Kotzebue Electric Association
Solar Thermal Alternative Residential Heating Methods
Final Report
10/2012
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 (see figure below for manufacturer, installation contractors, collector type and system type). 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. The main goal of this project is to reduce residential diesel fuel consumption for hot water and space heating.

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

Background:

In 2009 Kotzebue Electric Association submitted a grant application for round two of the Denali Commission's Emerging Energy Technology Grant 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 installed six (6) solar-thermal heating 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 had 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 in the Arctic.

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 expected to see a 30% reduction in fuel use for domestic hot water heating (DHW) and a less substantial reduction in home space heating.

The original grant proposal suggested at least four air-source heat pumps to be installed 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 cost 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 did 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 will have a slightly different configuration to allow KEA to make a comparison for each home and recommend system designs accordingly.

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.

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

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. This offer still stands.

Analysis by System

KEA's main goal with this project is to reduce the use of fossil fuels for residential systems. KEA has obtained historical fuel usage for five (5) of the six (6)[5] homes and has evaluated quantities for 2011 in comparison to three (3) year historical average fuel usage. The production values shown in data collection may or may not correspond to heating fuel saved.

System	2008	2009	2010	2008-2010 avg	2011	Change	decrees
1	522	829	502	617.67	585	-32.67	5%
3	562	562	832	652	443	-209.00	32%
4	575	606	506	562.33	550	-12.33	2%
5	693	1066	324	694.33	801	106.67	-15%
6	580	640	638	619.33	310	-309.33	50%

[3] Northwest Inupiaq Housing Authority
[4] Northwest Alaska Regional Native Association
[5] Historical fuel data not available for one of the homes (system 2).

Viessmann Systems (DHW Only)

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.

<u>Existing Equipment</u>

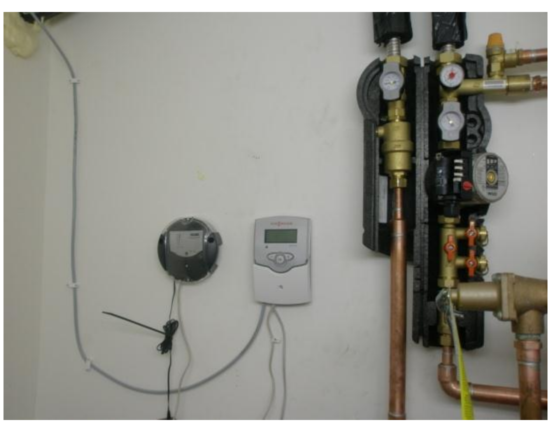
Water Heater	Oil Miser 148 - 5.1 gal indirect fired on-demand
Boiler	Oil Miser 180

<u>KEA installed Equipment</u>

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

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

Vitosol 300-TSP3 (30) Evacuated Tubes.



Viessmann 1: Utility Room

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

Fuel Usage(gal)

2008	2009	2010	2008-2010 avg	2011	Change	Decrees
522	829	502	617.67	585	-32.67	5%

System 1 is a Viessmann evacuated tube (30) array collector and serves domestic hot water (DHW) by utilizing an 80gal storage tank and a 5gal indirect fired on demand water heater. The home owner has realized a 5% decrees in fuel usage. This is less than what was expected. It is also unclear to what extent the reduction in fuel usage was due to the solar thermal system or the occupant's behavior. A DHW flow meter would help the analysis. This system is set to provide heat to the storage tank until it reaches 180F, at which point it can be dispatched by the DHW needs of the occupants. The system will dump heat if there is no call for it in the tank. For this reason households that use more DHW will realize higher production from the solar thermal system.

Additionally, during many high solar production months freezing temperatures occur that can drop below zero Fahrenheit. Evacuated tube collectors are more efficient at collecting solar radiation than flat plate collectors. Icing observed on the collectors remains longer throughout the day on evacuated tubes than on flat plate collectors. This reduces the availability of the evacuated tube systems.

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.

<u>Existing Equipment</u>

Water Heater	Amtrol WH 26 gal
Boiler	Oil Miser 180

<u>KEA installed Equipment</u>

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)

Viessmann 2: Utility Room

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

Historical fuel data was not available for this home. Production values (data sent to ACEP) shows lower than expected production. This system is on a single-occupancy home and is set up to provide DHW only. Homes with low DHW usage will show lower production values. A fuel flow meter as well as a DHW meter would aid in the analysis of this system.

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.

<u>Existing Equipment</u>	
Water Heater	Amtrol WH 26 gal
Boiler	Weil McClain Oil Heater 3.5gal burn rate
<u>KEA installed Equipment</u>	
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)

Viessmann 3: Flat Plate solar thermal collector

Utility room:
Very tight working space

David Lindeen (SES)

Wiring the DL2 data logger and the Control Unit

Fuel Usage(gal)

2008	2009	2010	08-10 avg.	2011	Change	Decrees
562	562	832	652	443	-209.00	32%

System 3 is a Viessmann flat plate collector and serves DHW by utilizing an 80gal storage tank and an indirect fired water heater. The home owners have realized 32% degrees in fuel usage. This is nearly identical to how KEA expected these systems to function. It is unclear to what extent the reduction in fuel usage was due to the solar thermal system or the occupant's behavior. A DHW flow meter would help the analysis.

Viessmann Systems Installation and 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 setup, 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.

Heliodyne Systems (DHW and Space 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.

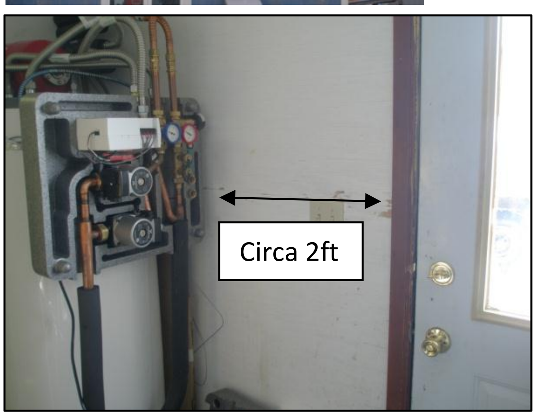
<u>Existing Equipment</u>

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

<u>KEA installed Equipment</u>

Solar Collector		King Span solar evacuated tube (30) (@ 68degrees)
Solar energy storage		80 gallon solar hot water storage tank
Pump		
Control	Integrated	Pro-lite controller and data logging
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)

Fuel Usage(gal)

System	2008	2009	2010	2008-2010 avg	2011	Change	Decrees
4	575	606	506	562.33	550	-12.33	2%

System 4 is a Heliodyne evacuated tube collector and serves both DHW and space heating by utilizing an 80gal storage tank and the existing boiler. This system has been problematic. A winter storm froze the water pump on the control unit (due to proximity to the front door) that caused the loss of availability of the system for at least 2 months in early 2011. After repairs were made several thermisters were also found to be faulty and replaced. The availability of this system is also reduced by icing similar to the Viessmann evacuated tube system (above). Overall the occupants realized 2% degrees in fuel usage. This is well below expected production. It is unclear to what extent the reduction in fuel usage was due to the solar thermal system or the occupant's behavior.

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 / Control / Data logging (Integrated)	
Control	Pro-lite controller and data logging
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). Mounting brackets rated to withstand 100mph winds.

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

Fuel Usage(gal)

System	2008	2009	2010	2008-2010 avg	2011	Change	Decrees
5	693	1066	324	694.33	801	106.67	-15%

System 5 is a Heliodyne Flat Plate collector that serves both DHW and space heating by utilizing an 80gal storage tank, the existing boiler, and the existing 40gal water heater. It is unclear at this time why the fuel usage seems to have increased over the three year average. However, there may be an error in the fuel total for 2010 that KEA received from Crowley Fuel Services. A fuel flow meter would help the analysis. This system's availability was compromised for nearly 2 months due to a closed flow valve that was discovered after exhaustive trouble shooting by KEA.

Additionally, one occupant of the house took a pro-active approach to this system, but without informing KEA. During the winter of 2011-2012 the occupant noticed that the 80gal storage tank was not wired into the electrical panel and performed the wiring himself. The storage tank was not wired in during installation because electrical heating of water is inefficient and was an option provided standard on the tank as a back-up (which requires a different wiring configuration that was performed). However, the direct wiring served as a primary heating source for the hot water tank. The result was: when there was a call for heat from the tank the electrical resistant heater preformed the heating function rather than drawing from the solar thermal system. KEA was not aware of this until the summer of 2012. This resulted in complete loss of solar-thermal production during peak shoulder seasons. KEA removed the wiring.

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.

<u>Existing Equipment</u>

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

<u>KEA installed Equipment</u>

Solar Collector		Gobi 410 flat plate (2)
Solar energy storage		80 gallon solar hot water storage tank
Pump		
Control	Integrated	Pro-lite controller and data logging
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)

Fuel Usage(gal)

System	2008	2009	2010	2008-2010 avg	2011	Change	Decrees
6	580	640	638	619.33	310	-309.33	50%

System 6 is a Heliodyne Flat Plate collector that serves both DHW and space heating by utilizing an 80gal storage tank, the existing boiler, and the existing 40gal water heater. The occupants have realized a 50% reduction in fuel usage. It is unclear to what extent the reduction in fuel usage was due to the solar thermal system or the occupant's behavior. Both fuel and DHW flow meters would aid this analysis.

Heliodyne System Installation 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.

Overall Lessons Learned
Data Collection

Data collection on these systems proved to be much more complicated than suggested by the manufacturers. Both Veissmann and Heliodyne system controllers are theoretically capable of direct internet connection for remote monitoring and trouble shooting. However, this proved to be considerably time consuming and complicated. The data from both Veissmann and Heliodyne control systems are recorded in 3-5 second steps. All data that was collected was sent directly to ACEP for analysis.

i. Veissmann

The Veissmann systems were unable to connect directly to WiFi. Communications with Veissmann engineers explained that though the systems were designed with this capability it has never worked. KEA elected not to attempt this interface. Data collection took place with direct hard links from each system controller to a portable laptop computer with the appropriate software installed. This proved to be hit or miss. Many times the uplinks worked as designed, other times the laptop was unable to locate the unit. There are gaps in the data from the Veissmann system.

ii. Heliodyne

The Heliodyne systems suggested an easier WiFi interface and after discussing options with ACEP, it was decided to attempt to connect these three (3) systems. ACEP funded the hardware (WiFi routers) and KEA funded travel and labor wages for one technician Alaska Battery Systems(ABS) to visit Kotzebue for several days. The technician was successful in linking two (2) of the systems. The routers purchased by ACEP were in accordance with ABS technician suggestions. However, the routers did not work (it was suggested later that they were too new for the software installed on the controllers). KEA located older routers in it’s shop and an exchange was made and a successful uplink was created. Within a few months one of the routers expired. To date only one system is online for remote access.

Data was still collected on the three (3) systems when available, but other connection problems arose from alterations made during the attempted WiFi set up. There are gaps in the Heliodyne data.

iii. Diesel Fuel

The goal of this project was to reduce residential diesel consumption for domestic hot water (DHW) and space heating. Therefore, KEA was most interested in the reduction of diesel usage with the addition of solar thermal systems. Four (4) years of diesel sales for five (5) of the six (6) systems were collected from Crowley Fuel Services in Kotzebue. Of these four (4) years, three (3) years of fuel sales were from before the systems were installed (then averaged) and one (1) year of fuel sales with the solar thermal systems installed. The average from the prior three (3) years was then compared to the one (1) year of solar thermal operation.

Fuel sales as reported by Crowley may not be an accurate assessment of the actual fuel used in each household covered by this study. As these systems were installed in Elders homes there is no way to verify if other fuel was gifted *to* the household, or gifted *from* the household. As fuel sales that were analyzed took place over a four (4) year period there was little recollection of fuel bills by the residents, and thus KEA was unable to verify the accuracy of the records. However, trends can be seen.

iv. General

It is the opinion of KEA that in future studies similar to this one, that a fuel meter be installed as well to accurately assess the total diesel consumption. Additionally, it is the recommendation of KEA that a DHW gauge also be installed to accurately monitor hot water usage. Systems that belong to households that use more hot water will see a greater benefit from solar thermal, i.e.—a house hold of one (1) person will use significantly less hot water than a household of four (4). During times when the space heating and/or hot water heat needs are met the solar thermal system will be idle, even if there is a sufficient delta-T to trigger the system into production.

Angle of Collector (solar thermal panel)

Industry standards suggest that the angle of the solar collector should be roughly approximate to the latitude of the installation area. In Kotzebue this angle would be 66 degrees. Because Kotzebue is at such a high latitude KEA wondered what gains might be had in the shoulder and summer months with a lower angle collector that could receive more solar radiation during the months when the sun does not dip below the horizon. Both of the Viessmann systems equipped with flat plate collectors (System 2 and 3) were installed with the collector at roughly 28 degrees (the angle of the roof). As noted above, system 2 has no fuel records and was not compared for system efficiency. System 3 had good production that was comparable to production seen in the heliodyne flat plate collectors installed at 68 degrees. The take-away lesson regarding system efficiency based on the angle of the collector may be in the data sent to ACEP.

However, during a severe winter storm in 2011 both of the Heliodyne flat plate systems were damaged due to excessive winds. The lower angle of the Viessmann system's flat plates emerged as an attribute in lowering the wind shear experience during high-wind storms. In future installations in rural Alaska a wall-mount system may be preferable to a roof-mount for two (2) reasons: 1) near total elimination of wind related system damage (except for possible flying debris), and 2) a simplified mounting system that does not require roof penetrations, or heavy equipment to place heavy collectors on the roofs.

Wind/Storm Damage

As noted above, a severe winter storm in 2011 damaged two (2) of the heliodyne flat plate collectors- one collector on each of the two (2) systems. A manufacturer's warranty was honored and the panels were replaced, but KEA was responsible for shipping and labor (which included flying a technician from Fairbanks to Kotzebue, lodging, and 3 days of labor, which resulted in an additional $5,000 of in-kind from KEA).

The collectors are rated for wind speeds up to 100mph but failed in wind speeds below 80 mph. It was determined that the installation was correct, but the angle of the wind produced a vacuum effect on the front of the panels which caused them to literally "blow out". Consultation with Heliodyne resulted in a recommendation to put banding straps on the collectors. KEA replaced the panels and added standard metal banding straps.

Flat Plate vs. Evacuated Tube

KEA installed both flat plate and evacuated tube solar thermal collectors in order to test the functionality of both designs in the Arctic. Overall, the flat plate collectors out produced the evacuated tube collectors. KEA believes the primary reason for this is icing on the evacuated tubes.

Evacuated tubes have been shown to be more efficient than flat plate collectors when tested in the lower 48 states. Evacuated tubes are more efficient at retaining solar radiation than flat plate collectors and have performed better in ice free environments. However, in Kotzebue during the shoulder seasons (spring and fall) there can be significant solar gain (partially due to refractions off of snow) while experiencing below freezing temperatures. These shoulder seasons are where solar thermal systems can be the most effective, especially for space heating.

KEA personnel observed evacuated tubes still covered in ice (thus not producing) as late as 11am during March. Meanwhile, at the same time flat plate collectors were ice free and producing significant heat. The reason is that flat plates are less efficient at retaining solar radiation—therefore more heat is refracted to aid in melting ice.

KEA would recommend, based on this experience that future installations in similar climatic environments use flat plate collectors in order to capitalize on significant solar gain during shoulder seasons.

Economics

Each of the six (6) systems cost different amounts to purchase and install. Each system is unique in regarding the exact components and additions to existing equipment, therefore the cost will vary.

Exact installation cost will vary widely depending on how many systems are installed and, more importantly, *where they are installed*—as this will change values for shipping, travel for technicians/plumbers, and lodging. Because KEA installed three (3) systems at a time, SES had to make two (2) trips, and there was piece-meal in-kind contributions from various installation parties (including KEA personnel, SES, IRA, and CETF) KEA will not be providing installation costs in this report.

System component costs (in 2010) are as follows:

System	Manufacturer	Collector	Use	Cost
1	Viessmann	Evacuated Tube	DHW	$14,197
2	Viessmann	Flat Plate	DHW	$11,426
3	Viessmann	Flat Plate	DHW	$11,635
4	Heliodyne	Evacuated Tube	DHW& SH	$11,164
5	Heliodyne	Flat Plate	DHW& SH	$9,664
6	Heliodyne	Flat Plate	DHW& SH	$9,664

Conclusion

Production data that is available will be sent to the Commission via ACEP. There may be several causes contributing to the lower than expected production values. KEA has solicited advice from industry experts and will continue to monitor each system. Currently, one (1) Heliodyne system is transmitting data in real-time. The installation of additional data collection equipment including pyranometers and DHW flow meters is planned.

Of the five systems that had historical fuel data available one set seems to be anomalous, showing a 15% increase in fuel with the solar thermal system installed, and this could be an error in the historical fuel data. Of the other four, the systems with flat plate collectors outperformed the evacuated tube systems. It is presumed that the difference in availability due to more overall icing hours on evacuated tubes is a contributing factor.

DHW flow meters will help determine the relationship between hot water usage by the occupant of the home and the utilization of solar radiation. Fuel flow meters would allow a much more precise measurement of the occupants fuel usage, currently KEA is relying on Crowley Fuel Services sales records.

KEA is also exploring options for the long term management of these systems. The Chukchi Campus and the Kotzebue Tech center have been approached for taking over management and maintenance of these systems to provide hands-on training in conjunction with upcoming renewable energy classes that may be offered.

Based on good performance from System 3 (Viessmann flat plate- DHW only) of a 32% reduction in fuel usage it appears that this simple system is viable in the Kotzebue region. It is thought that additional equipment that would allow this system to aid in space heating would further increase the fuel savings.

Performance of system 6 (Heliodyne flat plate- DHW and space heating) resulting in a 50% reduction of fuel usage is a model of the benefits of solar thermal technology in the Kotzebue region. This system shows a simple payback for equipment of less than ten (10) years based on diesel prices in 2008-2011.

Industry standard practices suggest that increasing the available storage in each system would increase the production and efficiency. Each of these six (6) systems was installed in “typical” 1000 ft2 village homes with small utility rooms. If more space was available more hot water storage would be possible which may increase the benefits of these systems and further drive down the simple payback period.