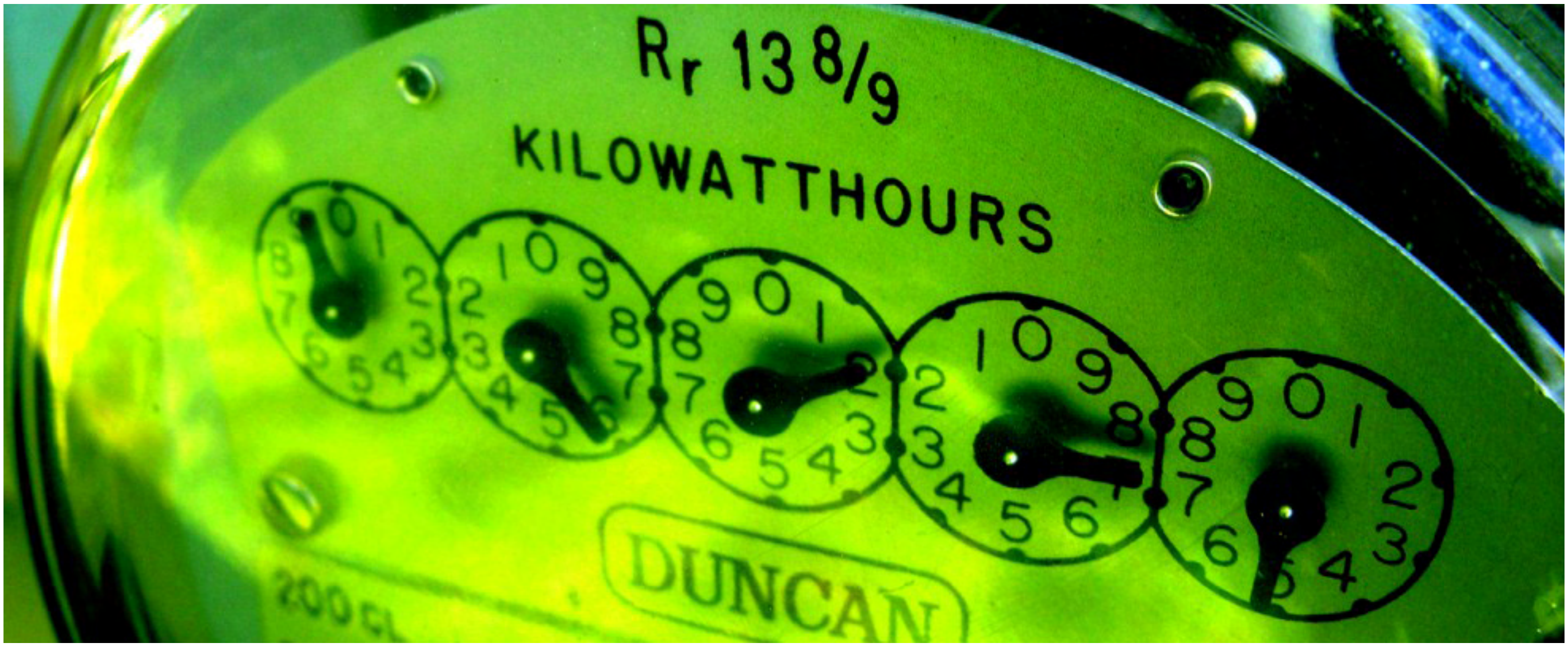


Overview

Garrett County Community Action Committee (GCCAC) installed energy conservation measures (ECMs) on residential housing in Garrett County. These ECMs consisted of various renewable energy technologies and energy-efficient appliances, specifically solar photovoltaic (PV), hybrid hot water heating, Air Source Heat Pump (ASHP), geothermal, wind, and split ductless systems. This document outlines the technologies used, shows the data collected, and contains guidelines for quantifying the savings that resulted from the implementation. The savings from installing these technologies was verified by comparing pre-installation utility data with new utility data.

WHY MEASURE & VERIFY?

- Accurately assess energy savings for a project
- Allocate risks to the appropriate parties
- Reduce uncertainties to reasonable levels
- Verify that the consumer achieves utility budget savings
- Monitor equipment performance
- Find additional savings
- Improve operations & maintenance
- Allow for future adjustments as needed

APPROACH TO DETERMINING ENERGY SAVINGS

Typically, savings is determined by comparing energy use before and after the installation of conservation measures, then making appropriate adjustments for changes in conditions. The *before* case is called the **baseline**. The *after* case is referred to as the **post-installation** or **performance** period. Proper determination of savings includes adjusting for changes that affect energy use, but are not caused by the conservation measures. Such adjustments may account for changes in weather, occupancy, or other factors between the baseline and performance periods.

Below is the general equation used to calculate savings:
Savings = (Baseline Energy Utility Data – Post Installation) +/- Energy Adjustments

There are two fundamental factors that drive energy savings: performance and usage. **Performance** describes the amount of energy used to accomplish a specific task, and may also be referenced as efficiency or rate of energy use. **Usage** describes the operating hours, or total time, that a piece of equipment runs.

Energy consumption is generally determined by multiplying performance (or efficiency) by usage (or operating hours). In all cases, these factors need to be known for both the pre- and post-retrofit conditions to determine energy consumption and savings, as shown in Figure 1.

Savings are determined by comparing the energy use of the pre-retrofit case, called the baseline, with the post-retrofit energy use. This means that the performance and usage factors must be known for both the baseline and post-retrofit cases in order to determine energy savings, as shown in Figure 1.

In addition, as shown in the equation above, both routine and non-routine adjustments may be used to account for any changes that may occur during the performance period. The purpose of adjustments is to express both baseline and post-installation energy under the same set of conditions. Routine adjustments are used to account for expected variations in independent variables and energy use. Regression analysis is often used to correlate energy use to independent variables.

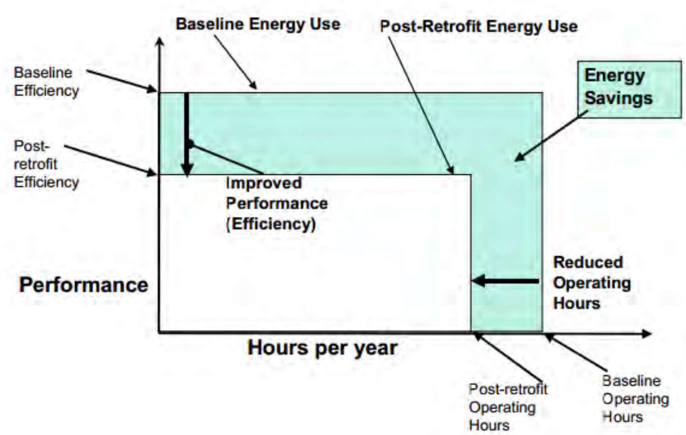


Figure 1

Unfortunately for the GCCAC EMV project, it isn't possible to use these adjustments because the majority of the information was produced from utility data. If additional data was taken to account for these energy adjustments, the data listed below would show more realistic data. Instead, BITHENERGY used the formula shown below

Savings = (Baseline Utility Data - Post installation Utility data) *

If data loggers were used in this project properly, the data would have shown which equipment performed the best based off the generation or energy savings. The analysis would then be split into two categories, *generation equipment* and *high efficiency appliances*.

The generation equipment category would include the following:

- Solar PV systems
- Wind Energy systems
- Geothermal systems

The high-efficiency equipment category would include the following:

- ASHP (Air Source Heat Pumps)
- Split Ductless
- Hybrid hot water heaters

To figure out which of the generation equipment performed the best, the following formula would be used:
Savings = (Energy Generated/YR * Value of electricity)

For the high-efficiency appliances, the following formula would be used:
Savings = (Baseline Logger data – Post installation logger data * Value of electricity)

After the energy savings for each piece of equipment was computed, it would then be ranked in its own category based on the highest value of electricity saved in each category from highest to lowest. Performing the analysis this way allows GCCAC to see the true performance of each type of system without having to have two control groups (weather adjusted & utility consumption).

Measurement & Verification Process

STEP 1: DEFINE THE BASELINE

Garrett County Community Action Committee (GCCAC) collected utility data as well as data collected using data loggers. Data was collected for two years before any equipment was installed. Unfortunately the information collected from the data loggers was incomplete and could not be incorporated into this analysis. All data presented in this report was forwarded from the electric service provider Potomac Edison.

STEP 2: INSTALL & COMMISSION EQUIPMENT

GCCAC, with consultation services from BITHENERGY, implemented the installation of several different types of renewable energy equipment and high efficient appliances ranging in cost and efficiency. Geothermal, wind energy, split ductless, solar PV, hybrid hot water heaters & ASHP systems were installed on 60 homes throughout Garrett County. The breakdown was as follows:

- 5 geothermal systems
- 3 wind energy systems
- 10 split ductless systems
- 16 solar PV systems
- 19 hybrid hot water heating systems
- 7 ASHP systems

GCCAC teamed with multiple contractors to get all systems commissioned properly. The following companies installed the equipment:

1. A. D. Naylor's Contracting (Geothermal, hybrid hot water heating systems)
2. Big D Electric (Solar PV systems, Wind energy systems)

3. Ray C Lapp Air Conditioning Inc. (Split ductless & ASHP HVAC systems)
4. Affordable Energy Solutions (Solar PV systems)
5. Power In My Back Yard (PIMBY) (Solar PV systems)

STEP 3: POST-INSTALLATION VERIFICATION

GCCAC collected utility data for a year after all systems were completely commissioned. The data collected before and after the installation were compared by its counterpart month to help get a more accurate analysis.

There are two uncontrolled variables that affect the analysis: weather variations year-to-year and human behavior around the consumption of energy. Ideally these variables should be accounted for to ensure accurate data.

BITHENERGY has noticed that when people get these technologies installed, they often are more careless with energy consumption, especially if the services provided were from a grant at no cost to the homeowner. GCCAC tried to gather more accurate consumption data using data loggers, but the loggers were unsuccessful gathering the data that was needed.

The following is the order of which technologies performed the best based on dollar value of average energy savings in each category:

1. Hybrid Hot Water Heating
2. Solar PV Systems
3. Split Ductless HVAC system
4. ASHP (Air Source Heat Pump)
5. Geothermal
6. Wind Energy Systems

Solar PV Systems

Every day, light hits your roof's solar panels with photons (particles of sunlight). The solar panel converts those photons into electrons of direct current or *DC* electricity. The electrons flow out of the solar panel and into an inverter and other electrical safety devices. The inverter converts that DC power (commonly used in batteries) into alternating current or *AC* power. AC power is the kind of electricity that your television, computer, and toasters use when plugged into the wall outlet.

A net energy meter keeps track of the all the power your solar system produces. Any solar energy that you do not use simultaneous with production goes back into the electrical grid through the meter (See Figure 2). At night or on cloudy days, when your system is not producing more than your building needs, you will consume electricity from the grid. Your utility service provider will bill you for the *net* consumption for any given billing period and provide you with a dollar credit for any excess during a given period. You can carry your bill credit forward for up to a year.

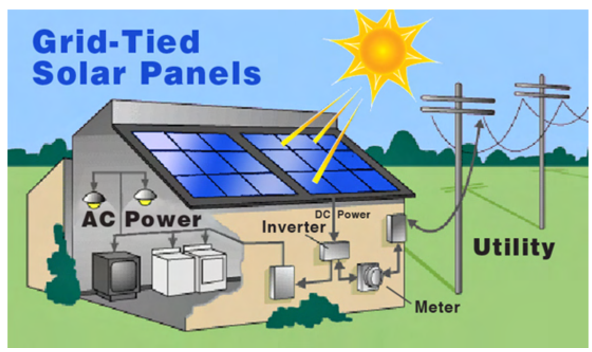


Figure 2

Solar cells are small, square-shaped panel semiconductors made from silicon and other conductive materials, manufactured in thin film layers. When sunlight strikes a solar cell, chemical reactions release electrons, generating electric current. Solar cells are also called photovoltaic cells or *PV cells* and can be found on many small electronics such as calculators.

SOLAR PHOTOVOLTAIC (PV) SYSTEM COMPONENTS

A PV system components include the following components:

- PV modules (groups of PV cells), which are commonly called PV panels
- one or more batteries if necessary
- a charge regulator or controller for a stand-alone system

- an inverter to covert solar power from direct current (DC) to the alternating current (AC) of the utility grid-connected system
- wiring
- mounting hardware or a framework.

A PV module arranges individual PV cells and the modules are grouped together in an array. Some of the arrays are set on special tracking devices to follow sunlight all day and improve system efficiency. The solar PV arrays installed with this grant had a nameplate capacity of 3KW.

A photovoltaic (PV) system needs unobstructed access to the sun's rays for most or all of the day to be effective. Shading on the system can significantly reduce energy output. Climate is not a major concern because PV systems are relatively unaffected by air temperatures, and snow cover typically melts quickly because panels are positioned directly into the sunlight. Abundant sunshine makes solar energy systems useful and effective nearly everywhere in Maryland.

PV systems today can be blended easily into both traditional and nontraditional homes, powering appliances and electric systems. PV cells can be installed as a stand-alone module that is attached to your roof or on a separate system, or using integrated roofing materials with dual functions - that as a regular roofing shingle and as a solar cell making electricity. The most common practice is to mount modules onto a south-facing roof or wall. PV systems likewise can be blended into virtually every conceivable structure for commercial buildings. You will find PV used outdoors for security lighting as well as in structures that serve as covers for parking lots and bus shelters.

MAINTENANCE & LONGEVITY

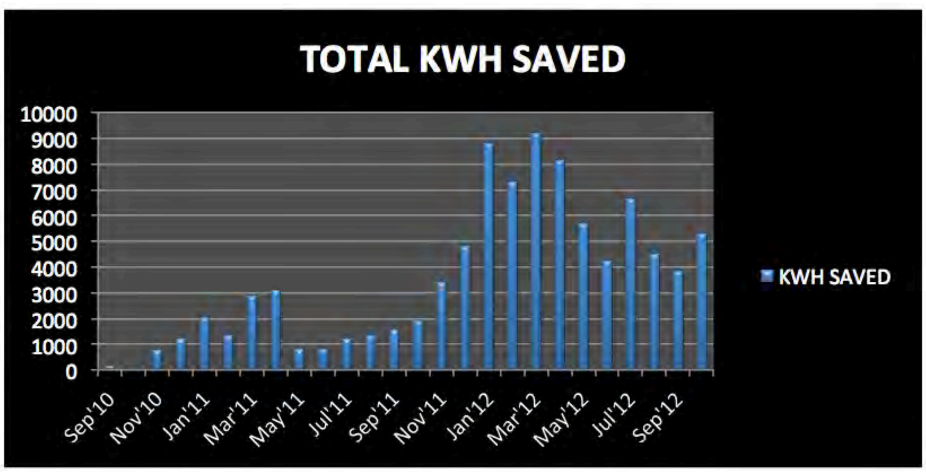
Although they are sophisticated electric systems, PV systems have few moving parts so they require little maintenance. The basic PV module (an interconnected, enclosed panel of PV cells) has no moving parts and can last more than 30 years while requiring little maintenance. The components are designed to meet strict dependability and durability standards to withstand the elements. The best way to ensure and extend the life and effectiveness of your PV system is by having it installed and maintained properly. Most PV system problems occur because of poor or sloppy system installation. Solar systems that receive rebates through Maryland utilities are required to have a 10-year system warranty. BITHENERGY uses components that have a minimum of 10 years but an average of 20 years.

PERFORMANCE SUMMARY

Average System Cost: $19,874.69
Average KWh Saved: 5,680.81
Average Savings: $596.48
Total KWh Saved: 90,893KWh
Average Utility Rate: $0.1050/KWh
Value of Electric Saved: $9,543.76

SOLAR PV SYSTEM SUMMARY

Period	KWH SAVED	Period	KWH SAVED	Period	KWH SAVED
Sep'10	166	Sep'11	1567	Sep'12	3852
Oct'10	0	Oct'11	1891	Oct'12	5267
Nov'10	761	Nov'11	3389		
Dec'10	1222	Dec'11	4790		
Jan'11	2038	Jan'12	8809		
Feb'11	1346	Feb'12	7314		
Mar'11	2847	Mar'12	9168		
Apr'11	3084	Apr'12	8136		
May'11	806	May'12	5697		
Jun'11	820	Jun'12	4238		
Jul'11	1219	Jul'12	6656		
Aug'11	1327	Aug'12	4483		



Wind Energy Systems

Wind turbine systems can range in size from 200w to several megawatts. The wind turbines installed on properties in Garrett County are smaller scale wind turbines, with nameplate capacities ranging from 1.8 kW to 3.5 kW. Regardless of system size, most turbines operate in the same manner. Wind turbines require a certain amount of wind to begin turning the blades to produce power. This is called *cut in speed*. Most wind turbine systems require 6+MPH of direct wind to start generation. Once the cut in speed is met, the blades will spin. The blades turn the shaft, which is connected to a transmission in some cases, or directly to the generation motor in other cases. As the input shaft spins, the generator motor should be spinning and producing DC (Direct Current) electricity. This electricity is not yet ready to be sent to your household for use because the United States standard electrical system runs off AC electric (Alternating Current).

The power is sent from the generator motor through compositors, then into an inverter. The inverter converts the DC electricity into AC electricity that is then ready to be used, or sent back onto the electrical grid. This electricity is then tied into a "Net meter/RGM," a meter used to keep track of the production of the turbine by the utility company. This meter is then used at the end of each month to offset the consumption meter. The difference between the consumption meter and the generation meter is the cost that the customer has to pay the utility company. After the energy is metered, it is tied into the main distribution panel, and used as needed or sent back onto the grid. (See Figure 3)

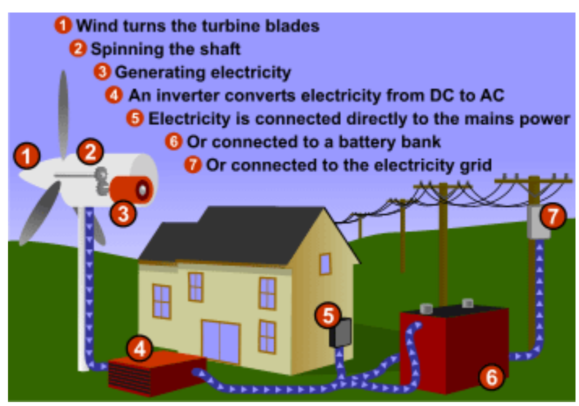


Figure 3

MAINTENANCE & LONGEVITY

Wind turbines require semiannual maintenance because these systems have a large number of moving parts. Residential-size turbine manufacturers are starting to recognize the need to minimize maintenance for homeowners so that residential turbines require less maintenance.

1. Blades on wind turbines should be re-torqued once a year to factory torque specs. It is very important that the blades are not over-tightened. Most blades are made of lightweight materials like fiberglass. If over-tightened, these blades can crack and break off during operation becoming a severe falling debris risk.

2. The shaft of the turbine has large bearings that should be re-greased at least once every two years. If this isn't done, it will create resistance on the shaft of the turbine that causes the performance of the turbine to drop drastically.

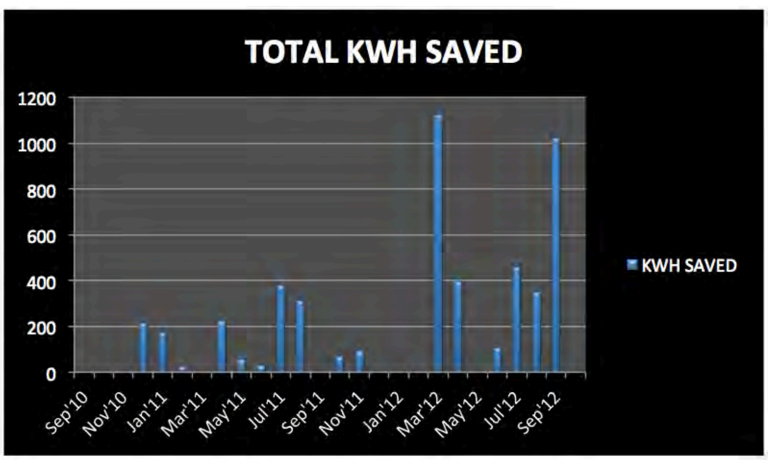
3. Some manufactured turbines have transmissions located inside of the turbine head. These transmissions work almost the same as the transmissions located in your average car. The transmissions typically need to be re-greased or re-oiled to operate as smoothly as possible. This prevents the gears from rounding themselves off from extreme heat and little lubrication. The turbines that were installed for GCCAC do not have transmissions. These turbines are direct-drive turbines so there is no need to change any gear oil.

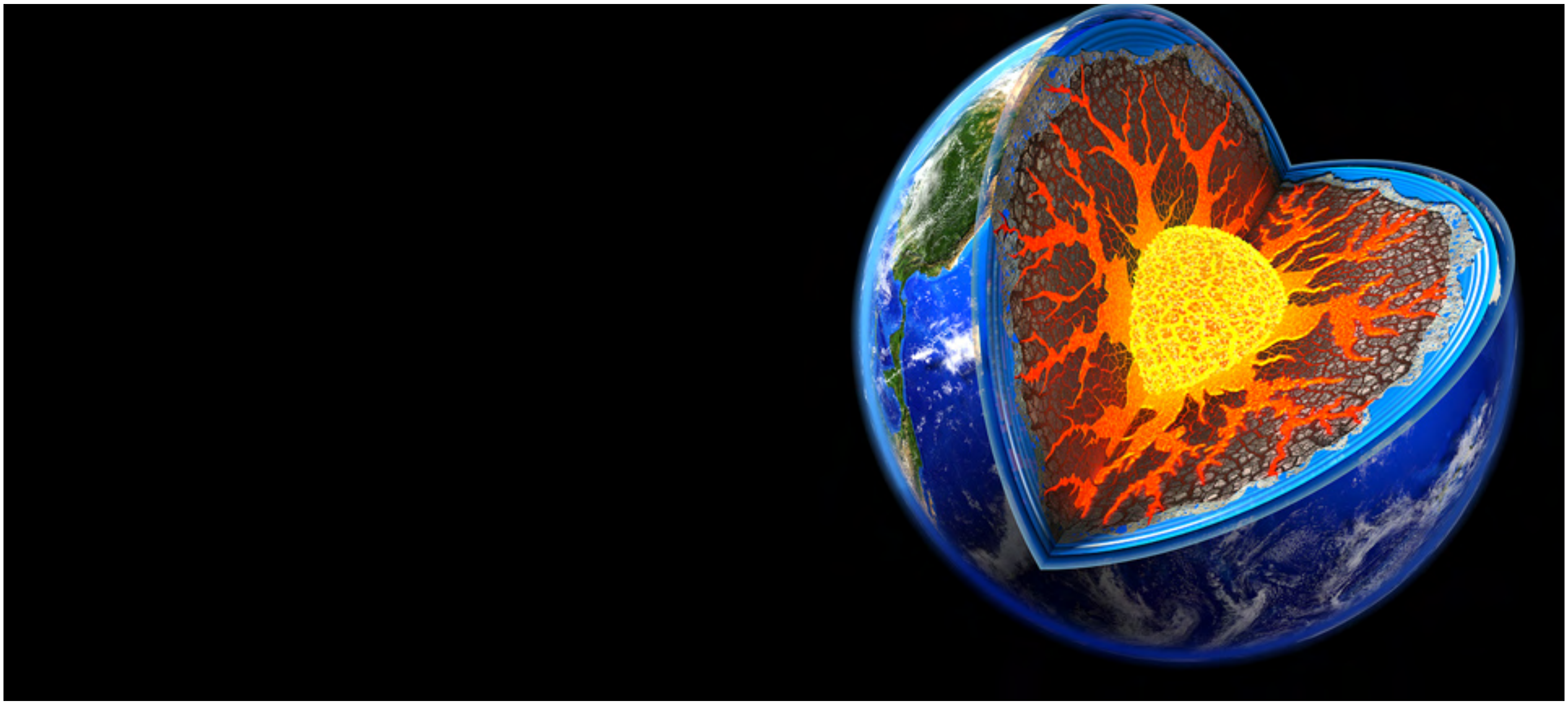
4. It is recommended to torque down the Yaw bolts (where the turbine meets the tower) to factory specifications. If all of these steps are taken a wind turbine system can last for up to 20 years. BITHENERGY only uses wind turbines that have a standard warranty of 5 years +. Some turbines even have a lifetime guarantee.

PERFORMANCE SUMMARY

Average System Cost: $23,270.00
Average KWh Saved: $1669.33
Average Savings: $175.28
Total KWh Saved: 5,008KWh
Average Utility Rate: $0.1050/KWh
Value of Electric Saved: $525.84

Period	KWH SAVED	Period	KWH SAVED	Period	KWH SAVED
Sep'10	0	Sep'11	0	Sep'12	1021
Oct'10	0	Oct'11	67	Oct'12	0
Nov'10	0	Nov'11	94		
Dec'10	213	Dec'11	0		
Jan'11	171	Jan'12	0		
Feb'11	23	Feb'12	0		
Mar'11	0	Mar'12	1121		
Apr'11	221	Apr'12	396		
May'11	52	May'12	0		
Jun'11	27	Jun'12	106		
Jul'11	379	Jul'12	459		
Aug'11	311	Aug'12	347		





Geothermal Systems

A ground source heat pump, or **geothermal system**, is nothing more than a series of interconnecting loops that work on the principle of the 2nd law of thermodynamics: "heat moves to cold."

- **Ground Loop** - This "loop" consists of piping buried in the ground in some manner. It can be vertical (bore holes), or horizontal (slinky loops), or even thrown in the bottom of a pond. A Water and Anti-freeze solution is circulated through the piping, through the use of typically 1 or 2 small circulator pumps. The fluid that passes through this piping is either much colder than the ground temperature in the winter (as the heat has just been removed the fluid inside the geothermal unit) or much warmer than the ground temperature in the summer (as the heat has just been added to the fluid inside the geothermal unit). If the fluid is colder than the ground, then the heat from the ground is transferred into the fluid, if the fluid is much warmer than the ground then the heat from the fluid is transferred into the ground. Ground loops may be installed in either a pressurized or a non-pressurized configuration.

- **Refrigerant Loop** - The fluid that has been circulated through the ground is now brought into the structure and into the geothermal unit. The fluid is now run through what is called a coaxial coil – this is nothing more than a tube inside of a tube. While the fluid that has been circulated through the ground is passing through one of the tubes, refrigerant (technically now R410a, generically 'freon') is passed through the other tube. Again the principle of the second law of the thermodynamics is utilized. The refrigerant is at either a much lower temperature (having just had its heat energy removed) than the fluid and id therefore able to absorb the heat from the fluid, or is at a much greater temperature than the fluid (having just had heat energy added to it) and is therefore able to reject its heat into the fluid. To make it simple, this refrigerant essentially has a very low boiling point, and therefore even when heated to just the 55 degree of so fluid coming in from having circulated through the ground, it is able to turn into a vapor. Once the refrigerant has changed states it is run through a compressor and then becomes a 'hot gas'

- **Distribution Loop** – Once the ground has heated the fluid, the fluid has heated the refrigerant, the refrigerant has changed state and been compressed the refrigerant is then passed through a heat exchanger of some sort. If this is going into forced air distribution then it is passed through an air coil that looks much like the radiator in your car. If it is a water distribution system then it is passed through another coaxial coil heat exchanger. With the forced air system, a blower pulls air from the house. The air is run over an air coil, which absorbs heat from the coil, or if the coil is colder than the air passing over it, the coil and refrigerant absorb heat from the air. The 'conditioned' air is then blown throughout the house. The same principle applies to the water to water unit applications.

- **Summary** - Fluid passing in the loop in the ground extracts heat from or rejects heat into the ground, refrigerant loop extracts heat from or rejects heat into the fluid in the ground loop, compressor section, changes state of refrigerant, distribution loop extracts heat from or rejects heat into the refrigerant loop, and then sends the heat out to the house or is extracting the heat from the house. (See Figure 4)

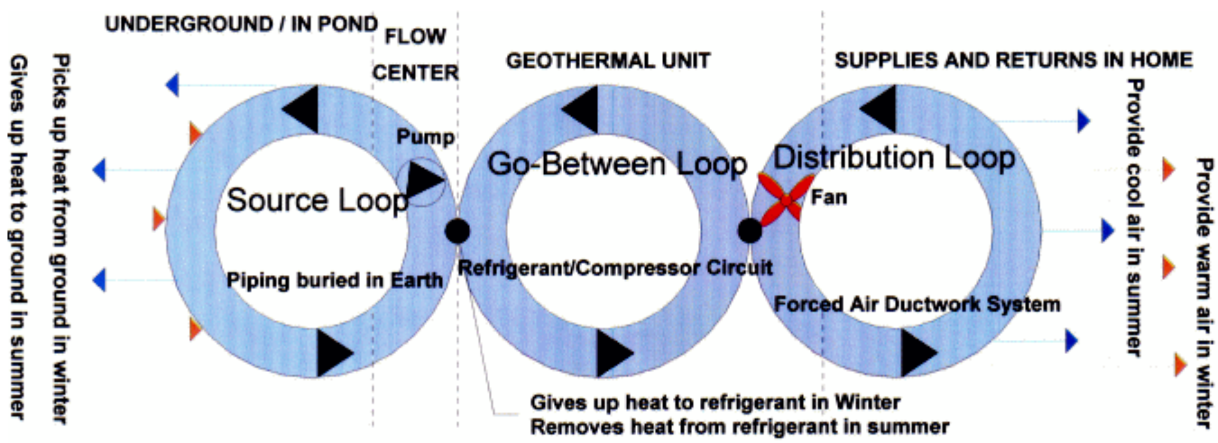
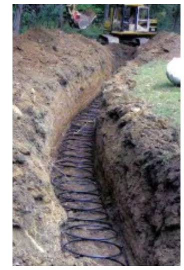


Figure 4

Types Of Loop Fields

- **Vertical Bore Holes** – Typically a 4 – 6" diameter hole drilled approximately 150 feet deep, usually containing ¾" or 1" HDPE pipe, that has a factory installed U-bend configuration at the bottom. The pipe is installed in the hole, and the hole is then filled back up with a bentonite grout to provide good heat transfer between the fluid in the pipe and ground surrounding it. Bore holes are typically installed at depths of 150 feet per ton on a 15 foot square grid.



- **Slinky Loops** - A slinky loop looks like a giant 'slinky' that has been stretched out and then is laid over flat on its side. Using either ¾" or 1" dia. HDPE pipe, roughly 750 feet of pipe is installed in 150 feet of trench. Trenches are dug approximately 3 feet wide x 150 feet long by 5 feet deep and the coil is laid flat on the bottom of the trench. 1 trench = 1 ton of system. The trenches need to have a minimum of 10 feet between them, but do not all need to be a straight line, they may curve around trees or go around corners.

- **Pond Loops** – A pond loop typically consists of about 300 – 400 feet of ¾" or 1" HDPE pipe that is laid out in a 'slinky' configuration then 'rolled' up into a 'ball'. Ideally the pond itself should be at least ½ acre in surface area and a minimum of 8ft deep. One 'slinky' ball equals one ton of system. NOTE: There are other loop configurations and methods for installation in ponds, like 'hyper-loops' and 'slim-jims'. While these have their place in larger residences and commercial structures, usually they are not as cost effective in small residential applications. Also note that the pond needs to be close to the home.

- **Open Loops** – An open loop system is where water is extracted from the ground, typically from a well, or a spring, or an artesian well, the water is run through the geothermal units coaxial heat exchanger and the water is discharged down a drain or another well or into a pond, etc. While these systems are highly efficient, as the incoming water temperature never changes, they are also extremely troublesome. Two things must be present for a 'good' open loop system:

    - Very good water quality – all equipment manufacturers have water quality specifications that must be met not only for the unit to function to its fullest capacity but also not to void the warranty on the unit.

    - Flow Rates – because an open loop system essentially extracts water from the ground uses and the dumps it out, it does not immediately replenish itself. Therefore an open loop system must be able to maintain a flow rate of 1.5 gallons per minute per ton of system 24 hours a day, 7 days a week, 365 days a year, etc. So, in the middle of August, when this 'well' is being used for your domestic water, your laundry, and your dishwasher, not to mention possible adding water to your pool, it has to have 1.5 gallons per minute still in 'reserve' or your air conditioning system will shut down.

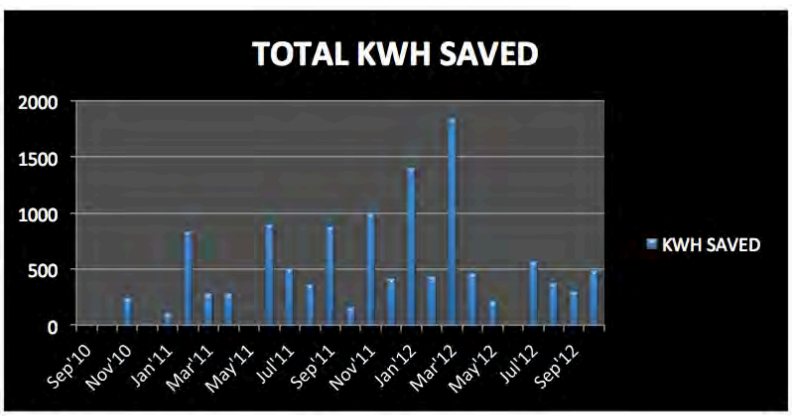
MAINTENANCE & LONGEVITY

Geothermal heat pumps are durable and require little maintenance. They have fewer mechanical components than other systems, and most of those components are underground, sheltered from the weather. The underground piping used in the system is often guaranteed to last 25 to 50 years and is virtually worry-free. The components inside the house are small and easily accessible for maintenance. Warm and cool air is distributed through ductwork, just as in a regular forced-air system. Since geothermal systems have no outside condensing units like air conditioners, they are quieter.

PERFORMANCE SUMMARY

Average System Cost: $37,198.18
Average KWh Saved: 2995.5
Average Savings: $314.52
Total KWh Saved: 11,982KWh
Average Utility Rate: $0.1050/KWh
Value of Electric Saved: $1,258.11

Period	KWH SAVED	Period	KWH SAVED	Period	KWH SAVED
Sep'10	0	Sep'11	872	Sep'12	295
Oct'10	0	Oct'11	152	Oct'12	486
Nov'10	236	Nov'11	994		
Dec'10	15	Dec'11	413		
Jan'11	100	Jan'12	1402		
Feb'11	835	Feb'12	428		
Mar'11	280	Mar'12	1840		
Apr'11	280	Apr'12	460		
May'11	0	May'12	210		
Jun'11	894	Jun'12	0		
Jul'11	505	Jul'12	563		
Aug'11	356	Aug'12	366		



Hybrid Hot Water Heating Systems

A hybrid water heater is a water heating system that integrates technology traits from both tank-type water heaters and tankless water heaters. The hybrid water heater maintains water pressure and consistent supply of hot water across multiple hot water applications, and like its tankless cousins, the hybrid is efficient and can supply a continuous flow of hot water on demand.

The hybrid approach is designed to eliminate shortcomings of other technologies. For example, hybrids are activated by either thermostat (similar to tanked) or flow (similar to tankless). Hybrids have small storage tanks that temper incoming cold water. This means hybrids only have to increase water temperature from warm to hot as opposed to tankless which has to raise completely cold water to hot. The defining characteristics of a hybrid water heater are:

- Combination of water flow of tank and efficiency of tankless of water heater
- Built-in small storage water reservoir as part of heat exchanger (typically between 2-20 gallons)
- Dual activation: flow sensing and thermostat control

Hybrid water heaters can be gas-fired (natural gas or propane), or be electrically powered using a combination of heat pump and conventional electric heating element. Gas hybrid water heater uses a modulating infrared burner that is triggered by water-flow or thermostat. The multi-pass heat exchanger drives heat down then recycles it through baffled pipes for maximum efficiency. Water fills the reservoir from the bottom up and spreads evenly around the heating pipes, producing continuous hot water with consistent pressure and temperature. During low-flow situations, the hybrid behaves like a tank-type heater by having minimum fixed fuel usage and thermostat activation. Although equipped with some storage capacity, the small volume minimizes standby fuel usage. Hybrids also share additional traits with tank-type heaters like a floor-standing installation, standard PVC venting, draining pan, and they can be installed with a recirculation pump for even more water efficiency.

During high demand, high-flow situations, hybrid technology behaves more like a tankless heater, with high BTU capacity and full modulation to supply a continuous stream of hot water across multiple applications. This produces fuel efficiencies similar to tankless heaters, but with higher flow capacity.

	Hybrid	*Tankless*	*Tank*
Fuel	*natural gas*	*natural gas*	*natural gas*
Material	*cast iron*	*copper*	*cast iron*
Efficiency	*average 86%*	*average 80%*	*average 60%*
Nitrous oxide emissions (PPM)	*5–30*	*30–40*	*60–90*
Carbon monoxide emissions (PPM)	*40–45*	*190–200*	*200–250*
Exhaust temp. (°F)	*128–155*	*390–410*	*480–500*

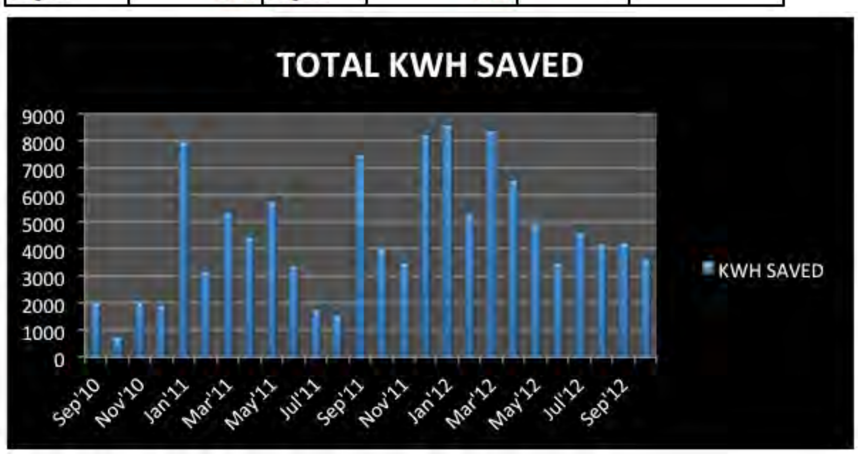
MAINTENANCE & LONGEVITY

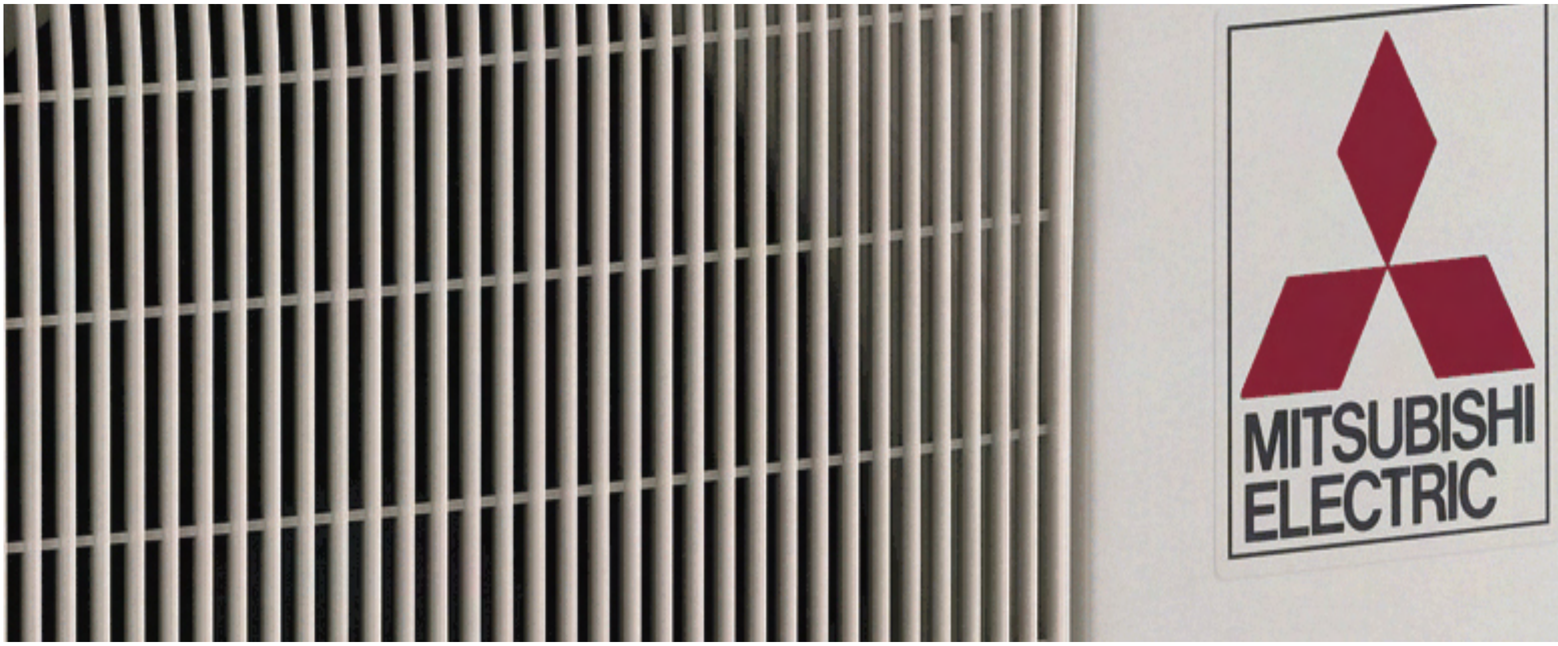
Hybrid hot water heating systems require no maintenance unless a problem occurs. Most hybrid hot water heating systems are warrantied for 5 years and are expected to last 20+ years and generally have the same longevity as your standard hot water heating system.

PERFORMANCE SUMMARY

Average System Cost: $2,636.20
Average KWh Saved: 5815.15
Average Savings: $610.59
Total KWh Saved: 116,303KWh
Average Utility Rate: $0.1050/KWh
Value of Electric Saved: $12,211.81

Period	KWH SAVED	Period	KWH SAVED	Period	KWH SAVED
Sep'10	1978	Sep'11	7456	Sep'12	4188
Oct'10	700	Oct'11	3986	Oct'12	3564
Nov'10	2024	Nov'11	3446		
Dec'10	1873	Dec'11	8227		
Jan'11	7957	Jan'12	8544		
Feb'11	3129	Feb'12	5254		
Mar'11	5329	Mar'12	8371		
Apr'11	4421	Apr'12	6534		
May'11	5727	May'12	4899		
Jun'11	3339	Jun'12	3444		
Jul'11	1708	Jul'12	4575		
Aug'11	1502	Aug'12	4138		

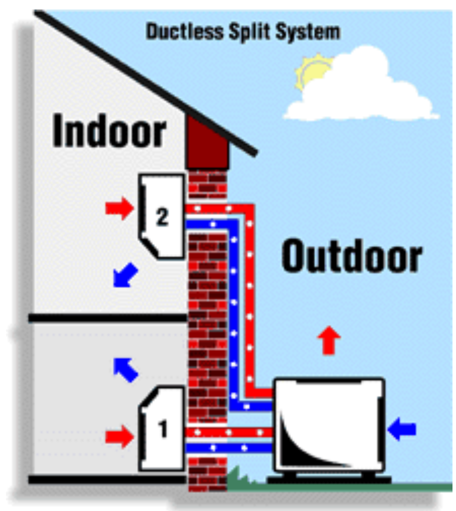




Split Ductless Systems

A ductless split system starts with a simple outdoor compressor. Like a traditional air conditioning model or heat pump, the air compressor provides the cooling and heating power needed by the rest of your home. However, because it has no ducts, you can control where that cool air is transferred.

One or a series of indoor units and refrigeration lines are used to transfer the cooled air from the outdoor compressor to the indoor units of your choice. It works in reverse with heated air in the winter. Units can be placed in any room you like and because each unit is individual, you control the specific temperature in that room instead of setting one thermostat for the entire house. As a result, you save money by cooling or heating only the space you are using. Mini-split indoor units are enough to keep most bedrooms comfortable, but full split units are generally needed for larger spaces.



Available in 1,2,3, & 4 Zones (2 Zone Shown)
Cooling Shown, also Available as Heat Pump

A ductless split system is a great option for a number of reasons. First, it allows you to install heating and air conditioning in homes that don't have ducts or space for them. Also, the refrigeration lines that run across your home for a ductless split system are inexpensive, quick to install and portable if you move to a new home. In general these systems are less expensive to install than other options and often they are also more energy efficient.

MAINTENANCE & LONGEVITY

Ductless splits may be simpler to install than a more traditional system with ductwork, but it should only be done by an expert who can measure the proper refrigeration lines, outline optimum positioning in each room, and ensure proper setup of the main compressor unit outside.

PERFORMANCE SUMMARY

Average System Cost: $13,000.64
Average KWh Saved: 8,674.60
Average Savings: $910.83
Total KWh Saved: 86,746KWh
Average Utility Rate: $0.1050/KWh
Value of Electric Saved: $9,108.33

Period	KWH SAVED	Period	KWH SAVED	Period	KWH SAVED
Sep'10	632	Sep'11	2954	Sep'12	3316
Oct'10	88	Oct'11	2161	Oct'12	2532
Nov'10	592	Nov'11	3709		
Dec'10	0	Dec'11	3982		
Jan'11	3940	Jan'12	6418		
Feb'11	2783	Feb'12	9996		
Mar'11	13339	Mar'12	7747		
Apr'11	368	Apr'12	3613		
May'11	1509	May'12	5901		
Jun'11	1424	Jun'12	1828		
Jul'11	1774	Jul'12	1727		
Aug'11	1197	Aug'12	3216		

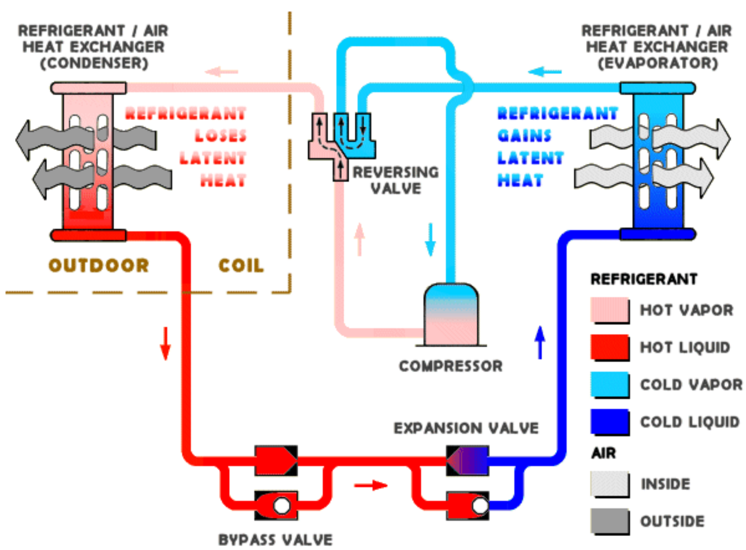
ASHP Systems (Air Source Heat Pumps)

A heat pump's refrigeration system consists of a compressor and two coils made of copper tubing (one indoors and one outside), surrounded by aluminum fins that aid heat transfer. In heating mode, liquid refrigerant in the outside coils extracts heat from the air and evaporates into a gas. The indoor coils release heat from the refrigerant as it condenses back into a liquid. A reversing valve, near the compressor, can change the direction of the refrigerant flow for cooling as well as for defrosting the outdoor coils in winter.

When outdoor temperatures fall below 40°F, a less-efficient panel of electric resistance coils, similar to those in your toaster, kicks in to provide indoor heating. This is why air-source heat pumps aren't always very efficient for heating in areas with cold winters. Some units now have gas-fired backup furnaces instead of electric resistance coils, allowing them to operate more efficiently.

The efficiency and performance of today's air-source heat pumps is one-and-a-half to two times greater than those available 30 years ago as a result of technical advances such as the following:

- Thermostatic expansion valves for more precise control of the refrigerant flow to the indoor coil
- Variable speed blowers, which are more efficient and can compensate for some of the adverse effects of restricted ducts, dirty filters, and dirty coils
- Improved coil design
- Improved electric motor and two-speed compressor designs
- Copper tubing, grooved inside to increase surface area.



Most central heat pumps are split-systems -- that is, they have one coil indoors and one outdoors. Supply and return ducts connect to a central fan, which is located indoors. Some heat pumps are packaged systems. These usually have both coils and the fan outdoors. Heated or cooled air is delivered to the interior from ductwork that passes through a wall or roof.

MAINTENANCE & LONGEVITY

As the marketplace for these systems has grown over the past couple of years in both the UK and continental USA, It has become increasingly apparent that problems in these systems occur due to the progressive degradation of the glycol-based thermal fluid. Glycols will slowly break down due to the chemical action of either heat or light. Glycol can also be degraded in much cooler conditions by the action of bacteria, which use glycol as a food source. Whether broken down by chemical or biological action, degraded glycol takes on an unpleasant and distinctly unhealthy appearance. It progressively discolors and becomes thicker and more viscous. This makes it more difficult to pump. Air source heat pumps then have to work harder, to the point where this outweighs the energy efficiency of the system in the first place. The freezing point of the fluid also rises as it degrades, meaning a progressive loss of frost protection for the system. By this stage things are going rapidly downhill. In order to fix this the system is simply just flushed of all fluids and refilled with manufacture recommended replacements. The expected life of an ASHP system is 20+ years.

PERFORMANCE SUMMARY

Average System Cost: $21,358.42
Average KWh Saved: 6030.71
Average Savings: $633.22
Total KWh Saved: 42,215KWh
Average Utility Rate: $0.1050/KWh
Value of Electric Saved: $4,432.57

Period	KWH SAVED	Period	KWH SAVED	Period	KWH SAVED
Sep'10	42	Sep'11	1444	Sep'12	3316
Oct'10	336	Oct'11	1615	Oct'12	762
Nov'10	387	Nov'11	2239		
Dec'10	4435	Dec'11	2127		
Jan'11	3280	Jan'12	866		
Feb'11	1569	Feb'12	579		
Mar'11	1717	Mar'12	276		
Apr'11	2083	Apr'12	220		
May'11	1238	May'12	643		
Jun'11	1029	Jun'12	2074		
Jul'11	1233	Jul'12	2184		
Aug'11	2889	Aug'12	3632