



Residential Heating in Remote Arctic Villages: Research Needs

WORKSHOP SERIES REPORT 1



A Report from the Arctic Renewable Energy Working Group
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About This Report

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Acronyms

ACEP – Alaska Center for Energy and Power
AEA – Alaska Energy Authority
AHFC - Alaska Housing Finance Corporation
ANTHC – Alaska Native Tribal Health Consortium
AREWG – Arctic Renewable Energy Working Group
AVEC – Alaska Village Electrical Cooperative
BSNC – Bering Strait Native Corporation
CCHRC - Cold Climate Housing Research Center
ISER – Institute of Social and Economic Research
USARC – United States Arctic Research Commission

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Introduction

A 2008 publication by the Institute of Social and Economic Research (ISER) at the University of Alaska Anchorage, reports that 79% of households in rural Alaska depend on diesel fuel to heat their homes, with the other 21% using wood, natural gas, propane, coal, or solar power.¹ The same report indicated that rural residents in the lowest income bracket spend 47% (median value) of their annual earnings on home heat compared to 8.7% for the same income groups in Anchorage, Alaska's largest city.¹

Although the global price of oil has fallen in 2016, heating and electrical costs for remote Alaskan villages remain high due to the nominal rigidity of the market/industry, fixed expenses of transporting fuel to the villages (by air or barge), the infrequency of fuel delivery, the cost of bulk fuel storage, and the high cost of operating and maintaining isolated and remote systems. These factors also lead to wide variation in the cost of fuel in Alaskan communities. For example, the January 2016 Alaska Fuel Price Report² indicated that communities in the western region of Alaska pay an average of \$5.66 per gallon for heating fuel, as compared to under \$4.00 per gallon in rural Alaskan communities in the Northern, Southeast, and Gulf Coast regions (Table 1). Even within regions, prices vary greatly, with communities in Interior Alaska paying prices ranging from \$2.32 to \$12.00 per gallon.²

The Regulatory Commission of Alaska (RCA) regulates the price of many home utilities—phone, water and wastewater, natural gas, refuse, and electricity. However, the cost of home heating fuel oil is unregulated.³

While this lack of regulation may play a part in the price variation of heating fuel, a more significant factor is the remote and isolated nature of many Alaskan communities, most of which are located off the road system and are accessible only by waterways (when not blocked by ice) or by air. This remoteness significantly increases the cost of fuel, as the expense of delivering fuel to the community is passed on to the customer. When accounting for distribution costs, a 2010 study by ISER⁴ found no evidence of excessive charges by fuel distributors in the western region of Alaska, where fuel prices are highest. Rather, most of the variation in fuel prices appears to be due to discrepancies in the retail price-setting practices at the community level.⁴ Suggested reasons for this include differences in the cost of debt for bulk fuel loans; collection approaches for operations and maintenance costs; the level of implementation of safety and environmental compliance; fuel sales operation hours; and the level of local mark-up practices to collect revenues.

In addition to the high and unstable cost of heating fuel, Alaskan villages are often challenged by limited access to a stable and trained workforce to operate and maintain the utility and heating systems on which the village depends. A stable governance to administer heating programs can also pose challenges.

In Arctic communities, where temperatures can plummet far below freezing, home heating is a critical utility that can be difficult and expensive to maintain.

TABLE 1. RETAIL HEATING FUEL PRICES PER GALLON ACROSS REGIONS OF ALASKA²

| | Gulf Coast | Interior | Northern | Northwest | Southeast | Southwest | Western |
|----------------|-------------------|-----------------|-----------------|------------------|------------------|------------------|----------------|
| High | \$6.05 | \$12.00 | \$2.50 | \$7.21 | \$4.65 | \$7.36 | \$7.32 |
| Low | \$2.35 | \$2.32 | \$1.40 | \$3.16 | \$2.85 | \$2.75 | \$4.12 |
| Average | \$3.44 | \$5.05 | \$1.79 | \$5.23 | \$3.43 | \$4.98 | \$5.66 |

¹ Saylor, B., S. Haley, and N. Szymoniak. 2008. Estimated Household Costs for Home Energy Use. Institute of Social and Economic Research, University of Alaska Anchorage, Note 1, 10 pp., <http://www/iser.uaa.alaska.edu/Publications/webnote/LLFuelcostupdatefinal.pdf>.

² Alaska Fuel Price Report: Current Community Conditions, January 2016, https://www.commerce.alaska.gov/web/Portals/4/pub/Fuel_Price_Report_Jan.2016.pdf.

³ The RCA regulates the oil and gas pipeline carriers that operate within the state.

⁴ Szymoniak, N. G. Fay, A. Villalobos-Melendez, J. Charon, and M. Smith. 2010. Components of Alaska Fuel Costs: An Analysis of the Market Factors and Characteristics that Influence Rural Fuel Prices. University of Alaska Anchorage, Institute of Social and Economic Research. Prepared for the Alaska State Legislature, Senate Finance Committee, 77 pp.

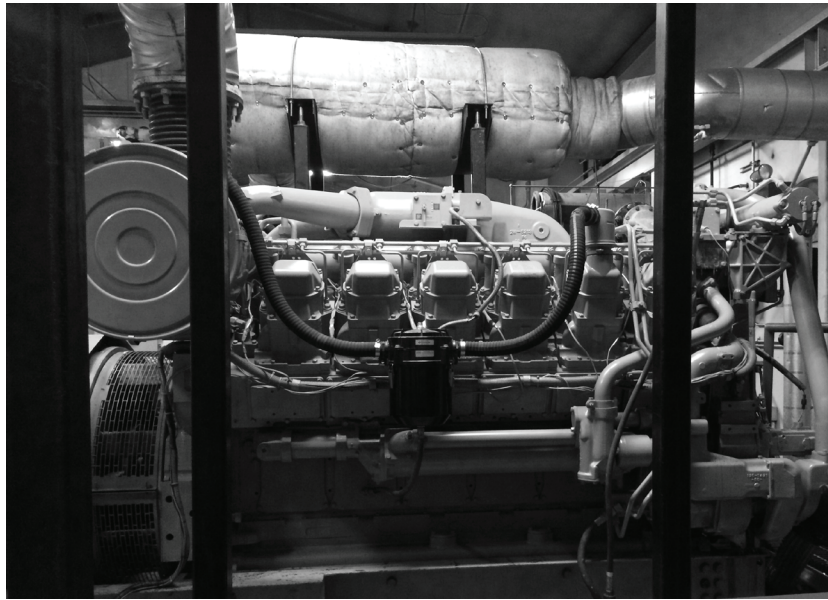


FIGURE 1. Village heating infrastructure, Anaktuvuk Pass, Alaska. Photo by USARC

The Arctic Renewable Energy Working Group (AREWG), coordinated by the US Arctic Research Commission (USARC), promotes research on renewable and efficient energy systems in remote Arctic communities. Formed in 2015, this working group benefits Arctic communities by identifying and addressing critical research needs in renewable energy and energy efficiency. Further information on this working group can be found at <https://arctic.gov/arewg/index.html>.

AREWG's initial efforts have focused on the home heating needs of remote Alaskan villages. To begin addressing this issue, the first of three heat-specific workshops was held on January 20, 2016. **The aim of this initial workshop was to identify data gaps and research needs related to how heat is used in villages in order to better understand how renewable energy systems, energy efficiencies, and education and/or policy level efforts might best address heating needs for remote communities.** Future workshops will focus on implementation of research recommendations (November 2016) and evaluation of efforts (2017).

Participants in the workshop included representatives from the Alaska Energy Authority (AEA), Alaska Center for Energy and Power (ACEP), Alaska Housing Finance Corporation (AHFC), Alaska Native Tribal Health Consortium (ANTHC), Alaska Village Electric Cooperative (AVEC), Renewable Energy Alaska Project (REAP), ISER, and USARC.

Several workshop participants noted that this was the first meeting focused solely on heat solutions for remote communities, and many felt this was highly responsive to the needs of rural residents.

Workshop Attendees

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Eric Hanssen (ANTHC)
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Residential Heating Needs

Residential Heating in Remote Communities: Data Gaps

The meeting began with a review of the status quo with respect to heating in remote Alaskan villages (with a focus on the Arctic as defined by the Arctic Research and Policy Act: <https://arctic.gov/maps.html>). Little data are available on home heating in rural Alaska. The attendees determined that there is a fundamental need to know the amount of fuel that is being used for home heating in the villages. Researchers and energy specialists do not have the quantitative “top-down” information required to fully understand heating fuel delivery to service sites, how the utility is administered, or the efficiency of heating fuel use.

The amount of fuel delivered to villages by suppliers (for heat and other uses) is not publicly disclosed, and most suppliers are unwilling to share this information. Total fuel delivery can be estimated but is subject to speculation and may not accurately reflect actual use. While this level of data may be obtained with permission of, for example, village councils/communities, the effort would likely group commercial and residential fuel supplies as one, not solving the data gap for fuel used for home heating.

Community-wide fuel usage can sometimes be determined from the bulk fuel tanks, specifically in communities participating in the state’s Power Cost Equalization program.⁵ Again, these data sets are not residentially specific and do not provide the *household* heat energy usage information needed by researchers (averages and outliers). Meeting participants also emphasized that until the dimensions of the problem (i.e., amount of fuel/energy for home heating that is needed) are known, it is difficult to generate feasible and economic solutions to reduce fossil fuel usage for home heating. To accurately model the cost savings and efficiency generated by any potential improvements from new technology, renewable energy sources, or energy efficiency implementations, reliable baseline data at the household scale are needed along with the temporal/seasonal scale of heating needs.

⁵ The Alaska Energy Authority’s Power Cost Equalization program provides economic assistance to communities and residents of rural electric utilities where the cost of electricity can be three to five times higher than for customers in more urban areas of the state. For more information on this program go to <http://www.akenergyauthority.org/Programs/PCE>.

In some communities, basic information such as the number of buildings and their size, use/function, and occupancy is not easily accessible given the logistics of reaching remote Alaskan villages.

Additional barriers to data collection discussed at the workshop include the practice of fuel tank sharing among public (non-residential) buildings, making it difficult to judge the efficiency of individual buildings on fuel usage alone. Additionally, few heating fuel meters are currently in use in rural communities. Without these “microdata”, neighbor-to-neighbor comparisons of heating fuel usage are impossible, making difficult rough estimates of comparative home efficiency.

The AHFC has done a large amount of efficiency and weatherization work in the villages, but needs still exist. The Cold Climate Housing Research Center (CCHRC; www.cchrc.org) has worked with tribes and housing authorities to design and build new cost-effective and energy efficient homes across the state. Additionally, CCHRC has performed extensive research and demonstration of weatherization and building envelope retrofit strategies that have been effective in reducing energy use. While new home construction has been inspired by CCHRC’s work, there continues to be a lack of cost-effective energy efficient housing in rural Alaska.

The Challenges

SHORT-TERM: Collect heat-related data to inform users and utility operators on heat use and efficiency (e.g., low cost/no cost behavioral changes that reduce fuel use, program effectiveness measures).

MID-TERM: Retrofit outdated energy infrastructure, learn which factors affect energy usage other than behavior, provide sufficient maintenance of infrastructure, etc.

LONG-TERM: Develop new building designs and construction methods that are energy efficient on a life-cycle basis and that incorporate renewable energy sources.

Another barrier to village-level energy efficiency and use of renewables is the lack of traditional project financing and poor understanding of energy project financing intricacies. Communities are often unaware of loans programs that may allow them to develop and implement infrastructure improvements to reduce their dependence on diesel fuel for heat. This may also involve a lack of awareness surrounding the loan process, loan qualification, credit history requirements, and steps they could take to improve loan eligibility.

Difficulties with project financing are not restricted to Alaska's remote villages, but they are exacerbated in poor communities in Alaska and elsewhere. In Alaska, technical assistance funds are provided to assist communities with this problem, but options are limited. Assistance is often available only to rare small businesses or agricultural projects, and even then often covers only approximately 25% of the project cost. Improving technical assistance for financing energy projects aimed at small municipal and tribal governments, local native corporations, and residents would dramatically increase the ability of these communities to make economically sound choices for their future energy use.

Heat-Related Needs by Stakeholder Group

Workshop participants created a list of heat-related needs for specific user groups in Alaska.

RURAL RESIDENT NEEDS

- The ability to heat ones' home at reasonable cost⁶
- Energy pricing/cost stability
- Fuel source available year round
- Homeowner options to monitor usage of heating fuel
- Systems that are simple and easily maintained, preferably by the homeowner or village-level maintenance worker
- Access to skilled repair/maintenance services at the village level
- Training and understanding of heating systems by local residents/home owners (resulting in a sense of ownership and improved functionality of system)
- Information on available energy efficiency upgrades programs/behaviors
- Minimize pollution from heat production so that air and water quality are not compromised
- Jobs and economic improvements: jobs and local money kept in the community leading to increased economic independence
- Education about holistic house functionality
- Local/regional energy champion(s) and a network of energy educators (remote villages can share knowledge)
- Creation of a path to augment "economies of scale"
- Long-term vision of where the State of Alaska is going with respect to building design and energy code (will this vision accommodate district heating system options?)

OPERATOR NEEDS (power utilities)

- Cost effective and efficient energy storage systems
- Trained and accountable operations and maintenance workforce (consider incentive systems)
- Information on available energy efficiency upgrades/ programs/behaviors
- Heat utility availability – reimagining heat as a service
- Energy and maintenance management services
- Simple and straightforward systems
- Network of educated/well-trained operators
- Heat recovery systems services provider (possible overlap with water and sanitation service providers)

AGENCY/REGULATORY/GOVERNING BODY NEEDS

(state/federal/local)

- Policies that influence behavior (carbon tax?)
- Information needed to develop "forward looking" (strategic, future) policies
- Policy alignment (of new and existing policies)
- Funding opportunities for solutions

INVESTOR NEEDS

- Minimize risk
- Return on investment (long and short term)
- Debt minimization
- Regionalized service (or larger) cooperative model approaches—economies of scale
- Maximize profit

INDUSTRY NEEDS

- Dependable consumer base/schedule
- Customers with the ability to pay
- Incentives to share data
- Regulation of distribution monopoly

⁶ Reasonable cost was estimated at this workshop as <10% of median home income.

Research Needs and Priorities

General Priorities/Data Collection Needs

- Compile and collect basic data at the individual residential home level—how much of what kind of fuel is being used to heat homes where? (important to include metered vs. unmetered homes in this analysis)
- Fuel metering data on homes (and potentially commercial buildings)
- Data on use of home heating appliances
- Basic data on rural infrastructure and buildings: a well organized, centralized data set of basic community information, would help in heat-use modeling. Ideally, this would include community name, the number of buildings in the community, owner of the building (resident, city, tribal, corporations, business), and their size, spacing and use/function, and current heating method. This information will inform cost estimates.
- Data review of “heat technology” research trials

General Priorities/Research Questions

- How would a reduction in energy subsidies impact communities?
- At what point do small, off the road system communities become non-viable under this scenario?
- Is the “district heating” model feasible in Alaska (Figure 2)? How can a centralized district heating distribution system be implemented?
- Would increased use of multi-family housing increase the viability of district heating systems? Is this something that would be socially acceptable in communities?
- How have other countries (especially Arctic) approached this model?
- What are the challenges to local implementation of energy efficiency projects in rural Alaska?
- What are the barriers to behavior changes to implement efficiencies?
- What organizational/capacity barriers exist?
- What opportunities are there for sewage, food waste, fish processing waste to be used as heat through small scale anaerobic digestion in rural communities? Is it feasible in rural Alaska, especially in Arctic and sub-Arctic locales?
- What is the potential for methane as a fuel in Alaska?
- How can we best leverage existing situations (i.e., with electrical distribution system infrastructure) to become more “energy secure”?
- What new technology provides the best options for energy storage in remote Alaska given our knowledge of conditions under which they would be used?
- How can we minimize risk to private investors in order to augment the installation of renewables in remote Alaska?
- What makes a “secure investment” and is it possible to move towards this in remote Alaska?
- How do we best reach and take advantage of an “economies of scale” approach to renewables in small, remote Alaskan villages?

Policy Priorities/Research Questions

- What is the role of policy on heating in rural communities?
- What are other international Arctic communities doing with respect to energy and renewables policy? Could alternative approaches used elsewhere work in rural Alaska?
- What is the best approach to prioritization and strategic planning in order to better inform renewable energy policy?
- Which policies influence behavior with respect to energy efficiency?

Coordination Priorities/Research Questions

- How do other international Arctic communities approach the administration of energy systems (both renewable and non-renewable)? Could alternative approaches used elsewhere work in rural Alaska?
- How can we increase opportunities to enhance public-private partnerships? (In which the community and private enterprise are in a win-win situation)?
- How do we provide more accurate information on energy efficiency upgrades/programs/behaviors to both villages and consumers so better choices can be made?
- What is Alaska's long term vision on renewable energy and energy efficiency? (especially with respect to building design and energy code). Some Alaskan communities and regions have implemented their own building standards, are these working? How far advanced are the building standards from state standards?
- What new approaches to energy and maintenance management services might be effective in remote communities (especially given the State of Alaska's fiscal situation in 2016)?
- How could a "network of energy educators" be created to:
 - > Provide information on whole house functionality?
 - > Provide information on what is working in other local villages/information sharing?

What is District Heating?

"District heating" refers to a heat distribution system that generates heat in a centralized location for residential and/or commercial heating requirements such as space or water heating. After generation, the heat is distributed to the customer via a network of insulated pipes through which pressurized hot water or steam is transported. Usually the pipes are installed underground but there are also systems with over-ground pipes. While earlier district heating systems were powered by fossil fuels, these systems are increasingly using renewable energy sources such as geothermal, biomass, solar and wind as their source of power generation.

District heating fueled by renewable resources has long been used in Europe to provide heating to small isolated communities as well as urban areas. In Iceland, 90% of households are connected to a district heating system fueled by geothermal resources.⁷ In contrast, renewable energy district heating has only recently begun to be implemented in North America. Drake Landing in Alberta, Canada, provides an example of a small (52 homes) community using solar energy to supply space and water heating throughout the year via a district heating system.⁸ Seasonal and short-term thermal storage allow solar energy to be collected and stored during the summer that is then used for space heating during the winter months.

In Alaska, several renewable energy district heating projects are being considered. Currently, a feasibility study is underway for a geothermal district heating system in Akutan, and a biomass fueled district heating system is being constructed in Galena. A small biomass fueled district heating loop is already operating in Gulkana and numerous diesel heat recovery loops are operating throughout rural Alaska where cooling water from the diesel generators is captured and routed to surrounding buildings.

⁷ Mims, C. 2008. One hot island: Iceland's renewable geothermal power. *Scientific American*, <http://www.scientificamerican.com/article/ice-land-geothermal-power>

⁸ <http://www.dlsc.ca/index.htm>

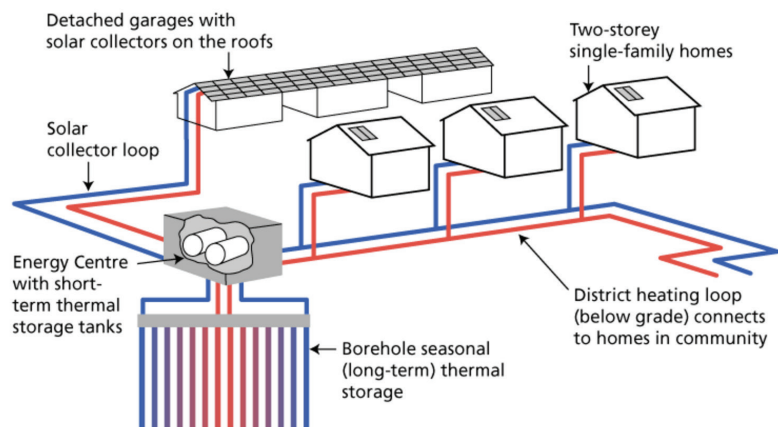


FIGURE 2. Solar seasonal storage and district loop.
Image from <http://www.dlsc.ca/how.htm>

Conclusion and Next Steps

How Do We Address These Needs and Research Questions?

The US Arctic Research Commission coordinates the Arctic Renewable Energy Working Group to promote research on renewable and efficient energy systems in remote Arctic communities. Initial working group efforts are being concentrated on the heating needs of isolated Alaskan villages with the development of a heat-related research plan for rural Alaska, focused on reducing heating oil consumption, increasing energy efficiency, and the integration of renewable energy.

Given the State of Alaska's 2016 fiscal climate and the lack of funding to the Renewable Energy Fund in the most recent state budget, identification and prioritization of data gaps and energy research needs is paramount.

At an initial workshop held in January 2016, our aim was to identify data gaps related to how heat is used in villages in order to better understand how renewable energy systems, energy efficiencies, as well as education and policy level efforts might best address heating needs for remote communities.

Throughout our discussions, the need for capacity-building as it relates to the operation of energy efficient and heating utilities in remote, rural villages was a reoccurring theme. Within a community, capacity is needed to envision, fund, organize, and execute projects such as a renewable energy project or utility. In Alaska, village-level capacity is highly variable and depends on strong community leadership and the experience and training of skilled individuals.

Human Capacity

Efficient management and operation of a community utility requires a trained and stable workforce. In small, remote villages that depend on a subsistence economy, such a workforce may be more difficult to secure and sustain than in more populated urban areas. While training opportunities may be available to educate new employees, turnover rates for operator positions are high as families leave villages for more lucrative positions, or employees take extended



FIGURE 3. The CCHRC demonstration home in Anaktuvuk Pass, Alaska. *Photo by USARC*

Capacity-Building Assistance Opportunities

Within the state of Alaska, there are several programs that provide assistance with the human and financial capacity issues facing utility management in rural communities. A few examples that may be applied to heat-related utilities follow:

The state of Alaska's Department of Commerce, Community, and Economic Development runs the Rural Utilities Business Advisor (RUBA) program with the aim of increasing the managerial and financial capacity of rural water and wastewater providers. This program offers capacity-building assistance and provides management training classes to rural utility operators throughout the state. This training may also be useful in operating renewable energy systems/utilities.

The Alaska Rural Utility Collaborative (ARUC), coordinated by the Alaska Native Tribal Health Consortium, assists communities with customer billing and with hiring and training local operators (and backup operators) that work towards professional certification. The ARUC is a statewide program that partners with communities to manage, operate, and maintain their water/sewer systems. This type of model could perhaps be expanded and applied to renewable energy and heating utilities.

leave in order to take part in traditional subsistence activities. As a result, village utilities generally require "backup operators" who understand the technical aspects of the utility and can step in when the lead operator is absent. In some small communities, finding two individuals with the desire and aptitude for these positions is challenging.

Financial Capacity

Infrastructure for renewable energy projects and utility operations in remote villages require a significant initial capital investment, followed by ongoing investment to maintain operations and management. Utility customer billing (user fees) is one source of income that ideally would cover the operations, maintenance, and management portion of the cost, but rarely do remote villages have the ability to cover the full costs of administering and maintaining a local utility. Nor do remote villages generally have the significant start-up funds needed to purchase the initial infrastructure, such as wind turbines or solar panels. As a result, communities must apply for grants or loans to cover these types of expenses. To be eligible for these type of financial assistance programs, communities must show they are credit-worthy in a cash economy paradigm. This poses a significant challenge given that many villages in remote Alaska are based on a subsistence economy which residents consider to be central to their way of life and important to their health and well-being. Rural and tribal communities would benefit from a clear path, and proper assistance, to secure funding opportunities for renewable energy projects and utility operations.

The Arctic Renewable Energy Working Group is focusing on finding solutions for remote Arctic communities with respect to:

- New options for home heating and electricity aimed at increasing energy efficiency/use of renewable energy and reducing heating oil consumption
- Promote data standardization and sharing of renewable energy metrics
- Storage of energy produced by renewables, with particular focus on improved battery technology
- Indirect community benefits of renewable and efficient energy use that do not get figured into typical renewable energy cost/benefit analyses
- Increasing potential for industry investment in remote renewable energy projects (decreasing uncertainty by identifying and mitigating risk)

Most of these topics are related to heat. The Arctic Renewable Energy Working Group will use its expertise, the information generated by the workshop, and subsequent follow up workshops, to move forward on these objectives to develop a heat-related research plan. Future efforts in this workshop series will address the issue of village-level capacity and determine implementation, funding, and evaluation strategies for heat-related research needs.

Additional information on the Arctic Renewable Energy Working Group (AREWG) can be found at <https://arctic.gov/arewg/index.html>

BACK COVER PHOTO: Kotzebue, Alaska.
Photo by USARC

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