Kotzebue Electric Association
Solar Thermal Alternative Residential Heating Methods
Quarterly Report
3/31/2011

Prepared by Jesse Logan (KEA)

Funding

Denali Commission	$127,000
KEA[1] In-Kind	$5,000
CETF[2] In-Kind	$12,000
Total	**$144,000**

Heliodyne Flat Plate Solar Collector.
Jesse Logan (KEA).

Project Summary:

This project will assess the feasibility of solar hot water heating systems on residential units in the NANA Region of Kotzebue. The Kotzebue Community Energy Task Force (CETF) had identified up to ten (10) Elders homes which are most in need of home heating assistance. System design and budget were considered for each home as well as southern exposure. After detailed review of designs and costs six (6) homes were identified to serve as test sites where solar-thermal systems, some using flat plate and some using evacuated tubes, have been installed. If the technology proves feasible above the Arctic Circle, these systems could be installed in homes throughout the region and serve as a model for alternative methods to heat homes without the use of fossil fuels.

[1] Kotzebue Electric Association
[2] Community Energy Task Force

Background:

Kotzebue Electric Association was awarded a grant in round two of the Denali Commission's Emerging Energy Technology Grant program for a total amount of $127,000, with a $17,000 in-kind match (11%). The total project cost is $144,000.

Solar thermal systems are not new technology. Using solar thermal power to actively supplement other methods of water and space heating has many benefits; however the deployment in northern Alaska has been nearly non-existent for several reasons, but primarily economic. As fossil fuel prices continue to rise the benefits of solar thermal will become increasingly obvious. Initial modeling done in ReScreen showed a payback on these systems in less than 8 years-finance depending- but must first be demonstrated in order to streamline the design of these systems using off-the-shelf technology. However, in the time between the initial grant application and the following award the price structures of the equipment and labor increased.

The objective of this project is to mitigate the rising costs of home heating in rural Alaska. KEA has installed six (6) solar-thermal systems, each in different homes, to assess the feasibility of this technology above the Arctic Circle. To our knowledge not many people have experimented with this technology at this latitude, however Alaska Battery Systems has installed one system in Nome, and the Cold Climate Housing Research Center has installed both an evacuated tube space heating solar thermal system and a glazed panel water heating system in Fairbanks. Each has their advantages and disadvantages. The purpose of this project is to determine the most efficient combination for home space and/or water heating.

Modeling done in RetScreen has shown that the Northwest Arctic Region can obtain a 50% solar refraction on a properly designed system. Meaning solar energy could reduce their current energy use by half. However, conservatively, KEA is expecting to see a 30% reduction in fuel use for domestic hot water heating and a less substantial reduction in home space heating.

The original grant proposal suggested installing at least four air-source heat pumps to determine if the technology would reduce energy costs to homeowners in the Arctic. However, due to their technical challenge and to poor track record as related from an NRECA report it was determined that the defrost cycles experienced in states such as Ohio would have constituted a large energy cost increase to the home owner. Therefore, KEA has decided to focus on flat plate and evacuated tube solar collectors for water and space heating. Tracking mounting for solar collectors was also discussed but again risked the increase of electrical consumption for the home owner. In keeping with the attempt of reducing home owner's cost of energy and ease of operation (as home owners are Elders) track mounting options were dismissed.

Hybrid air source heat pump hot water heaters (GE 50-Gallon GeoSpring™ Hybrid Water Heater) have also been discussed with one eligible home identified as suitable for this installation. Up to 20% of the total heating fuel in the Northwest Arctic Borough is used to heat hot water. While solar thermal hot water is practical up to nine months of the year, these hybrid hot water heaters utilize both air-source and electrical energy. By combining the two, KEA had hoped to provide reliable hot water to this home while attaining the manufacturers estimated 62% reduction in electrical consumption for hot water. However, budget constraints may not allow this installation.

There are numerous ways to design solar thermal space and hot water heating systems with flat plates or evacuated tubes. Each installation has a slightly different configuration to allow KEA to make a comparison for each home and recommend system designs accordingly.

Project Work Plan

A. Site Identification, Planning, and Equipment

Site Identification: *Complete as reported last quarter.*
Planning: *Complete as reported last quarter.*

Equipment:
In order to best demonstrate the capacity of solar thermal collectors to reduce fossil fuel consumption, and therefore energy cost, KEA deemed it necessary to install both DHW (domestic hot water) systems as well as combined DHW and hydronic base board heating capacity. Again, the selection of which homes would receive DHW or combined systems was based on costs of installation and space within the home's utility room to accommodate the necessary equipment.

This demonstration project also needed to evaluate the production differences between flat plate and evacuated tube solar collectors. There are several manufacturers with respectable reputations that make both types of collectors, but only two that are well represented with installation companies here in Alaska: Viessmann Manufacturing Company Inc. represented by Gensco Alaska and installed by Susitna Energy Systems (SES), and Heliodyne Inc. represented and installed by Alaska Battery Systems (ABS). KEA elected to split the 6 homes between the two manufacturing and installation companies as well as purchases both flat plates and evacuated tubes from each.

Generally, evacuated tube solar thermal collectors have performed slightly better than flat plate collectors in the lower 48. However, evacuated tubes are more expensive and have the capacity to be more troublesome and fragile. Therefore, in the interest of installing and testing the most systems, KEA elected to install 2 evacuated tube and 4 flat plat systems as follows:

Manufacturer	Installer	Collector Type	System Type
Viessmann	SES	1 evacuated tube	DHW
Viessmann	SES	2 flat plate	DHW
Heliodyne	ABS	1 evacuated tube	DHW and Space Heat
Heliodyne	ABS	2 flat plate	DHW and Space Heat

The specific angle of each solar collector was also considered. Generally a solar collector is south facing with an angle approximate to the latitude on site. This is the case with 4 of the collectors. The Two Viessmann flat plate collectors were installed at the angle of the roof (approximately 29 degrees) for two reasons: 1) reduced wind resistance lowering the possibility of damage to the unit, and 2) to determine if the DHW only systems would benefit from increased production during summer months when the sun in Kotzebue stays high in the sky for18-24 hours and the boiler systems in the homes generally are not running to produce space heating.

All equipment was ordered from the manufacturers through the installation/design firms listed above and have followed the procurement procedure of ACEP/UAF. See Appendix 1 for additional equipment details.

B. Installation: *Complete*

All six (6) systems were installed and commissioned by December 23, 2010. There are three major installation components to each system: rooftop solar collector, plumbing, and controls.

The installation of solar thermal systems in homes requires mounting of collectors on roof tops, placement of thermal storage tanks, wiring and connection of control/data logging units, plumbing of solar loop, plumbing to auxiliary heating systems and hot water distribution systems. A certified plumber is required to do the majority of the plumbing work. Labor availability (certified plumber) constraints pushed the final installation of the SES units back farther than was initially anticipated. However, final commissioning in Dec of 2010 was on schedule in accordance with KEA's contractual agreement with the Commission.

See Appendix 1 for system details, lessons learned, and preliminary data collected.

C. Administration, Management, and Reporting

KEA is responsible for the short- and long-term management, operations and maintenance of the solar thermal systems, in cooperation with CETF, NIHA[3] and NANA[4]. The Alaska Technical Center will have the opportunity to offer hands on training of the operation and maintenance of the installed systems, however only peripheral discussions have taken place so far. No students were available during installation. Additionally, the Chukchi Campus, a University of Alaska satellite campus, has recently developed a renewable energy training program. While no classes were offered at the Chukchi Campus during the semester of installation, discussions have taken place with program directors regarding a possible role for Chukchi's long term involvement with data collection and analysis.

In the spring of 2011 the Bristol Bay campus of the University of Alaska system has offered a distance education class on renewable energy systems. One student of this class is located in Kotzebue and has joined the KEA effort. She has worked closely with the project manager, Jesse Logan, to acquire historical fuel usage for each home with a solar thermal system as well as gathering historical climate data (i.e. heating degree days in Kotzebue) and in developing a matrix for analyzing the data in cost benefit ratio and simple payback schemes.

D. Conclusion

This demonstration project proved to be somewhat complex due to the coordination of several entities as well as several home owners with different equipment. As with any complex project unforeseen problems arose (see Appendix 1 for more details) and KEA has worked diligently to address each problem in a timely and cost efficient manner.

The originally proposed budget could not foresee the increased price structure of the equipment and labor and for this reason the project was scaled back from 10 systems to 6. Nor could the original budget foresee the lack of availability of a plumber to be donated as In-Kind from CETF. CETF has been invaluable in coordinating communications between KEA, NIHA,

[3] Northwest Inupiaq Housing Authority
[4] Northwest Alaska Regional Native Association

Crowley Fuel Services, and the home owners. However, a local plumber was not available as donated labor and therefore KEA hired one and this hourly wage will be coming directly from the budget. This additional expense was not anticipated. Other labor invoices have not been received by KEA, but by the best estimation the project is on budget aside from the plumber. For this reason the purchase and installation of an air-source hybrid hot water heater is on hold. It is possible that KEA will be able to absorb some of CETF's In-Kind contribution but if an unsustainable threshold is reached KEA will attempt to recoup costs from future grants and/or other sources.

Preliminary production data is unavailable for all but one (1) of the systems, see Appendix 1 for details. A complete data set from 2/26/2011- 3/28/2011 for System 6 is available upon request.

Appendix 1

System Details

This appendix provides details for each of the six (6) solar thermal systems installed in Kotzebue, Alaska, including equipment installed, lessons learned and preliminary production data where available. As stated above, KEA installed three (3) systems from Viessmann (for DHW only) and three (3) systems from Heliodyne (for combined DHW and space heating).

Viessmann Systems for DHW

System 1

For this system KEA did not remove the water heater- as it was small and efficient- instead an 80gal single coil solar thermal storage tank was added to the system. Additional plumbing and expansion tank as well as miscellaneous equipment is not shown here.

Existing Equipment

Water Heater	Oil Miser 148 - 5.1 gal indirect fired on-demand
Boiler	Oil Miser 180

KEA installed Equipment

Solar Collector	Vitosol 300-TSP3 (30) Evacuated Tube (@ 68 degrees)
Solar energy storage	Vitocell-V 100CVA- Single Coil Tank (80 gal)
Pump	Solar Divicon DN-20 w/ Star 16U-15 Circ Pump
Control	Viessmann Solar Control Unit SCU 124 (7416043)
Data logging	Resol Data logger DL2
Solar fluid line set	Insulated Corrugated stainless steel piping

Vitosol 300-TSP3 (30) Evacuated Tubes.

Viessmann 1: David Lindeen (SES) and Jesse Logan (KEA)

Preliminary wiring From Left to Right:
Resol Data logger DL2
SCU 124 (7416043) Control Unit
Solar Divicon DN-20 w/ Star 16U-15 Circ Pump

Viessmann 1: Utility Room

System 2

For this system KEA removed the water heater and replaced it with an 80gal double coil solar thermal storage tank. Additional plumbing and expansion tank as well as miscellaneous equipment is not shown here.

Existing Equipment

Water Heater	Amtrol WH 26 gal
Boiler	Oil Miser 180

KEA installed Equipment

Solar Collector	(2) Vitosol 200-F Vertical Flat Plate Collector (@29degrees)
Solar energy storage	Vitocell-B CVB Dual Coil Storage Tank (80gal)
Pump	Solar Divicon DN-20 w/ Star 16U-15 Circ Pump
Control	Viessmann Solar Control Unit SCU 124 (7416043)
Data logging	Resol Data logger DL2
Solar fluid line set	Insulated Corrugated stainless steel piping

Viessmann 2: Flat Plate Collector

(2) Vitosol 200-F Vertical Flat Plate Collector (@29degrees)

Vitocell-B CVB Dual Coil Storage Tank(80gal)

System 3

This system is similar to System 2; the major difference is the existing boiler. KEA removed the water heater and replaced it with an 80gal double coil solar thermal storage tank. Additional plumbing and expansion tank as well as miscellaneous equipment is not shown here.

Existing Equipment

Water Heater	Amtrol WH 26 gal
Boiler	Weil McClain Oil Heater 3.5gal burn rate

KEA installed Equipment

Solar Collector	(2) Vitosol 200-F Vertical Flat Plate Collector (@29degrees)
Solar energy storage	Vitocell-B CVB Dual Coil Storage Tank (80gal)
Pump	Solar Divicon DN-20 w/ Star 16U-15 Circ Pump
Control	Viessmann Solar Control Unit SCU 124 (7416043)
Data logging	Resol Data logger DL2
Solar fluid line set	Insulated Corrugated stainless steel piping

(2) Vitosol 200-F Vertical Flat Plate Collector (@29degrees)

Utility room:
Very tight working space

David Lindeen (SES)

Wiring the DL2 data logger and the Control Unit

Lessons Learned

As with all the Viessmann systems the controls and data logger are separate units and communicate via a VBus connection. Data is stored in the DL2 and retrieved via SD card slot or connected to a computer via Ethernet LAN. SES was not familiar with the DL2 and could offer very little assistance in the set up, logging or data retrieval methods. Resol software is required to communicate with the DL2 directly or alternatively, to format retrieved data via SD card.

Though the DL2 has vast storage capacity, it was discovered in early March 2011 that the DL2 was not receiving or storing the total amount of energy (in BTUs) input into the system from the solar collectors. Thermistors (thermal sensors) are placed on the solar collector and in the storage tank- these are necessary for the control to assess the temperature differential (delta T) to run the system. A third sensor on the solar fluid return line is needed to measure the amount of energy actually input to the storage device. This sensor was not installed by the contractor (as they had very little experience logging the data).

Appropriate sensors were ordered from Viessmann's Rhode Island facility. These were installed in March 2011 and the control unit and DL2 for all Viessmann systems were reconfigured. Due to this error, no BTU data is available for the Viessmann systems for the spring of 2011. KEA will continue to collect data through the spring of 2012 to ensure a full 12 months of data is available for ACEP and the Commission.

Heliodyne Systems for DHW and Hydronic Base Board Heating

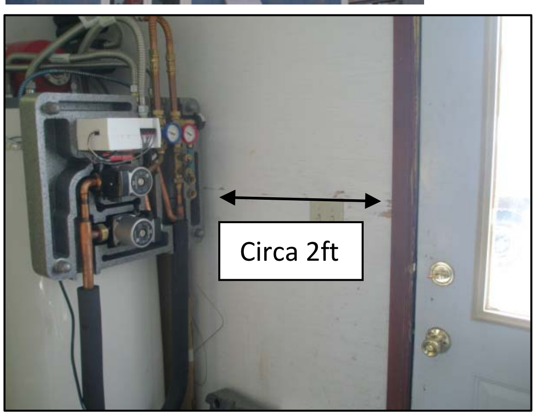
System 4

For these systems KEA did not remove the existing water heaters, rather, 80gal solar thermal storage tank were added to the systems. Additional plumbing and expansion tank as well as miscellaneous equipment is not shown here.

Existing Equipment	
Water Heater	Boiler Mate WH9L (26gal)
Boiler	Weil McClain Oil Heater 3.5gal burn rate

KEA installed Equipment	
Solar Collector	King Span solar evacuated tube (30) (@ 68degrees)
Solar energy storage	80 gallon solar hot water storage tank
Pump / Control / Data logging (Integrated)	Pro-lite controller and data logging Hilio-pack pro heat exchanger with Wi-Fi and data logging
Exchanger to hydronic system	Flat plate heat exchanger w/ auxiliary circ pump
Solar fluid line set	copper

King Span solar evacuated tube (30) (@ 68degrees)



Pro-lite controller and Hilio-pack pro heat exchanger with Wi-Fi and data logging. (uncovered)

Pro-lite controller and Hilio-pack pro heat exchanger with Wi-Fi and data logging. (insulated cover)

System 5

For these systems KEA did not remove the existing water heaters, rather, 80gal solar thermal storage tank were added to the systems. Additional plumbing and expansion tank as well as miscellaneous equipment is not shown here.

Existing Equipment	
Water Heater	50 gallon
Boiler	Oil Mieser- OM 180

KEA installed Equipment		
Solar Collector		Gobi 410 flat plate (2)
Solar energy storage		80 gallon solar hot water storage tank
Pump	Integrated	
Control	Integrated	Pro-lite controller and data logging
Data logging	Integrated	Hilio-pack pro heat exchanger with Wi-Fi and data logging
Exchanger to hydronic system		Flat plate heat exchanger w/ auxiliary circ pump
Solar fluid line set		copper

Gobi 410 flat plate (2). Mounting brackets rated to withstand 100mph winds.

Auxiliary pump and flat plate heat exchanger for hydronic base board heating loop.

System 6

This system is similar to system 5. For these systems KEA did not remove the existing water heaters, rather, 80gal solar thermal storage tank were added to the systems. Additional plumbing and expansion tank as well as miscellaneous equipment is not shown here.

Existing Equipment	
Water Heater	26 gallon water heater
Boiler	Oil Mieser- OM 180

KEA installed Equipment	
Solar Collector	Gobi 410 flat plate (2)
Solar energy storage	80 gallon solar hot water storage tank
Pump Control Data logging — Integrated	Pro-lite controller and data logging Hilio-pack pro heat exchanger with Wi-Fi and data logging
Exchanger to hydronic system	Flat plate heat exchanger w/ auxiliary circ pump
Solar fluid line set	copper

Gobi 410 flat plate (2) (@68degrees)

Pro-lite controller and Hilio-pack pro heat exchanger with Wi-Fi and data logging. (uncovered)

Pro-lite controller and Hilio-pack pro heat exchanger with Wi-Fi and data logging. (insulated cover)

Lessons Learned

The Heliodyne system controls and data loggers are a single unit. The controls settings and data logger features are accessible via WiFi communication (the unit itself sends a short range WiFi signal that a WiFi enabled laptop can connect to). Each system has a unique IP address to log enable communications. This makes interfacing with the controls and downloading data very simple.

On System 4 the Helio-pack was mounted to the storage tank as usual. This was in a heated entry way. However, during a severe winter storm in January 2011 high winds penetrated the front door of the home. The circa 2ft proximity of the Helio-pack was insufficient to protect the lower of the two pumps (DHW) shown in the pictures. This pump froze. Appropriate measures had been taken when plumbing this system and KEA was able to isolate this circulation line with no disruption to DHW for the house. However, this rendered the solar thermal system inoperable awaiting the installation of a new pump.

Due to plumbing labor shortages the replacement of the faulty pump did not occur until March 2011. It was also discovered at this time that the thermistor (thermal sensor) located on the roof in the solar collector had become faulty. This may have been due to high solar gain during March 2011 previous to the replacement and re-commissioning of the system; without proper circulation of fluid the heat exchanging manifold on the evacuated tubes may have become hot enough to disable (fry) the thermistor. The thermistor was replaced and the system re-commissioned.

On System 5 KEA was unable to read a flow rate of solar thermal fluid. Several attempts were made to trouble shoot this issue, and it was believed that a faulty vortex sensor was the cause. However, after extensive wiring examination, with the aid of ABS technicians via telephone, it was determined that the sensor was working properly. A blockage in the fluid line was then suspected. The blockage was located in a closed check valve. This valve had been closed by the contractor in order to fill the line-set with solar fluid, and was mistakenly not re-opened. The valve was manually opened and the system re-commissioned.

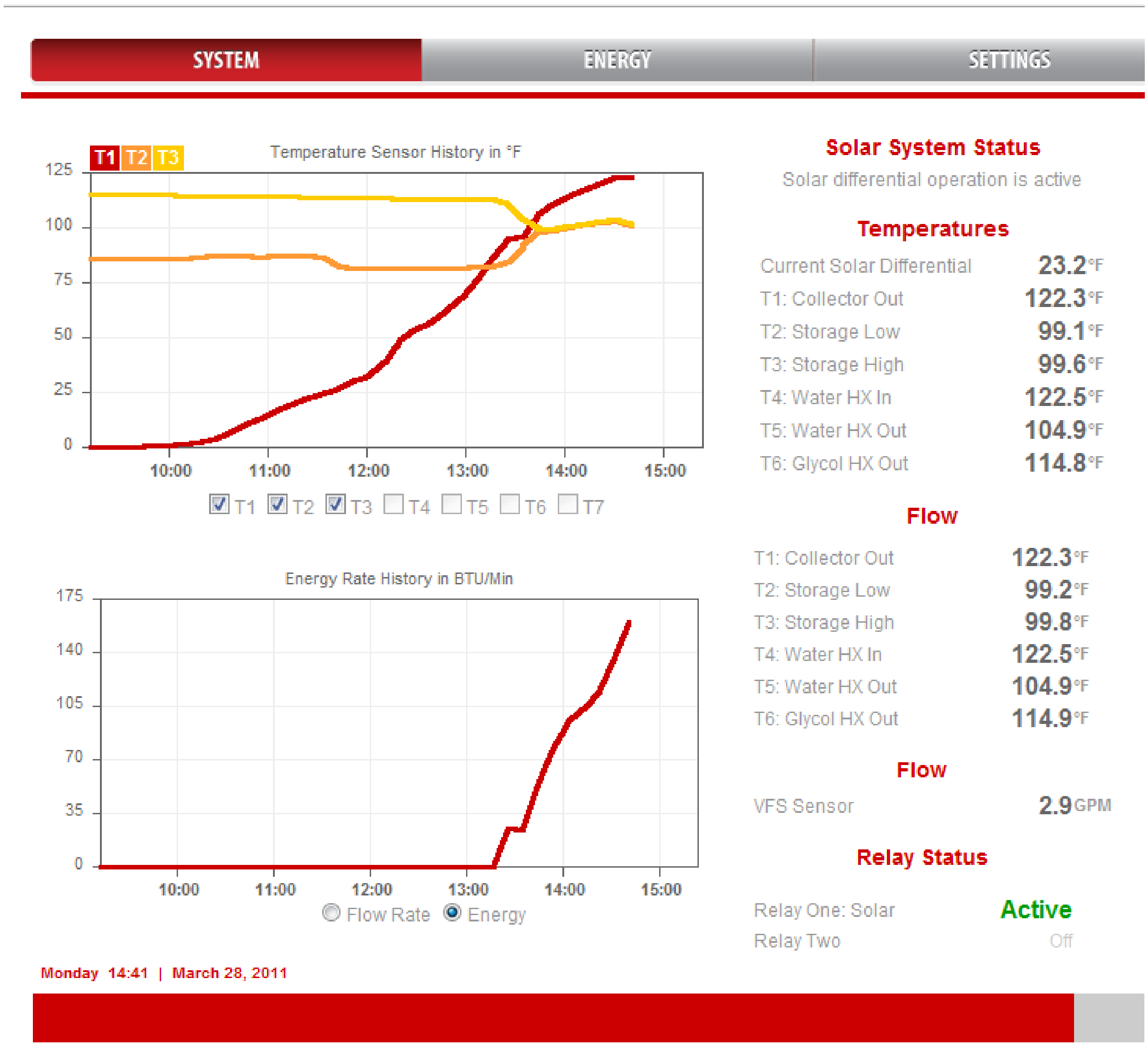
Due to these issues with Systems 4 and 5, KEA has no production data to report for the spring of 2011. However, the following are production values for system 6.

System 6

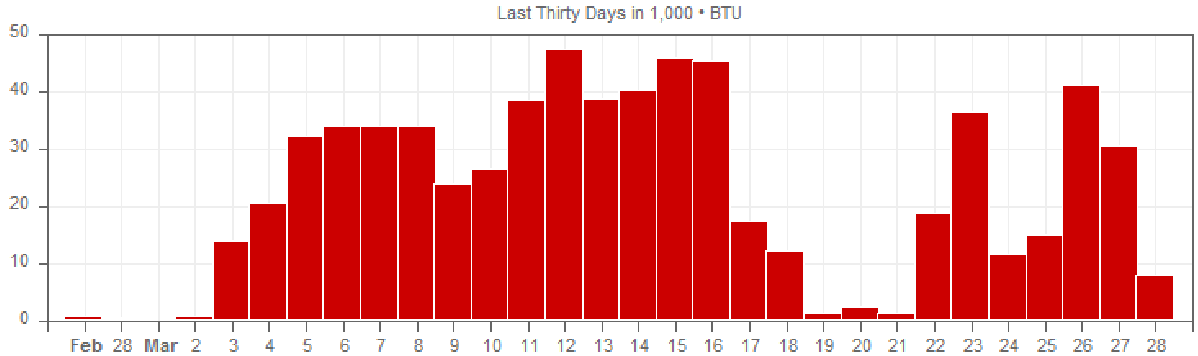
Heliodyne Gobi Flat Plate Collector

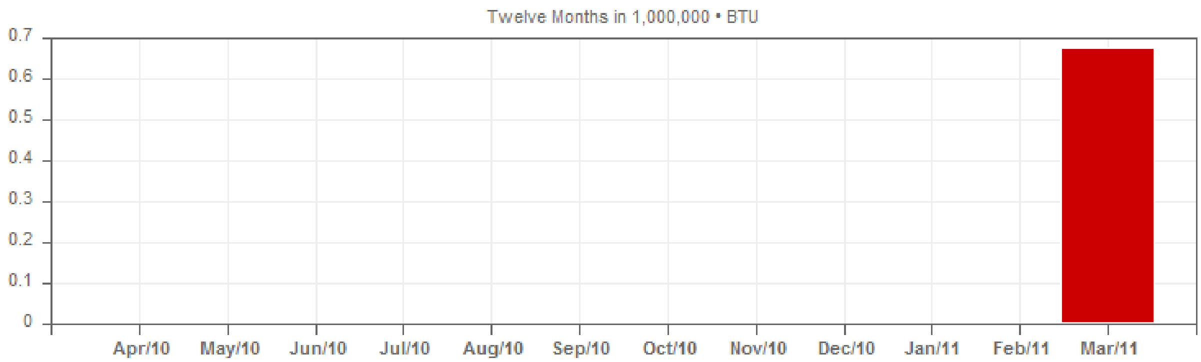
Combined DHW and Hydronic Base Board Heating

Preliminary Data (2/28-3/28)



SYSTEM | ENERGY | SETTINGS





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