Kotzebue Electric Association  
Solar Thermal Alternative Residential Heating Methods  
Quarterly Report  
12/15/2010

**Funding**

<table>
<thead>
<tr>
<th>Source</th>
<th>Amount</th>
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</thead>
<tbody>
<tr>
<td>Denali Commission</td>
<td>$127,000</td>
</tr>
<tr>
<td>KEA(^1) In-Kind</td>
<td>$5,000</td>
</tr>
<tr>
<td>CETF(^2) In-Kind</td>
<td>$12,000</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$144,000</strong></td>
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Project Summary:

This project will assess the feasibility of solar hot water heating systems on residential units in the NANA Region of Kotzebue. The Community Energy Task Force (CETF) has identified up to ten Elders homes which are most in need of home heating assistance. These homes will serve as test sites. Up to ten solar-thermal heating systems, some using flat plate and some using evacuated tubes, will be 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.

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.

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\(^1\) Kotzebue Electric Association  
\(^2\) Community Energy Task Force
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 will install up to ten 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 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 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 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 will have 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*
KEA has coordinated with the Kotzebue CETF to identify homes that are suitable for this demonstration project. KEA and CETF had over 25 applicants and 10 met the following criteria: Elders status in Kotzebue, full-time Elders residence, and currently on State Energy Assistance. KEA then worked with CETF and Susitna Energy Systems (SES) designers to identify the homes with the least amount of equipment needed in order to demonstrate the most systems. After careful review, and pricing evaluations, 6 homes where selected for solar collectors and one additional home was identified as suitable for a hybrid air-source electric hot water heater, if the budget allows.

Planning: *Complete*
Several of the 6 homes selected for this demonstration project utilize hydronic base board heating to heat the homes. In this type of home heating system a glycol based fluid is heated by the same boiler that domestic hot water is heated. It is therefore possible to allow a solar thermal collector to pre-heat both systems. This requires slightly more complex plumbing as well as more advanced thus more expensive, storage tanks.

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.

Viessmann Inc was reluctant to install their equipment to serve as combined DHW and heating as it was designed for DHW only. Therefore KEA chose to purchase 2 flat plate and 1 evacuated tube collector from Viessmann to be installed by SES. Heliodyne was more flexible in their system design capacity and with ABS having experience installing a combined DHW and heating solar thermal system in Nome, KEA felt comfortable purchasing 2 flat plat and 1 evacuated tube collector from Heliodyne to be installed by ABS.

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:

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Installer</th>
<th>Collector Type</th>
<th>System Type</th>
</tr>
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<tr>
<td>Viessmann</td>
<td>SES</td>
<td>1 evacuated tube</td>
<td>DHW</td>
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<tr>
<td>Viessmann</td>
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<tr>
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<td>1 evacuated tube</td>
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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 for 18-24 hours and the boiler systems in the homes generally are not running to produce space heating.

Equipment
All equipment was ordered from the manufacturers through the installation/design firms listed above and have followed the procurement procedure of ACEP/UAF.
At the time of this report the installation of all 6 solar thermal systems is 83% complete. There are three major installation components to each system: rooftop solar collector, plumbing, and controls. The remaining 17% represents the wiring of 3 control units for the SES systems. This will be complete by December 22\textsuperscript{nd} which is on track for all 6 systems commissioned and running by January 1, 2011 as per the contractual agreement with Denali Commission and ACEP.

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. However, labor availability constraints pushed the final installation of the SES units back farther than was anticipated.

In October of 2010, SES and Gensco sent 3 installation technicians to Kotzebue to work with KEA on the initial installations of 3 systems. The local IRA organization provided a plumber to work in conjunction with KEA as per CETF’s In-Kind labor contributions. However, before plumbing was complete overriding duties called the IRA plumber away to other jobs. SES and KEA successfully mounted the solar collection units and plumbed the line-set into the houses. No further work could continue until the plumbing within the house, including thermal storage tanks, was complete.

In November of 2010, ABS sent 2 installation technicians to Kotzebue to work with KEA on the installations of the 3 other systems. During their stay a local plumber was located and worked with the ABS team. All aspects of the installation were complete by November 22\textsuperscript{nd}. Some minor glitches were found in the control units and rectified. These systems are currently up and running and final commissioning will take place in December 2010.

Final plumbing on the first 3 SES systems took place between November 23\textsuperscript{th} and December 19\textsuperscript{th}, 2010.

On December 19, 2010, SES will be sending 1 installation technician to Kotzebue to work with KEA to complete the installation and commissioning of the SES systems. All that remains is to wire in the control units and fill the solar thermal line-set with a food-grade glycol-based solar thermal solution. These units will be commissioned on or before December 22, 2010.
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\textsuperscript{3} and NANA\textsuperscript{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.

D. Conclusion

This demonstration project proved to be somewhat complex due to the coordination of several entities as well as several home owners. The accomplishments to date are listed in the above narrative: Site Selection is complete; the planning phase is complete; the installation is 83% complete and on schedule.

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, 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.

\textsuperscript{3} Northwest Inupiaq Housing Authority
\textsuperscript{4} Northwest Alaska Regional Native Association
E. Pictures of Work Performed

Viessmann Flat Plat solar thermal collector installed.
Viessmann Evacuated Tube Installation of line-set. *Left:* Derek Fox (Gensco, Inc) *Right:* Mark Kuhlman (Gensco, Inc)
Viessmann Evacuated Tube Racking Mount- awaiting final plumbing.
Viessmann Flat Plat Solar Collector.
Heliodyne Flat Plate Collector.
Heliodyne Flat Plate Installation. Jesse Logan (KEA)
Heliodyne Evacuated Tube Solar Collector.
Helodyne Thermal Storage tank, control unit and plumbing.
Heliodyne Thermal Storage Tank, Controls and Plumbing.

Heliodyne plumbing system. Tim Karka (KEA)
Funding

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KEA\(^1\) In-Kind $5,000
CETF\(^2\) In-Kind $12,000

Total $144,000

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.

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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.

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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.

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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,

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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

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
**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
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

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**

<table>
<thead>
<tr>
<th>Equipment</th>
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<tbody>
<tr>
<td>Water Heater</td>
<td>Boiler Mate WH9L (26gal)</td>
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<tr>
<td>Boiler</td>
<td>Weil McClain Oil Heater 3.5gal burn rate</td>
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</tbody>
</table>

**KEA installed Equipment**

<table>
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<th>Details</th>
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</thead>
<tbody>
<tr>
<td>Solar Collector</td>
<td>King Span solar evacuated tube (30) (@ 68degrees)</td>
</tr>
<tr>
<td>Solar energy storage</td>
<td>80 gallon solar hot water storage tank</td>
</tr>
<tr>
<td>Pump</td>
<td>Integrated</td>
</tr>
<tr>
<td>Control</td>
<td>Pro-lite controller and data logging</td>
</tr>
<tr>
<td>Data logging</td>
<td>Hilio-pack pro heat exchanger with Wi-Fi and data logging</td>
</tr>
<tr>
<td>Exchanger to hydronic system</td>
<td>Flat plate heat exchanger w/ auxiliary circ pump</td>
</tr>
<tr>
<td>Solar fluid line set</td>
<td>copper</td>
</tr>
</tbody>
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King Span solar evacuated tube (30) (@ 68degrees)
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
- 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.
**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.

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<td>26 gallon water heater</td>
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<td>Boiler</td>
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</table>

| Solar Collector    | Gobi 410 flat plate (2) |
| Solar energy storage | 80 gallon solar hot water storage tank |
| Pump               | Pro-lite controller and data logging |
| Control            | Hilio-pack pro heat exchanger with Wi-Fi and data logging |
| Data logging       | Flat plate heat exchanger w/ auxiliary circ pump |
| Exchanger to hydronic system | copper |
| 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 Helodyne 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)
Kotzebue Electric Association
Solar Thermal Alternative Residential Heating Methods
Quarterly Report
6/30/2011
Prepared by Jesse Logan (KEA)

**Funding**

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**Total** $144,000

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**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.

---

\(^1\) Kotzebue Electric Association  
\(^2\) Community Energy Task Force
### A. 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.

### B. Progress Update

Due to unexpected challenges several of the systems were not operational until March of 2011, see KEA’s March Quarterly Progress Report Appendix 1 for details. At present all six (6) systems are operational. Below is a summary of BTUs utilized by each system in April and May 2011.

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\(^3\) Northwest Inupiaq Housing Authority  
\(^4\) Northwest Alaska Regional Native Association
### Preliminary Energy Results for April and May 2011

**Susitna/ Viessman Systems (DHW only)**

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<tr>
<th>System</th>
<th>BTUs</th>
<th>Diesel Equivalent (gallons)</th>
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<tbody>
<tr>
<td>System 3(FP)</td>
<td>2,562,637</td>
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<tr>
<td>System 1(EVT)</td>
<td>1,852,878</td>
<td>14.82</td>
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<tr>
<td>System 2(FP)</td>
<td>75,070</td>
<td>0.60</td>
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**ABS/ Heliodyne Systems (Combined DHW and Heat)**

<table>
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<tr>
<th>System</th>
<th>BTUs</th>
<th>Diesel Equivalent (gallons)</th>
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</thead>
<tbody>
<tr>
<td>System 5(FP)</td>
<td>3,050,000</td>
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<tr>
<td>System 6(FP)</td>
<td>2,650,000</td>
<td>21.20</td>
</tr>
<tr>
<td>System 4(EVT)</td>
<td>270,000</td>
<td>2.16</td>
</tr>
</tbody>
</table>

### Analysis

The production values, above, are below what KEA was expecting to see in the spring months. However, several factors may contribute to the seemingly underproduction and KEA has solicited the advice of both Heliodyne and Viessmann corporate offices as well as the contractors to narrow the possibilities. 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) homes. KEA will evaluate fuel usage for 2011 later this year.

First, the production values, shown above, are derived from the difference between the temperature of the solar fluid before entering the storage tank and upon exiting the same storage tank. Therefore, the total amount of BTUs that the system produces is not calculated, only what is utilized by the system for domestic hot water (DHW) and space heating. Observationally, the households with a larger number of residents have systems that are reporting higher BTU values. This seems straight forward: A single Elder living alone would have less need for hot water than a household of six (6), so even if the system has enough solar radiation to begin pumping, if there is no call for heat in the storage tank the system will not transfer any heat.

Over the next quarter KEA will be doing household surveys to get a better picture of DHW and space heating needs (use) and may explore options of installing flow meters on the DHW loop.
in order to understand the usage for each system. Still, the main criteria for judging the appropriateness of this technology will be reduced diesel fuel use.

Second, KEA, as well as Alaska Battery Systems (ABS) and Susitna Energy Systems (SES), had expected to see greater production from the Evacuated Tube (EVT) systems. However, as shown above, Flat Plate collectors are out-producing the EVTs. One possible reason for this is lower ambient air temperatures during the spring months in Kotzebue. Though ambient air temps have very little effect on the temperature of the collector, frost could contribute to lower production. During the spring months in Kotzebue there is often frosting at night. Flat plate collectors are less efficient and therefore radiate more heat (solar radiation) back into the atmosphere. This would make them frost free earlier in the day. The project manager has observed frost on the EVTs as late as 11am, while the FP collectors were frost free and in full production.

Additionally, it is possible that the thermistor sensors on some of the systems may not be calibrated correctly. This would result in lower production (as the system would not have accurate information to dispatch heat), and also lower production reports. However, KEA feels fairly confident that this is not the case.

Another possible contributing factor to lower than expected production values could be the angle of the collectors. Generally, solar collectors face south and are at an angle near the same as the latitude of the site. However, Kotzebue is above the Arctic Circle and this unique sun angle in the summer has not been tested with solar thermal units. Therefore, KEA has placed two (2) (system 2 and system 3) of the solar collectors at 30degrees, rather than the customary 68degrees, in order to capitalize on the increased angle of the sun during summer months. However, as can be seen with the preliminary data above, system 3 has produced on par with other systems while system 2 has a much lower production value. More production value over the course of the summer and fall seasons is necessary to fully understand this relationship.
C. 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 KEA’s March 2011 quarterly report for details) and KEA has worked diligently to address each problem in a timely and cost efficient manner.

Preliminary production data is available and 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. As well, KEA feels that more observation is needed and that data over the course of a full year will be necessary to fully evaluate the economics of these systems.
Funding

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Total $144,000

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B. Progress Update

At present all six (6) systems are operational. Due to technical issues acquiring data from the different system’s data loggers the Heliodyne systems will soon be connected to WiFi internet for remote access. The data from both Veissmann and Heliodyne control systems are recorded in 3-5 second steps. There are gaps in the annual 3-5 second step data for the Heliodyne systems. However, the annual totals are complete. There has been no loss of data on the Veissmann systems, though acquisition has proved to be hit or miss.

The three Heliodyne systems are equipped with short range WiFi on their control unit. ACEP and KEA are moving forward with the work necessary to allow remote access to the control units and the data sets. This will comprise of installing cable internet into the house (from OTZ in Kotzebue), a modem, and a small alteration to the control unit on the solar thermal system.

\(^3\) Northwest Inupiaq Housing Authority
\(^4\) Northwest Alaska Regional Native Association
itself. Currently, parts are on order and it is expected that these units will be online in October, 2011.

Data sets are being acquired and sent to ACEP for analysis.

a. Analysis

The production values, overall, are below what KEA was expediting to see. However, 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) homes. KEA will evaluate fuel usage for 2011 beginning in December. The production values shown in data collection may or may not correspond to heating fuel saved.

Several factors may contribute to the seemingly underproduction and KEA has solicited the advice of both Heliodyne and Viessmann corporate offices as well as the contractors to narrow the possibilities.

There may be a discrepancy between the control unit’s calculated BTU input and the actual fuel saved. KEA and ACEP will analyze fuel savings versus heating degree days beginning in December of 2011. KEA is currently still exploring other options to modify the systems to gain better performance. These options include, but are not limited to: changing the angle of the collectors, increasing/decreasing pump speeds, modifying the Viessmann systems to provide space heating as well as DHW, re-calibrating the thermistors, and adding flow meters to understand DHW usage.

ACEP and KEA have ordered flow meters for the Heliodyne system to better understand the DHW usage in the households. Still, the main criteria for judging the appropriateness of this technology will be reduced diesel fuel use.

---

5 Historical fuel data not available for one of the homes.
C. 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 KEA’s March 2011 and June 2011 quarterly report for details) and KEA has worked diligently to address each problem in a timely and cost efficient manner.

Production data is available and 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. As well, KEA feels that more observation is needed and that data over the course of a full year will be necessary to fully evaluate the economics of these systems.
Kotzebue Electric Association
Solar Thermal Alternative Residential Heating Methods
Quarterly Report
12/29/2011
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

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At present four (4) of the six (6) systems are operational. Due to technical issues acquiring data from the different system’s data loggers the Heliodyne systems were slated be connected to WiFi internet for remote access. However, after severe wind damage occurred to two (2) of the Heliodyne systems the WiFi connection was put on hold.

\(^3\) Northwest Inupiaq Housing Authority
\(^4\) Northwest Alaska Regional Native Association
In November of 2011 a severe winter storm hit the west coast of Alaska causing damage from Nome to Kotzebue. Recorded winds were above 70 miles per hour in the Kotzebue region. While both the Viessmann and Heliodyne systems are rated for wind speeds in excess of 100 miles per hour severe damage occurred to two Heliodyne flat plate collectors- one collector on two different systems (see pictures below). A wind loading analysis was done by ABS and found no fault in the installation site, placement, or angle. The orientation of both of these collectors is within 5 degrees of due south and the strongest wind gusts came from the East by Northeast. It is possible that strong wind collided with the collector’s eastern corner and produced a vacuum on the front of the collector panel causing the protective layer to sheer off. These systems are currently not functional.

(As a side note, the two (2) Veissmann flat plate collectors were installed at an angle equal to the pitch of the roof, around 29 degrees, and were not affected by the strong winds.)

Heliodyne has agreed to honor their manufacturer’s warranty and will replace the two (2) flat plate collectors. KEA is in discussion with the installation company (Alaska Battery Systems, Fairbanks) to find the most economical way to ship and install the new collectors. Severe winter conditions in the Kotzebue region during January and February may delay the installation. It is not thought that the down-time of these systems (occurring in November through January or February) has caused a significant loss of production due to lack of solar radiation during these months above the Arctic Circle.

a. Analysis

The production values, overall, are below what KEA was expediting to see. However, 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) homes. KEA will evaluate fuel usage for 2011 at the end of December. The production values shown in data collection may or may not correspond to heating fuel saved.

Several factors may contribute to the seemingly underproduction and KEA has solicited the advice of both Heliodyne and Viessmann corporate offices as well as the contractors to narrow the possibilities.

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5 Historical fuel data not available for one of the homes.
ACEP and KEA have ordered flow meters for the Heliodyne system to better understand the DHW usage in the households. However, this is also on hold until the Heliodyne systems can be repaired. Still, the main criteria for judging the appropriateness of this technology will be reduced diesel fuel use.

C. 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 KEA’s March 2011 and June 2011 quarterly report for details) and KEA has worked diligently to address each problem in a timely and cost efficient manner.

Production data is available and 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. As well, KEA feels that more observation is needed and that data over the course of a full year will be necessary to fully evaluate the economics of these systems.

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.

Following this report the 12 month observation period will come to an end. KEA will be assessing fuel savings for five (5) of the six (6) systems to better understand the economics of installing solar thermal above the Arctic Circle. The final report to The Commission will detail these findings.
Picture 1: Wind damaged Heliodyne flat plate collector

Picture 2: Wind damaged Heliodyne flat plate collector
Kotzebue Electric Association
Solar Thermal Alternative Residential Heating Methods
Quarterly Report
4/20/2012
Prepared by Jesse Logan (KEA)

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Heliodyne agreed to honor their manufacturer’s warranty and has replaced the two (2) flat plate collectors.

In March 2012 one technician from ABS traveled to Kotzebue and, in conjunction with KEA, completed the replacement of the two (2) damaged collectors. KEA has paid the expenses including the shipping of the new collectors out of pocket. This expense is In-Kind from KEA and represents an additional $5,000 of In-Kind support for this project. Currently all six (6) systems are functional.

The data from both Veissmann and Heliodyne control systems are recorded in 3-5 second steps. There are gaps in the annual 3-5 second step data for the Heliodyne systems. However, the annual totals are complete. There has been no loss of data on the Veissmann systems, though acquisition has proved to be hit or miss.

ACEP has recently acquired a “data collection package” to help KEA acquire and transmit data. The package includes equipment for three (3) of the systems. As the Viessmann systems are not compatible with online data transmission in real-time ACEP has elected to continue data collection primarily from the three (3) Heliodyne systems. The data packages included pyranometers, domestic hot water flow meters, and wireless Wi-Fi routers. However, the routers purchased were incompatible with the Heliodyne systems. KEA located some older Wi-Fi routers and two (2) of the systems are currently transmitting data online. This data is stored in the Heliodyne server and is accessible to both KEA and Tom Johnston of ACEP. KEA was unaware of the flow meters and could not schedule a qualified plumber to install them during the ABS technician visit to Kotzebue.

This project was scheduled to close during this quarter, but KEA and ACEP have agreed to extend the data collection past the original 12 months. KEA and ACEP will continue data collection and system monitoring through September 2012.

a. Analysis

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) 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.

Historical fuel data not available for one of the homes.
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<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>2008-2010 avg</th>
<th>2011</th>
<th>Change</th>
<th>Decrees</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>522</td>
<td>829</td>
<td>502</td>
<td>617.67</td>
<td>585</td>
<td>-32.67</td>
<td>5%</td>
</tr>
<tr>
<td>3</td>
<td>562</td>
<td>562</td>
<td>832</td>
<td>652</td>
<td>443</td>
<td>-209.00</td>
<td>32%</td>
</tr>
<tr>
<td>4</td>
<td>575</td>
<td>606</td>
<td>506</td>
<td>562.33</td>
<td>550</td>
<td>-12.33</td>
<td>2%</td>
</tr>
<tr>
<td>5</td>
<td>693</td>
<td>1066</td>
<td>324</td>
<td>694.33</td>
<td>801</td>
<td>106.67</td>
<td>-15%</td>
</tr>
<tr>
<td>6</td>
<td>580</td>
<td>640</td>
<td>638</td>
<td>619.33</td>
<td>310</td>
<td>-309.33</td>
<td>50%</td>
</tr>
</tbody>
</table>

1. a. System 1

Fuel Usage(gal)

<table>
<thead>
<tr>
<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>2008-2010 avg</th>
<th>2011</th>
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<tbody>
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<td>829</td>
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<td>585</td>
<td>-32.67</td>
<td>5%</td>
</tr>
</tbody>
</table>

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.

b. System 3

Fuel Usage(gal)

<table>
<thead>
<tr>
<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>08-10 avg.</th>
<th>2011</th>
<th>Change</th>
<th>Decrees</th>
</tr>
</thead>
<tbody>
<tr>
<td>562</td>
<td>562</td>
<td>832</td>
<td>652</td>
<td>443</td>
<td>-209.00</td>
<td>32%</td>
</tr>
</tbody>
</table>
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.

c. System 4
Fuel Usage(gal)

<table>
<thead>
<tr>
<th>System</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>2008-2010 avg</th>
<th>2011</th>
<th>Change</th>
<th>Decrees</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>575</td>
<td>606</td>
<td>506</td>
<td>562.33</td>
<td>550</td>
<td>-12.33</td>
<td>2%</td>
</tr>
</tbody>
</table>

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 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.

d. System 5
Fuel Usage(gal)

<table>
<thead>
<tr>
<th>System</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>2008-2010 avg</th>
<th>2011</th>
<th>Change</th>
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</tr>
</thead>
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<td>1066</td>
<td>324</td>
<td>694.33</td>
<td>801</td>
<td>106.67</td>
<td>-15%</td>
</tr>
</tbody>
</table>

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.

e. System 6
Fuel Usage(gal)

<table>
<thead>
<tr>
<th>System</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>2008-2010 avg</th>
<th>2011</th>
<th>Change</th>
<th>Decrees</th>
</tr>
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<tbody>
<tr>
<td>6</td>
<td>580</td>
<td>640</td>
<td>638</td>
<td>619.33</td>
<td>310</td>
<td>-309.33</td>
<td>50%</td>
</tr>
</tbody>
</table>

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.

C. 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, two (2) Heliodyne systems are 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.