COOPERATIVE EXTENSION SERVICE
UNIVERSITY OF ALASKA FAIRBANKS

Active Solar Heating

Factsheet

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Active solar heating is most commonly used to provide heating applications using the sun's energy to residences and businesses. Thermal solar energy is a very efficient way to use the sun's energy beneficially in our homes in Alaska. In active solar heating applications, heat from the sun is collected, stored and used primarily for domestic hot water heating. The reason the system is called active is because pumps and fans are used to transfer the captured heat to an area where it can be stored or used. The main components of an active solar system are the collectors, the collector controls, the storage tank, and the distribution system. This factsheet is only designed as an introduction to active solar heating systems in an Alaska context.

The interested reader who wants to further apply these technologies is advised to go to Web site: www.alaska-sun.org and look at the active solar heating chapter of the *Solar Design Manual for Alaska*, which is located at that Web site.

New Information as of 2007

Because of recent changes in Federal legislation, it is now possible to install active solar water heating systems in Alaska and receive a federal bottom-line tax credit equal to 30 percent of the actual capital cost of the solar collector system in total or $2,000, whichever is less.

This tax credit is available if you use the solar water heater on your primary residence, but only if the system is able to provide at least 50 percent of the hot water needs for your residence. Anything less than that would not quality for the tax credit. This tax credit is also due to expire at the of 2008 but it may be renewed. Please see any updates for information beyond 2008.

Solar Collectors

A flat-plate collector is the most common choice for domestic heat and hot water from solar energy. (See Figure 1.) Either liquid or air acts as the heat absorbing medium. Fluid-filled collectors can utilize a mixture of antifreeze and water, necessitating the use of a heat exchange loop in the system to avoid contamination and freezing problems.

Recently, solar collector technologies have been improved. Collector systems engineers are eliminating equipment and moving parts, which have made modern active collectors more efficient and maintenance-free.

WARNING: Solar heating systems must eliminate freezing risks in any Alaskan application. Anything less than an antifreeze system for circulation outside of the heated area of the house is an insufficient system for Alaska. Under no circumstances would we recommend that any system in Alaska be installed, which circulates liquid water without any freeze protection outside the house. Although this has been tried, it has never succeeded and systems ultimately fail that use this option. Only consider systems that use an exterior circulation loop of antifreeze for Alaska applications.

While solar active heating systems are most appropriate for heating hot water for domestic use, they are becoming more adaptable to all types of applications. A backup heating system is necessary in all situations, however, to ensure year round service.

The Solar Energy Resource

In Alaska, active solar heating will not economically meet all required domestic hot water and space heating needs. But, it can significantly reduce dependence on fossil fuels, especially when used in conjunction with passive solar heating and conservation.

Solar radiation is measured in terms of the number of BTUs striking a square foot of surface during a specific time period. The amount of radiation received at a given point in a day is dependent upon the percentage and thickness of cloud cover, as well as the sun angle and the number of hours of available sunlight. Because of the interplay of these factors, insolation statistics do not correlate strictly with latitude. For example, Juneau does not necessarily receive more solar radiation than Fairbanks. In Alaska, this means those regions with continental (Interior) and transitional (Southcentral, Southwest, and Northwest) climates are the area where solar heating would most likely be practical.

Maximum and minimum average monthly insolation data for Anchorage, Bethel, and Fairbanks are presented

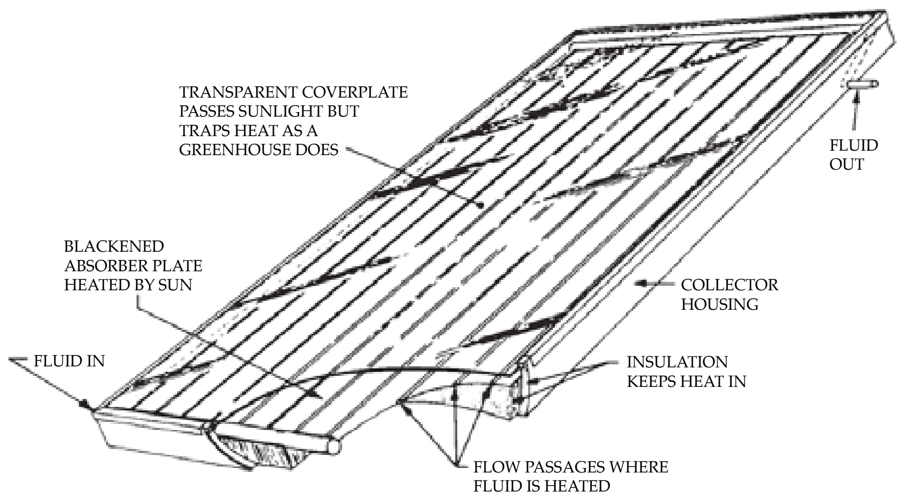

Figure 1. Schematic view of a typical flat-plate solar collector. Solar radiation (primarily visible wavelengths) strikes the surface of the glazings and is transmitted through them with a loss of 10-13 percent for each layer of glazing (only one glazing is illustrated). About 95 percent of the solar radiation striking the blackened collector plate is absorbed. This surface reradiates energy in the form of infrared radiation, which is trapped between the glazings and the absorber plate; this causes the collector plate to get hot. The collector fluid (liquid or air) is pumped through the collector to move the heat to where it is needed (figure from Seifert, 2005.)

for a vertical, south-facing surface in Table 1. The average solar radiation varies considerably with the seasons in a pattern that is out of phase with the highest heating loads. Economically, active solar heating cannot totally replace the use of fossil fuels for either space heating or domestic hot water in Alaska. Technologies are well developed for collectors and distribution systems.

			BTU/ft²/day
Anchorage	Max.	April	1205
	Min.	December	190
Bethel	Max.	April	1364
	Min.	December	349
Fairbanks	Max.	April	1554
	Min.	December	95

*90° tilt (Andrew-Walker National Renewable Energy Laboratory - 2001)

Table 1. Average Solar Radiation on a *South-Facing Vertical Surface.

Sizing a Collector

Numerous factors must be considered in sizing an active flat-plate solar collector such as the available solar energy, the efficiency of the collector, local energy costs and the heating needs of the building. Collector efficiency, in turn, depends on location, orientation and collector surface tilt angle as well as the workmanship and insulation on all parts of the system. Computer programs have been developed to predict optimum collector size for particular combinations of physical and economic factors. Simulations have been run for several Alaskan locations. (See Seifert, 2005.)

Table 2 is an FChart computer simulation of an active domestic solar water heating system for Fairbanks, Alaska. This run was produced by Mr. Jake Tornatzky for a Solar Installers Workshop held in Fairbanks in the spring 2007. It shows the expected modeled output for a standard year in Fairbanks using National Renewable Energy Laboratory solar radiation data to predict the performance by month, of the output from a standard solar water heating system, in this case, a Heliodyne system manufactured by a company in Richmond, California.

The system has a collector panel area of 32.30 sq. ft. each and there are two of those for a total area of 64 sq. ft. At the bottom of the chart you see four columns listed by month with a million Btus in parentheses underneath three of the columns. The final column is interesting because it is the fraction of heating requirements for domestic hot water, which is provided by solar by month. As you can see from the chart, 27 percent is provided in February and at the bottom of the chart 54 percent is provided on a year-round basis. So this system would in fact qualify for the tax credit since it provides more than 50 percent of the annual heating required. Note that in April, May, June, July and August, the collector provides more than 80 percent and at times more than 90 percent of the heat required for hot water. But note that in the winter time during December and January no heating is obtained from the solar system. This gives a good indication of the variable annual performance and indicates why a backup system is necessary.

Active Domestic Hot Water System		
Location	FAIRBANKS AK	
Water volume / collector area	1.50	gallons/ft^2
Fuel	Gas	
Efficiency of fuel usage	70.00	%
Daily hot water usage	60	gallons
Water set temperature	125.0	F
Environmental temperature	67.3	F
UA of auxiliary storage tank	0.00	Btu/hr-F
Pipe heat loss	No	
Collector-store heat exchanger	Yes	
Tank-side flowrate/area	14.000	lb/hr-ft^2
Heat exchanger effectiveness	0.55	
Flat-Plate Collector		
Number of collector panels	2	
Collector panel area	32.30	ft^2
FR*UL (Test slope)	0.870	Btu/hr-ft^2-F
FR*TAU*ALPHA (Test intercept)	0.730	
Collector slope	50	degrees
Collector azimuth (South=0)	0	degrees
Incidence angle modifier calculation	Value(s)	
Collector flowrate/area	14.000	lb/hr-ft^2
Collector fluid specific heat	0.84	Btu/lb-F
Modify test values	Yes	
Test collector flowrate/area	11.000	lb/hr-ft^2
Test fluid specific heat	1.00	Btu

	Solar	Dhw	Aux	f
	[10^6 Btu]	[10^6 Btu]	[10^6 Btu]	[ ]
Jan	0.574	1.546	1.546	0.000
Feb	1.326	1.391	1.011	0.273
Mar	2.712	1.529	0.527	0.656
Apr	3.325	1.465	0.181	0.876
May	3.457	1.500	0.104	0.931
Jun	3.337	1.442	0.039	0.973
Jul	3.292	1.489	0.080	0.946
Aug	2.754	1.494	0.277	0.814
Sep	2.078	1.454	0.552	0.621
Oct	1.415	1.518	1.002	0.340
Nov	0.853	1.486	1.350	0.091
Dec	0.195	1.543	1.543	0.000
Year	25.319	17.858	8.213	0.540

Table 2. An FChart Computer Simulation of an Active Domestic Solar Water Heating System for Fairbanks, Alaska.

Economics

Solar energy systems are still fairly expensive, but with the tax credit and the ever increasing costs of fuel, solar water heaters have never been more economic or interesting than they are in mid-2007. Although it is certainly advisable and possible to home build solar energy collectors, these collectors would not qualify for the tax credit. That is because the tax credit also has the stipulation that the solar collectors used in a residential system must be certified by a national testing certification agency. The system modeled in the collector sizing example (Table 2) is a certified system tested at the Florida Solar Energy Center.

One must have reasonable expectations about performance. Solar radiation is at its minimum in Alaska during November, December and January. This does not mean that no energy can be extracted from the short duration and low sun angle of the winter sun—it can, but the amount of heat energy gained per dollar invested in the system falls short. During these months a back-up system is necessary. But an active solar hot water heating system is practical in several regions in Alaska where fuel prices are high and the climate is good. Why does a solar water heater work when solar space heaters won't? We use hot water all year long not just in the winter. So more solar heat is available for hot water heating than for space heating: it is more useful all year round, since we need hot water in summer, but don't need to heat our homes when the sunlight and heat are plentiful.

Recently at the Cold Climate Housing Research Center three different active solar water heaters were installed on the roof as a testing option to demonstrate their performance and make this information available to the public. This is a major step forward in promoting and proving up solar water heaters for Alaska.

One of the systems is an evacuated tube collector type system and as you can see from Figure 2, the efficiency of the three main solar thermal technologies is really a function of solar radiation and ambient temperature. This fact should be very strongly considered depending on what kind of heating you need to do. For instance, Figure 2 shows clearly that if you want to heat water to temperatures from 10° to 50°C above the ambient, which is mostly the case for when solar water heating is efficient in Alaska, a flat plate collector is the best choice.

However evacuated tube type systems are best for circumstances when more than 50°C above ambient is the application of choice. This seems to infer that evacuated tubes are best for very cold temperatures, but since very cold temperatures in Interior Alaska also mean short solar periods, the ultimate annual performance may not be that crucially advantageous with an evacuated tube collector. The true productivity from evacuated tube system remains to be seen in our climate as none has really been tested. That is the purpose of the new

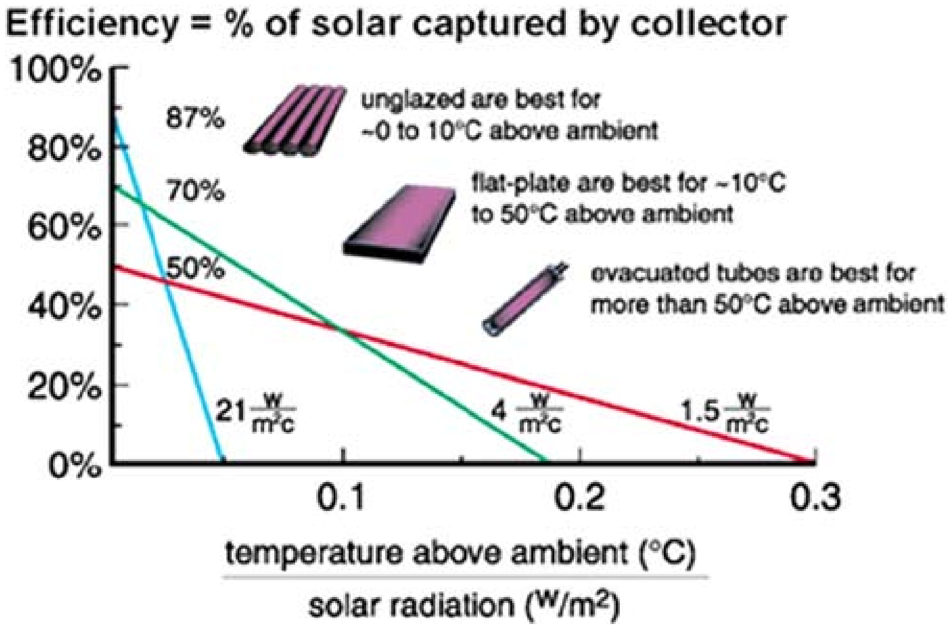

Figure 2. Efficiency of the three main solar thermal technologies as a function of insolation and ambient temperature.

installations at the Cold Climate Housing Research Center. We look forward to making this information available in the future and will do so through this publication.

For more information about solar heating technologies and applications, call the Cooperative Extension Service's statewide energy specialist at 474-7201 or 1(800)478-8324, or see the Web site www.alaskasun.org

References

Seifert, R. *2005. A Solar Design Manual for Alaska*. Fairbanks: University of Alaska, Cooperative Extension Service, 3rd ed. UAF Publication EEM-01255. $10 purchase.

Beckman, Klein and Duffie. 1977. *Solar Heating Design by the F-Chart Method.* John Wiley & Sons.

Web sites: www.uaf.edu/ces/faculty/seifert
www.nrel.gov; www.ases.org; and
www.alaskasun.org

Visit the Cooperative Extension Service Web site at www.uaf.edu/ces and Rich Seifert's homepage at www.uaf.edu/ces/faculty/seifert

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This publication (revised and updated in 2007) is an effort of Cooperatitve Extension and the University of Alaska Fairbanks to support a developing solar applications and commercial industry for Alaska to better serve our energy needs with renewable energy.

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