ACEP
Alaska Center for Energy and Power

CCHRC
Cold Climate Housing Research Center

Fostering development of innovative solutions to Alaska's energy challenges.

Project Snapshot: Statewide Assessment of Ground Source Heat Pumps

Project Summary

While ground-source heat pump (GSHP) technology for space heating and cooling is well established, with widespread implementation across the U.S., information and experience specific to the practicality of using it in cold climates is limited. In Alaska, the use of GSHPs for residential and commercial space heating is uncommon; however, several recent high-profile installations indicate that there is a broader interest among homeowners, businesses and government entities to explore this alternative space-heating method.

Within the U.S., the South has the highest percentage of GSHP installations (35%), followed by the Midwest (34%), the Northeast (20%) and the West (11%). Ground-source heat pumps in the U.S. are typically sized for the cooling load. This sizing is in contrast to GSHPs in Alaska and other northern areas, where the capacity of a GSHP is determined by the heating load of the building. Furthermore, in cold climates it is probable that a GSHP will be used only for heating, whereas in more moderate climates the ground is used for both heat extraction (space heating) and rejection (space cooling). This difference presents two disadvantages for GSHP efficiency in cold climates: heat is being extracted from relatively cold ground and it is not being balanced by heat rejection used for space cooling.

Ground loops await installation at Weller Elementary School in Fairbanks. Courtesy of Cold Climate Housing Research Center, UAF.

Despite the relative novelty in Alaska, GSHPs are widely used in other cold climate regions in the world, as evidenced by their popularity in Scandinavian countries. In Sweden, 30% of the houses have GSHP systems. Ground-source heat pumps in Sweden are typically designed to cover 90% of the annual heat energy demand, with an electric heating system as the backup heat source. In Norway, 15,000 GSHP systems have been installed, including 250 medium- and large-capacity nonresidential systems, and Finland has an estimated 46,000 units installed. Heat pumps are widely used in Canada, and in Europe, the market is growing.

The authors of this project have investigated and summarized information pertaining to the viability of GSHPs in cold climates in order to clarify the state of GSHP utilization in Alaska and provide a comprehensive resource of current knowledge for those interested in GSHP installations in cold climate regions such as Alaska.

Major Findings

Ground-source heat pumps have been successful in cold climates.
Performance of ground source heat pump systems is commonly measured by the Coefficient of Performance (COP), a ratio of heating or cooling provided to electrical energy consumed. Based on prior work, the range of COPs expected for professionally installed systems in Alaska is approximately 2.0 to 3.5 across a broad suite of locations, installers, heat sources and heat pump manufacturers.

UAF University of Alaska Fairbanks

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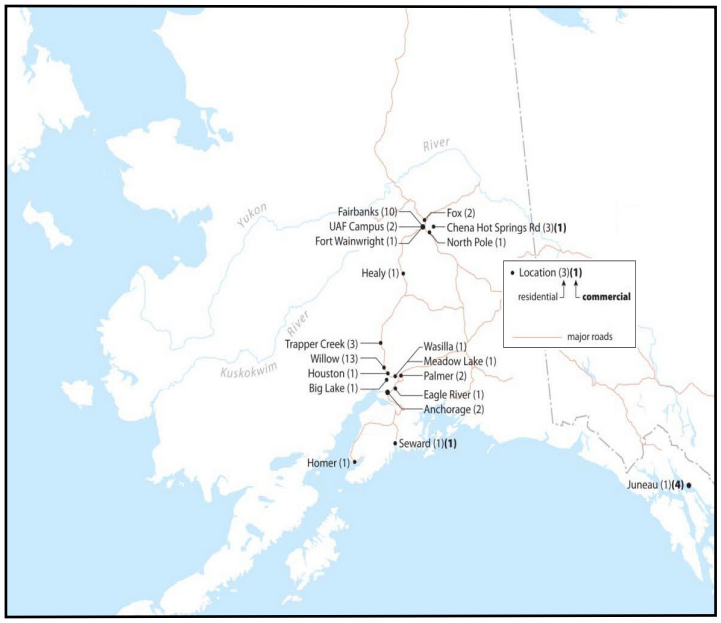
Thermal imbalances caused by GSHPs depend on the specific location.
Other sources have addressed the issue of thermal imbalances that can be created in the soil because of a GSHP. Thermal inbalances are a concern because if too much heat is removed from the ground without the ability for it to recover, it can create unstable soil situations like ice lenses, and even permafrost. While the long-term effects of GSHPs in soil with subfreezing temperatures is unknown, the concern of thermal degradation is site-specific. Whether ground temperatures can recover in the summer will depend on the region's climate, soil conditions at the site of the ground loop and the sizing of the ground loop. In locations with low ground temperatures and a high annual heating demand, thermal imbalances are a major concern and should be considered in the design of the system.

Barriers to growth are consistent with other areas.
Studies have identified barriers to growth of the GSHP market in the U.S. Barriers include high capital cost and lack of consumer knowledge and confidence in the technology. Similarly, market diffusion is limited in Canada by factors such as high capital costs, nonstandardized systems and actual performance that is less than promised. The GSHP market in Alaska faces these same problems.

Proper design and installation are critical to performance.
In any part of the world, adequate design is necessary for GSHPs to meet performance expectations and have fewer maintenance issues. It is especially important in cold climat for GSHP system designs to match the parameters of the location. Poorly designed systems can result in a number of problems. For example, if the ground loop is undersized, COPs will decrease because the soil cannot thermally recover. If the GSHP system is oversized, the capital costs will be higher than necessary, and excessive on-off cycling can stress the heat pump unit and reduce its operational efficiency. A common error in colder climates is to make the ground loop small and the heat pump large, which results in increased electrical use and decreased efficiency.



Previous and current ground-source heat pump systems of Alaska. Courtesy of ACEP

More long-term data is necessary.
A lack of data on long-term GSHP applications in cold climates makes the decision to install one difficult. The longest study on using a GSHP in Alaska focuses on the ability of a GSHP to cool soil and maintain permafrost, not on heating a building. Other studies note that longer monitoring projects are needed to determine under what circumstances a GSHP will cause thermal degradation and whether the COP can be maintained for several years.

The Alaska Industry
Alaska's GSHP industry is small, but has recently shown growth, with some prominent commercial installations in Juneau and several residential installations in Fairbanks. One large-profile commercial GSHP system has recently been installed at the Juneau International Airport terminal. In addition to reducing operating costs at the terminal, the project's primary motivation, planners hope to increase public awareness of energy conservation and alternative energy (Fritz, 2008). This installation and other recent commercial installations are summarized in the report to provide examples of larger GSHP applications in Alaska. Residential GSHP owners interviewed for this report had installed a GSHP for a variety of reasons, but each homeowner reported that long-term cost savings was a strong motivation. Some homeowners found their systems to be low-maintenance, and more than one homeowner installed a GSHP in part because it is a partially renewable-energy technology. All of the residential GSHP owners interviewed reported satisfaction with their systems.

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