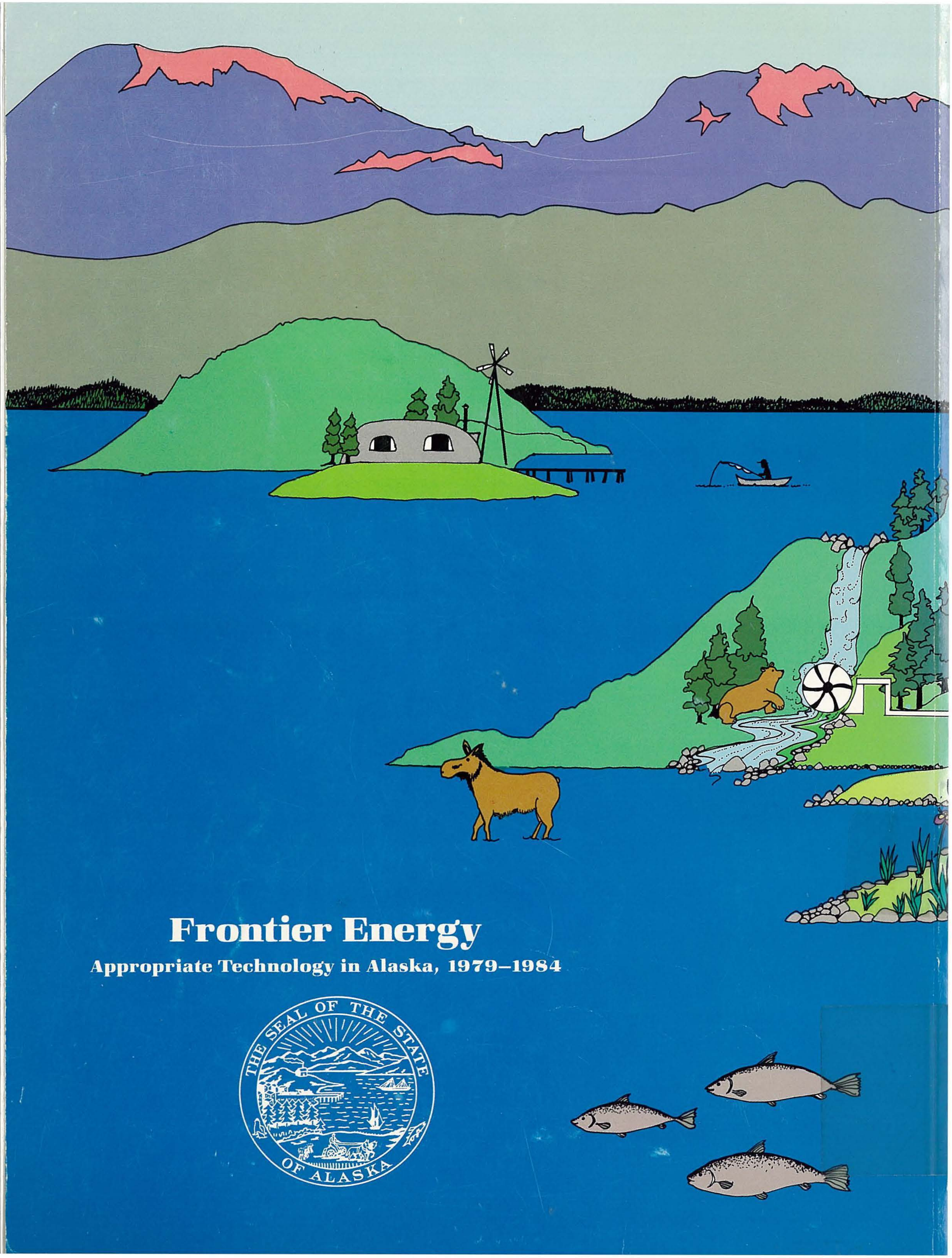
Grant awards returned or not accepted

Dan Denslow, Ambler, Wind Powered Freezer	$ 3,500
Tom Miller, Kodiak, Insulating Shutter	675
Walt Cunningham, Bare Island, Alcohol Production	2,750
Ricardo Quiroz, Anchorage, Wood-Heat Systems	8,000
City of Tununak, Energy Conservation Workshops	4,414
Joann Schoonover, Anchorage, Rainwater System	15,000
Charles Vowell, Anchorage, Wind-Powered Heat Pump	8,200
Kodiak Community College, Ahkiok, Energy-Efficient Home Building	6,260
St. Mary's School District, St. Mary's Greenhouse	25,540
Alice Campbell, Fairbanks, Compost-Heated Greenhouse	290
Alas-Can Energy Expo 80, Anchorage, High School Energy Fair	2,000
William Major, Glennallen, Solar Collector	4,200
Lower Kuskokwim Coast Corporation, Kipnuk, Earth-Sheltered Office Building	50,000
Kodiak Mental Health, Kodiak, Greywater Heat Recovery	19,153
City of Dillingham, Dillingham, Wind Monitoring Equipment	10,000
Matanuska Electric Association, Inc., Palmer, Wind Monitoring Equipment	1,458
Gary Nowobielski, McKinley Station, Hydraulic Ram	1,115

APPENDIX D

Grant projects terminated before completion

Craig H.F. Anderson, Palmer, Solar Collector	$ 400
Nome Veterinary Hospital, Nome, Solar Thermal Storage	2,576
Arctic Technical Services, Inc., Kotzebue, Solar System	24,900
William Arterburn, Willow, Air to Air Heat Exchanger	2,162
Hughes Village Council, Hughes Alternative Energy Study	3,000
Sandra Tahbone, Nome, Sod House	1,266
James Keck, Fairbanks, Passive Solar	313
William Hightower, Moose Pass, Methane Digester	1,922
Patrick Yourkowski, Homer, Wood-Heat and Storage System	3,081
John Hodge, Fairbanks, Hydrate Energy Storage System	183
George Bennett, Fairbanks, Energy Efficient Garage/Shop	7,860
Kodiak Winds, Kodiak, Wind Monitoring System	8,251
Dean Jarosh, Takotna, Micro-Hydro System	2,710



Frontier Energy

Appropriate Technology in Alaska, 1979–1984