

DESIGN



ASSESS



CONTROL



Equinox House 2012 Report

Ty Newell; January, 2013

Equinox House, a 100% solar powered home with rainwater harvesting, is located in Urbana Illinois. Construction was completed in the fall of 2010, with occupancy in November, 2010. This report summarizes performance aspects of Equinox House during 2012, its second year of occupancy. In addition to being the home for Deb and Ty Newell, Equinox House serves as a demonstration of the economic viability of renewable energy powered residences in challenging climates.

Newell Instruments, Inc, an engineering R&D firm (Newellinstruments.com) located in Urbana IL, designed Equinox House based on the objective of creating an economical, sustainable, comfortable, and healthy dwelling. This design philosophy results in a higher quality residence that has lower lifetime costs when compared to a modern, conventionally constructed home. A homeowner's monthly expense is lowered and more money is spent locally for labor and materials. Lending institutions also benefit directly through additional mortgage income and indirectly through the creation of local employment opportunities. Because utility bill vicissitude is replaced by stable mortgage payments, lending institutions' financial risks are also reduced.

Newell Instruments formed a new business unit in 2012 named "Build Equinox" (BuildEquinox.com). The mission of Build Equinox is to work toward creating healthy and comfortable living environments that are sustainable and economically superior to current housing stock. Build Equinox has three products entering the market in 2013:

1. [ZEROS™](#) (Zero Energy Residential Optimization software, an online residential design tool)
2. [Black Box IAQ™](#) (indoor air quality and comfort condition assessment test for interior spaces)
3. [CERV™](#) (Conditioning Energy Recovery Ventilator; an Underwriters Laboratory listed, advanced fresh air conditioning system for residences)

Health and Comfort

Equinox House has been designed to provide exceptional comfort with excellent indoor air quality at all times and in any type of weather. Comfort and air quality are the primary objectives of Build Equinox design projects. The CERV™ fresh air conditioning system, coupled with an advanced air-source heat pump, provides fresh air to the living areas of Equinox House while simultaneously purging air from the "wet", odorous areas of the home (kitchen, bathrooms and laundry room). A Black Box IAQ™ comfort and air quality assessment report for Equinox House during a week in December, 2012 is attached with this annual summary.

Our BB IAQ™ monitors temperature, humidity, carbon dioxide concentration and VOC (Volatile Organic Compound) concentration every 5 minutes over a one week period. Comfortable conditions (based on the definition of comfortable temperature and humidity as defined by the American Society of Heating, Refrigeration and Air Conditioning Engineers) were maintained 100% of the time in Equinox House during the December test period. The CERV™ fresh air conditioning system in Equinox House maintains air quality in an energy efficient manner throughout the year. Average carbon dioxide and VOC concentrations were maintained below 1000ppm (parts per million). Radon levels, obtained from a certified radon test laboratory, averaged 1.2picoCuries per liter, a very low level in comparison to many Illinois homes.

Water

Equinox House became the first home within an Illinois municipality to receive permission from the Illinois Department of Public Health for utilizing rain water indoors. Build Equinox engineers designed the rain water harvesting system and the adjacent rain garden overflow area. Monthly monitoring of untreated rainwater in the Equinox House cistern has shown minimal biological activity over its two years of operation. The rain water harvesting system also collects dew and frost water, which provides an additional 200 gallons per month to the system during the "dewier" and "frostier" months of the year.

To date, nearly 20,000gallons of rainwater and dew/frost have been collected, totaling 40 percent of Equinox House water requirements. Figure 1 shows the accumulated rainwater collection over the past two years. No makeup water has ever been added to the Equinox House cistern, even with severe drought conditions during the 2011 and 2012 summer months, indicating that rainwater harvesting is a viable technology for central Illinois.

Figure 2 is a plot of bacterial activity. Untreated water quality is excellent, with all monthly readings except one being free of *e coli*. During October, 2012, high levels of both general coliforms and *e coli* were measured. The bacteria levels were similar to the level measured in water collected from the adjacent rain garden immediately after a heavy rain with cistern overflow. We discovered that the air flow gap between the cistern's overflow pipe and the rain garden spillway was blocked with grass and leaf debris, allowing water to pool around the overflow pipe outlet. The air gap was cleaned, and after a few rains without any sanitizing treatment to the cistern, *e coli* completely disappeared and the general coliform population returned to previously measurement levels.

The State of Illinois is currently working on developing rainwater collection and usage guidelines that may be ready for release during the summer of 2013. Atlanta Georgia passed regulations during the fall of 2012 allowing homeowners to collect rainwater for household usage. Hopefully the Illinois legislation is a balanced approach encouraging household use of rainwater while providing sufficient guidelines for helping the public to keep their water safe.

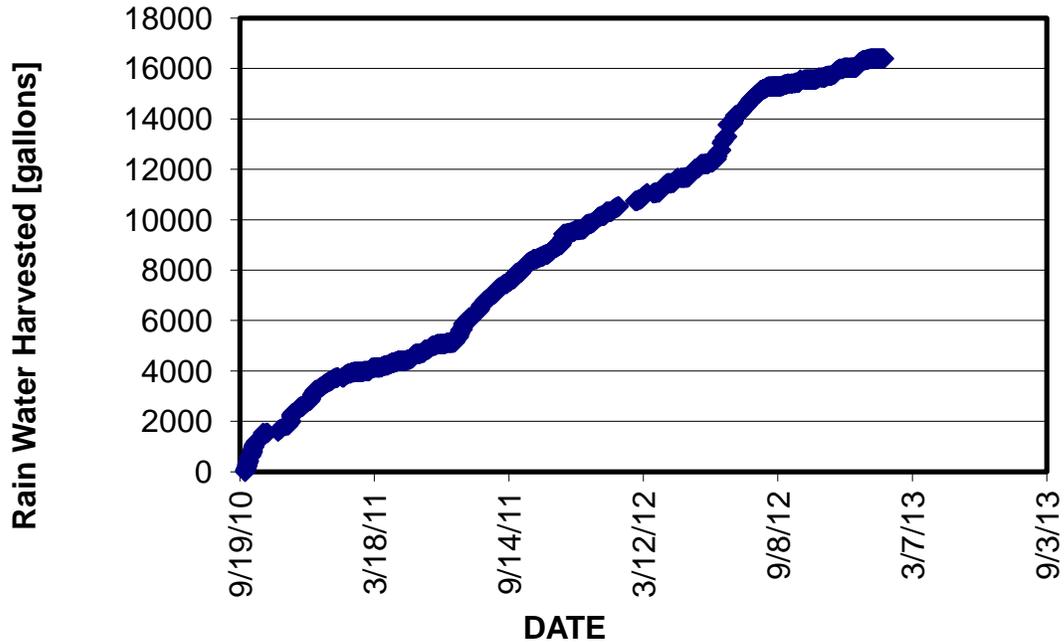


Figure 1 Rainwater usage in Equinox House since September 2010.

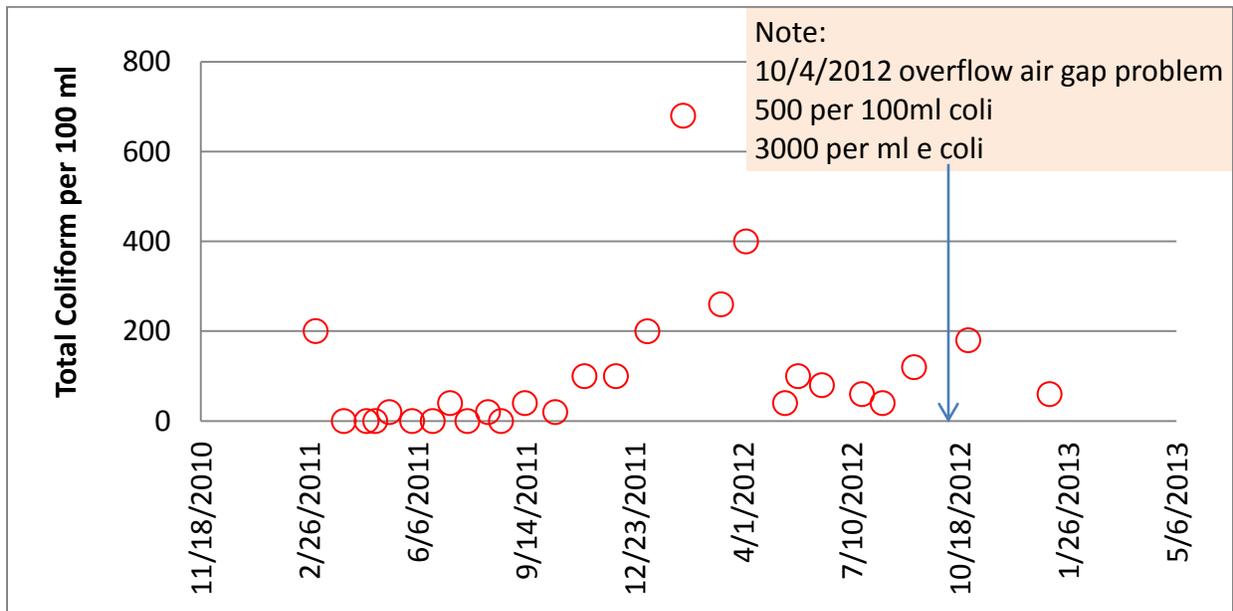


Figure 2 Total coliform test results from Equinox House untreated cistern water.

Equinox House Energy

Economically optimizing energy interactions during the engineering design phase of Equinox House resulted in a cost effective, energy efficient home with all of the conveniences expected in a modern house. Figure 3 below shows the monthly breakdown of electrical energy usage in Equinox House. Overall, Equinox House required 6940kWh of electrical energy during 2012, significantly less than a comparable home of equal size (2100 sqft) in central Illinois. Many of the design features of Equinox House are described in a 12 month article series authored by Ben Newell and Ty Newell for the ASHRAE Journal (American Society of Heating, Refrigeration and Air Conditioning Engineers). Free access to these publications is available through the [BuildEquinox.com website](http://BuildEquinox.com).

July's energy usage is low because Deb and Ty were away for half of the month, picking up their Ford Focus electric vehicle in New York. Equinox House was kept "comfortable" as we continued to collect data during this time period.

Figure 4 compares the average daily energy requirement for each month of the year of Equinox House to the actual energy usage of five other modern (built since 2000) homes in the Urbana area. A combination of better insulation, better sealing of the building envelope, and proper design and placement of windows are the three keys to achieving high performance.

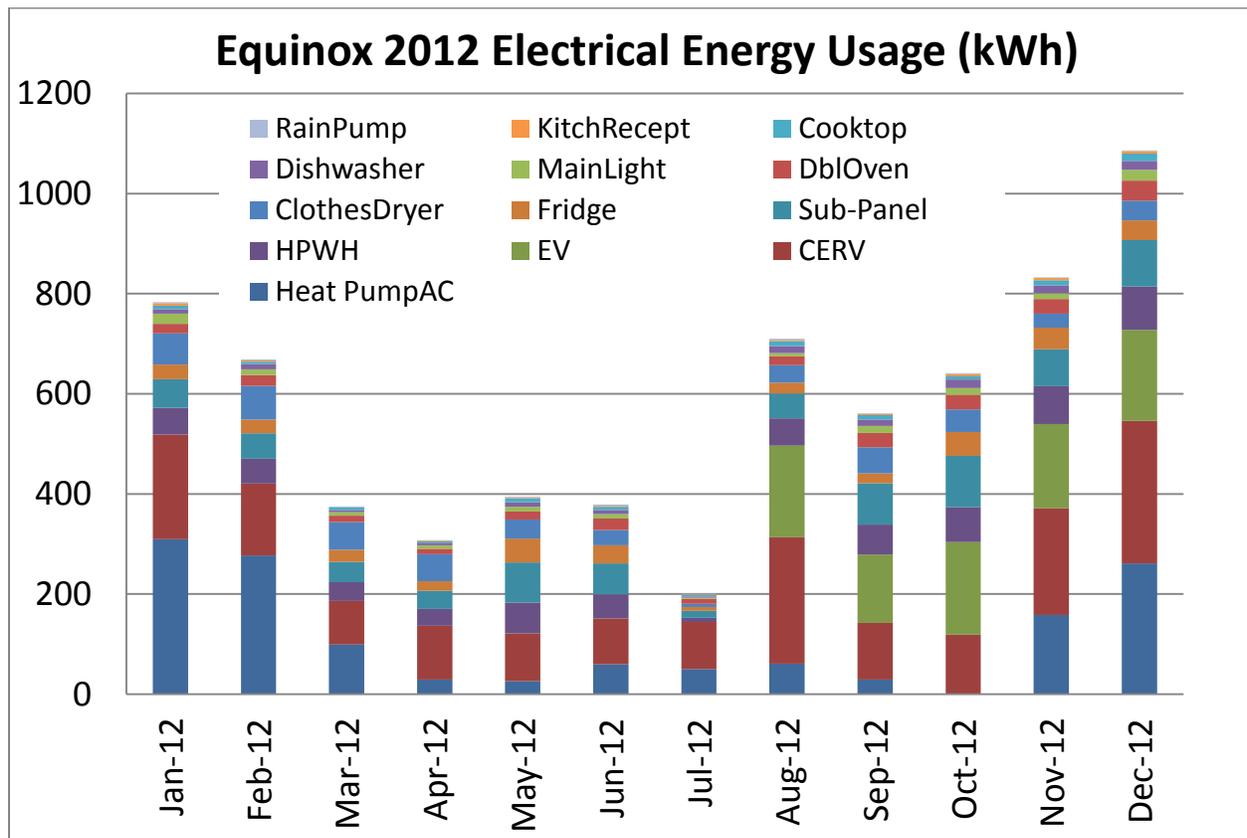


Figure 3 Equinox House (Urbana Illinois) monthly energy usage for 2012.

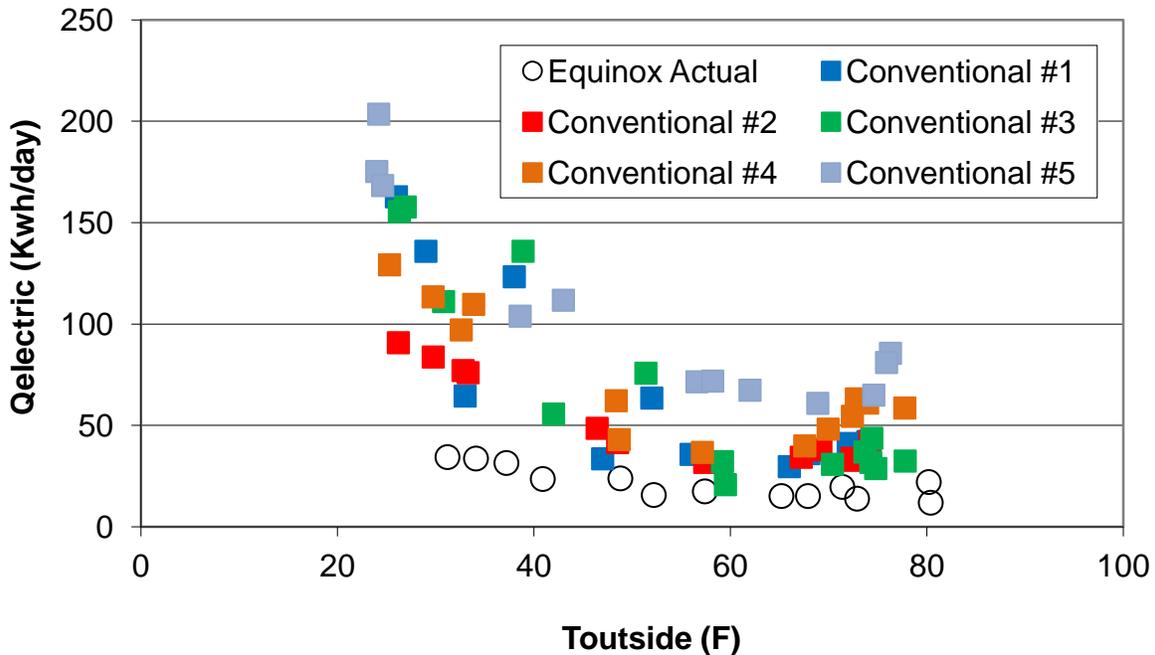


Figure 4 Comparison of actual Equinox House energy requirements with actual data for 5 modern, conventionally constructed homes in Urbana, IL. All homes are all-electric. Note that Conventional homes #1 and #5 have "ground source" (also called "geothermal") heat pumps.

Note that as an all-electric home, Equinox House saved \$10,000 of cost by not installing natural gas service. Installation of natural gas service, piping, and flues would cost \$5000, and the monthly customer service fee over 20 years costs \$5300 in our area. An additional indirect cost savings is realized because of fewer drafts and leaks caused by natural gas flue vents. The \$10,000 savings represents 50% of the \$20,000 installed cost of the solar PV system that supplies 100% of Equinox House annual energy needs.

In addition, eliminating natural gas from home usage results in better indoor air quality, reduction of respiratory illness "triggers" associated with natural gas combustion, elimination of an indoor source of carbon monoxide poisoning, elimination of potential natural gas explosions, and minimization of an important contributor to global warming. Natural gas is an important bridge to a fossil free future, but it has better uses and is not economically competitive in new, energy efficient homes.

Solar Energy

Many people worry about the unreliable nature of solar energy. We are happy to report that the sun did report for duty every day over the past year, appearing promptly at the predicted time for sunrise, and punching out each day at the appointed sunset time. During cloudy days, we celebrated the sun as well, because this meant water for our cistern. Again, the sun is always working for us if we let it do so.

To add some perspective to the value of our rain, the continuous power of 100 large (1000MW) nuclear or coal power plants would be needed to distill, transport, and condense fresh water from far away oceans in order to supply Champaign County Illinois (an area of approximately 30 miles by 30 miles) with its expected 36 inch annual precipitation.

The solar PV (photovoltaic) system has performed reliably with no problems over its three years of operation (switched on February 23, 2010; energy from the ground mount solar system with its energy used for building Equinox House....see our ASHRAE J article that describes how much energy is required to build a home, and that a solar energy collection system for powering the home has more than enough capacity to build it, too).

The solar energy system is "grid-tied", in which excess energy collected during daytime periods is fed into the utility grid. The utility benefits by selling the excess solar energy at a higher cost to other customers. During the evening and the winter, when Equinox House draws energy from the grid, the utility also benefits as these are low demand periods when it is looking for more customers.

Figure 5 shows the solar energy collection since February 23, 2010, with over 35,000 kWh of energy collected (approximately \$3500 worth of electrical energy). Figure 6 is a plot of the difference between solar energy collected and the electrical energy used by Equinox House. Equinox House has always and will always be fully solar powered. To date, an excess production of nearly 10,000kWh has accrued. Three primary reasons for the excess solar energy production are:

- 1) Equinox House is designed for solar powered transportation with an electric vehicle (EV), which was unavailable for purchase until the summer of 2013 (see following section)
- 2) The solar system on Equinox House has collected 15% more solar energy on average (11,820kWh actual collection vs 10,310kWh predicted) than predicted. Part of the additional solar energy collection is due to the reflection from the white north roof on Equinox House to the ground mount solar collector array
- 3) The 2011/2012 winter was unseasonably warm with much lower winter heating loads

All indications are that Equinox House will continue to supply the grid with some excess energy. Let's just consider that a small payment toward a large debt we owe to future generations.

Figure 6 marks locations where the transition from fall to winter and winter to spring occurs. The transition marking energy deficit (winter) and energy surplus (summer) times of year are quite sharp. Also marked on Figure 6 is the time when we acquired our Ford Focus EV. The net solar energy gain is reduced after the Focus arrived, due to an average of 6 to 7 kWh per day of additional energy usage.

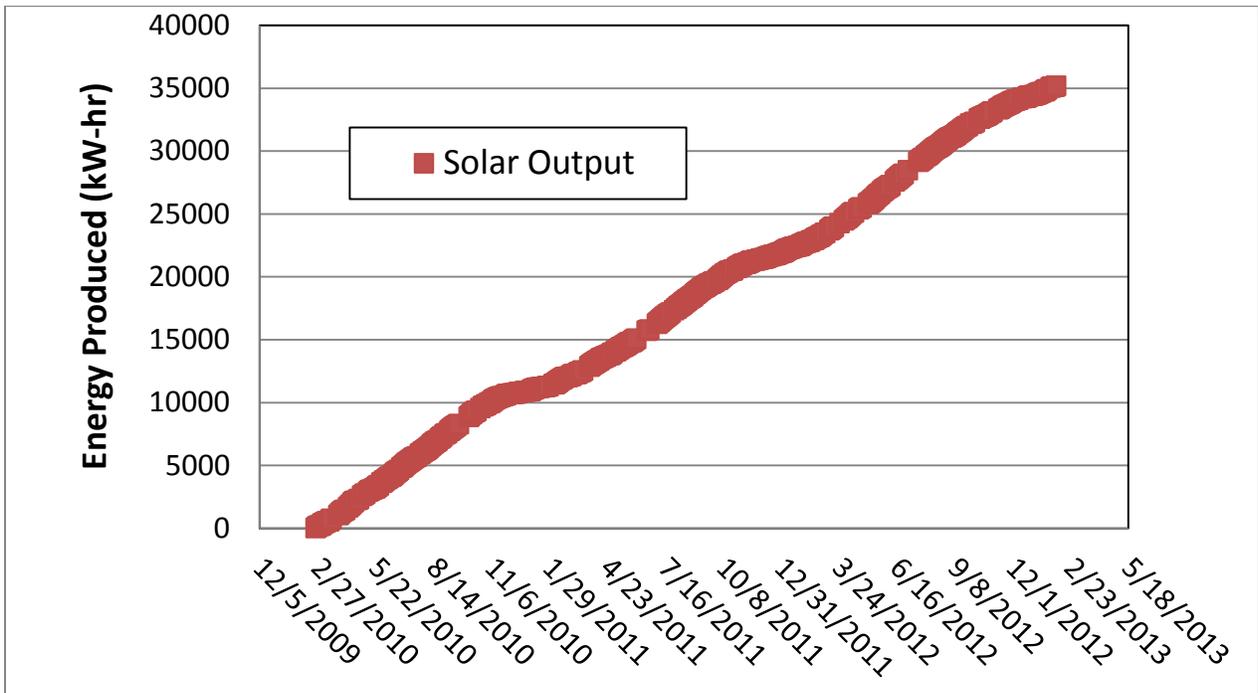


Figure 5 Equinox House solar array output since being turned on February 23, 2010.

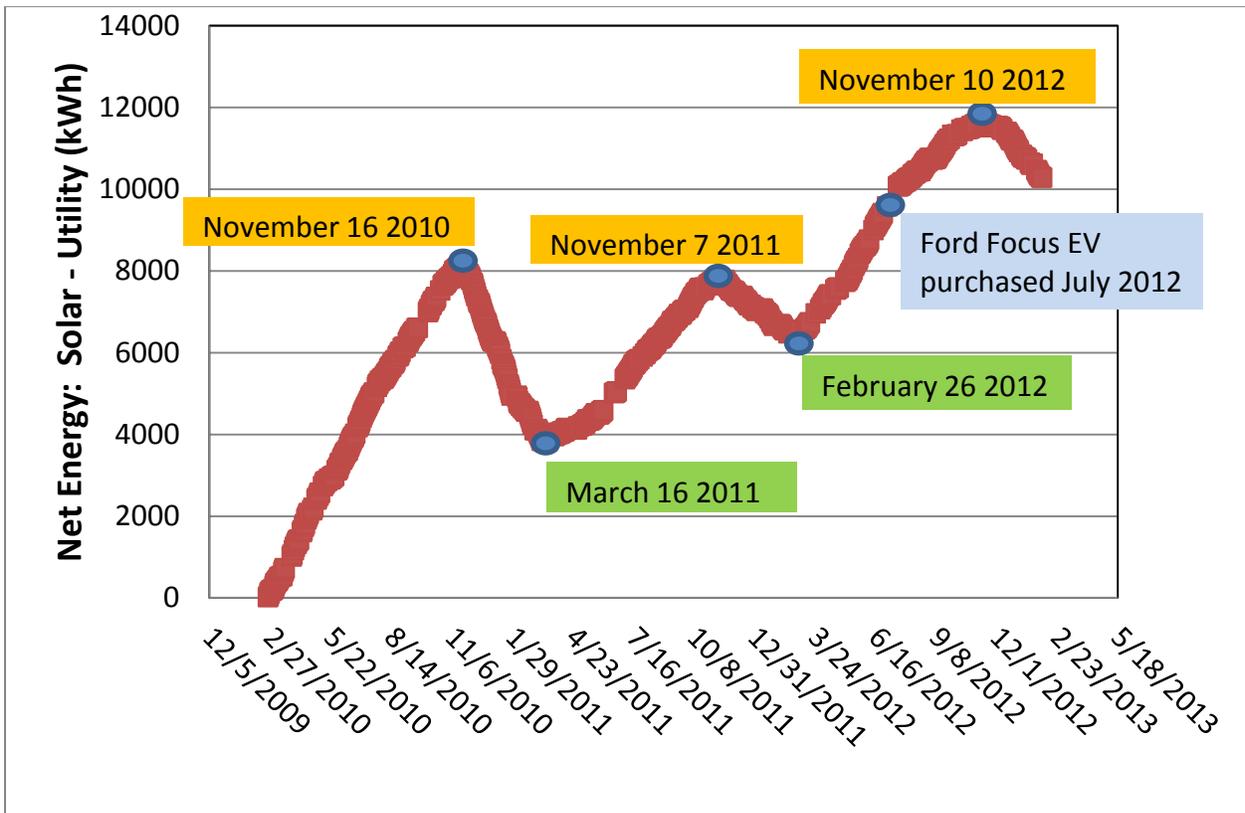


Figure 6 Net difference between Equinox House solar energy collection and utility energy usage.

Solar Powered Transportation

We had been anxiously awaiting the availability of electric vehicles to complete Equinox House. As you may have read in some of our other papers and presentations, electric vehicle transportation is a game changing technology.

The cost of solar generated electricity at Equinox House is 12.5 cents per kWh (see our [ASHRAE J paper](#) on solar energy system cost), which results in 3 to 4 cents per mile transportation energy cost. Compare this cost to the average gas vehicle. The current fleet average for US vehicles is approximately 30 miles per gallon. Assuming \$3.50 per gallon for gasoline, this is a cost of 12 cents per mile. At 100,000 miles, a gas vehicle costs \$8000 to \$9000 more than a solar powered EV for its energy. But it gets even better as EVs require no oil changes for another savings of \$600 to \$1000, plus a savings of your time and effort. And even better as there is no exhaust system to replace and most likely, if you are an efficient driver, no brake replacements as these cars will completely stop by electric regenerative braking. Most drivers spend 12 hours of their life per year inhaling toxic fumes in horrible weather at a gas pump. With an EV, it is plugged in at night like your cell phone.

Figure 7 shows the distance driven and the energy used in our Ford Focus EV since August, 2012. All EV transportation energy is included in the net solar to utility energy balance shown in Figure 6. The car was purchased in March 2012 as soon as the Focus EV became available, and we picked up the car on July 2, 2012 from a Long Island NY dealership. Deb and Ty drove the car home, with a stop in Detroit to visit Ford's Michigan Assembly Plant (the plant is the site of one of Michigan's largest solar power systems, so the car was partially built from solar energy). You can read more about Deb and Ty's recreation of Roy Chapin's historic 1901 journey from Detroit to New York City on their blog at: FocusOnSolar.com.

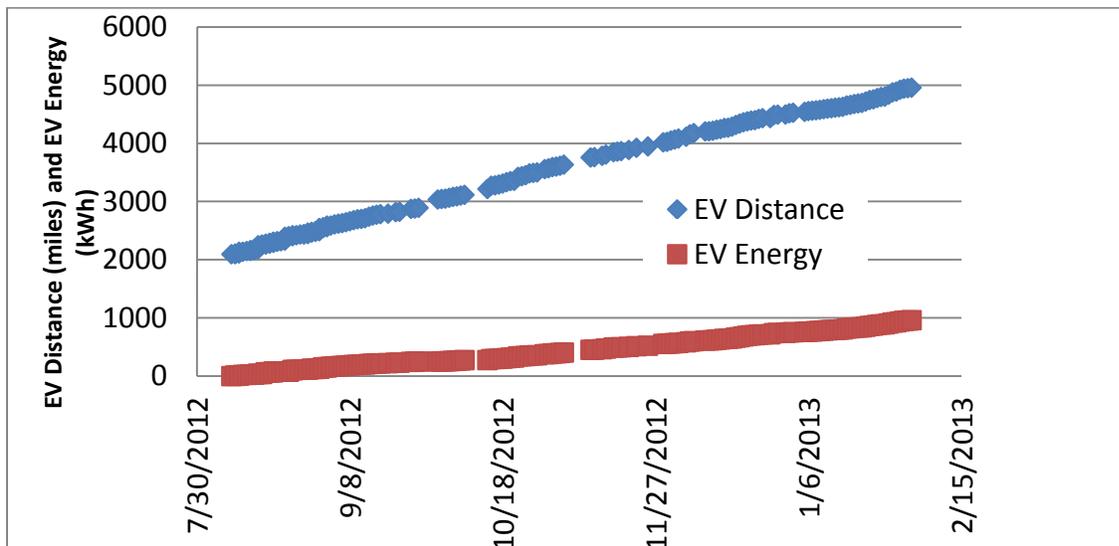


Figure 7 Sun Catcher (Ford Focus EV) miles driven since August 2012, and electric energy supplied by Equinox House for Sun Catcher transportation.

Summary

We hope this information provides you with the knowledge and confidence that living on our daily allowance of solar energy is real, economical, and does not require waiting for any technological advancements or political action. Our research, data collection and analyses are derived from our real-world experience.

Periodically check our website (BuildEquinox.com) for continuing developments and additional information. Learn how to use our free, online [ZEROS™](#) modeling software to improve your home or to design a new home that is powered by the sun.

Living on solar energy does not mean a decrease in quality and convenience. In fact, designing more intelligently results in the opposite as Equinox House continues to demonstrate. It has all the conveniences one expects in a modern home, with the added bonus of exceptional indoor air quality and comfort every hour of every day throughout the year.

And, maybe you will sleep a bit easier knowing that you have made a positive contribution to future generations who have no say in what we do, but will pay the price for our poor behavior.

