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Preliminary Performance Evaluation of a Near Zero Energy Home in Gainesville, Florida

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Introduction

The U.S. Department of Energy's Building America (BA) program is working to increase the energy efficiency of new and existing homes while increasing comfort, and durability and reducing resource use. As part of this program we pursue opportunities to research highly efficient homes with the goal of understanding what works, what doesn't work, and the most economic ways to reach very high efficiency targets. The program aims to create cost neutral zero energy homes by 2020. In pursuit of this goal, this home and other research homes around the country designed to approach or achieve the zero energy goal are being built and studied.

The performance summary on a near zero energy home (NZEH) presented here was a result of collaboration between the Florida Solar Energy Center (FSEC), the Florida H.E.R.O., an innovative developer and builder in Gainesville, Florida under the auspices of the U.S. DOE sponsored Building America Industrialized Housing Partnership (BAIHP) project . This paper briefly reviews the design and then focuses on the first half year energy performance of the project home during the second half of 2008.

In general, a zero energy home is designed to produce as much energy as it consumes over the course of a full year. The BA program definition is more specific: A zero energy home is designed to offset as much source energy as it consumes over a typical year (based on TMY3 data) using BA Benchmark assumptions for typical occupant behavior. To achieve zero energy the home exchanges energy with the utility power grid. It delivers energy to the grid when the photovoltaic (PV) system is producing more energy than is being used in the home and draws from the grid when the PV system is producing less energy than needed in the home.

The particular project here is termed "a Near Zero Energy Home" (NZEH) with the intention that it provide 70% of its annual electrical energy and 62% of its annual site energy requirement (including natural gas) when evaluated over a full year. This project is a case study of reaching near the zero energy goal within a hot humid climate in a more cost effective manner than in earlier efforts.

NZEH Design

When Building America became involved in the project, the lot orientations were already determined and could not be altered – the primary reason for the solar systems on the West roof. The energy analysis of the single story home, shown in Figure 1, was performed using *EGUSA* software (Parker, et. al. 1999) to achieve a building that would have a 70% reduction to annual energy use relative to a Benchmark building in the same climate. This engineering approach was developed in partnership with the developer and builder in Gainesville, FL. The 1,770 ft^2 home specifications are summarized in Table 1.

Figure 1. Near Zero Energy Home in Gainesville, FL as viewed from the southwest.

Table 1. Summary of Gainesville NZEH Attributes

Square footage	1772 ft^2; single story construction
Number of bedrooms	3 bedrooms, 2 baths
Number of occupants	2 adults
Design heating load Design cooling load	21,500 Btu/hr 15,100 Btu/hr
Walls	2 x4" walls with 3.5" of cellulose Nominal R-value = 13 hr ft^2 F/Btu
Ceiling/Roof	IR reflective metal tile roof (Solar Absorptance= 0.65) Radiant barrier under roof deck with 1:300 attic ventilation Ceiling insulation R value = 30 hr ft^2 F/Btu
Floor	Uninsulated slab floor 80% tile floor for passive earth contact cooling
Windows	274 ft^2 (15.5% glazing); Low-e, low SHGC U = 0.34 Btu/hr ft^2 F, SHGC = 0.28
Miscellaneous Electric load control	None
Occupant Energy Information	Real time energy feedback installed in home (T.E.D.)
Water heating Solar water heating	Drainback closed-loop gycol solar system facing west, 5/12 tilt 80 ft^2 AET-40 collectors with 120 gallon storage tank Auxiliary electric water heater for backup (EF= 0.90)
Ducts	Very low duct leakage tested Qn=0.022; all ducts in conditioned space framed out below ceiling
Space heating Space cooling	Fully condensing natural gas furnace (AFUE=0.94); *Carrier 58MVB060* SEER 19 two speed, 2-ton air conditioner (*Carrier 24ANA124A300)*
Lighting	Hard wired fluorescent and compact fluorescent throughout the house (owner provided with replacement CFLs, 92% lights are CFL's)
Appliances	*Energy Star Whirlpool* clothes washer *(WFW 83005)*, dishwasher *(DU850SWP)* and refrigerator *(GR25HWXPB02)*. Natural gas dryer and range.
Solar electric	Nominal 3.150 kW_p DC photovoltaic system (Conergy S 175MU modules) with 94% efficient SMA 3300 inverter; west facing (azimuth= 270)
Infiltration/Ventilation	Tight construction: tested leakage of 3.1 ACH @50 Pa pressure; Low noise, high efficiency bathroom fans, supplemented by 29 cfm of runtime whole house mechanical ventilation and dedicated kitchen ventilation
HERS Index for the house	29

Figure 2: Interior duct system showing roughed in ducts and framing details.

Figure 3. Finished interior duct system passing over kitchen area.

The envelope of the home is a single stud wall design 16" on centers with ladder T's and blown cellulose (R-13 hr/ft^2-F^o/Btu). The attic ceiling has R-30 blown cellulose insulation. Although the slab floor is uninsulated, we chose to use an 80% tile flooring to take advantage of passive cooling from the earth contact portion of the building.

Figure 4. Eighty percent tile floors in the NZEH home improves earth contact cooling.

Figure 5. R-30 cellulose attic insulation, radiant barrier vented attic and R-6 flex duct.

The single-story home is designed to largely reject solar gain in Florida's hot humid climate. Two foot overhangs are used around the plan. The windows are double-glazed low-e with vinyl frames. An IR reflective metal shingle roof with a solar absorptance of only 65% is used to reject heat from the top of the building. An attic radiant barrier is used underneath to provide additional reduction to attic heat gain. The attic is normally ventilated (1:300 vent ratio) with both soffit and off-ridge vents.

With these shell efficiency features, the peak design heating load for the home is small – about 21,500 Btu/hr (5.3 kW). This load was met using a 56,000 Btu/hr natural gas furnace (*Carrier 58MVB060*) with an AFUE of 94%. The design cooling load was even lower: 15,100 Btu/hr with the cooling load addressed by a two-ton SEER 19 Btu/Wh, two-stage air conditioner (*Carrier 24ANA124A300*). The matched *CNPVP3617A* air handler includes a variable speed blower with a brushless DC motor.[1] The combination has an EER of 13.9 Btu/Wh at the 95/80/67 ARI rating condition.

All mechanical equipment is contained within this thermal envelope.Within the construction, the ducts were located underneath the insulation on the interior and thus within the insulated envelope. The air handler is located in an interior utility room. Water heating is accomplished using a solar thermal system and 120 gallons of water for thermal storage. The solar system has 80 ft^2 of collector area which faces west because of the building orientation. The solar water heating system was sized to provide a high solar saving fraction year round, and a drainback configuration is used to prevent the need for a glycol loop and heat exchanger.

The grid-tied solar electric PV system consistes of eighteen 175-Watt *Conergy S175MU* modules connected to an *SMA 3300* inverter. Due to the home's lot orientation and available roof space, the roof-mounted PV and solar DHW systems face west.

[1] Full details and performance map of the air conditioner, air handler and furnace unit can be found on the internet: http://www.docs.hvacpartners.com/idc/groups/public/documents/techlit/24ana1-2pd.pdf

Figure 6. SEER 19 AC system on east side of home with grid-tied SMA inverter in background.

Data Acquisition System Design

A data acquisition system was installed to determine if the home met its energy design goal of near zero energy. The system was designed to allow disaggregation of the PV energy production and some end uses. A summary of the data points and the equipment used is given in Table 2.

Data were collected on 15-minute intervals. A dedicated website was created to aggregate daily and monthly averages and sums and to create graphics on the performance of the home for daily troubleshooting (www.infomonitors.com/nzg). All electrical end use measurements were in place by August 2008. However, the water flow and natural gas end use monitoring will not be complete until March 2009. This report summarizes preliminary data from the project from July – December of 2008. Long term data will be collected on the project over the next year through spring 2010.

Table 2. Measurements and Components of the Data Acquisition System

Measurements	Component
Electrical energy measurements House total power Heat pump compressor power Air Handler power Heat pump pump power DHW power	Pulse output watt-hour transducers
Natural gas measurements	
Space heat Total gas consumption	Diaphragm gas meters with pulse output
Temperatures & humidity	Temperature & RH transmitter
Ambient air Indoor air temperature Indoor relative humidity Inlet water temperature Solar from system Return air temperature & humidity Supply air temperature & humidity	Capacitive type hygrometer Type T thermocouples
Water flow	
Hot water use	Positive diplacemnent flowmeter
Weather related measurements	
Outdoor temperature and RH Solar radiation - horizontal Solar radiation - plane of collectors	T&RH sensor w/shield Pyranometer Pyranometer
Data Logging Equipment	
	Campbell data logger
Communications	
	Thermocouple multiplexer Switch closure multiplexer Telephone modem

Measured Home Energy Performance

The home is located in Gainesville, Florida which is approximately 115 miles northwest of Orlando. Gaineville has 1305 heating degree days and 2838 cooling degree days (65^{o}F base; NOAA 2007). Using the *EnergyGauge USA* simulation (Version 2.8), the home has a preliminary HERS rating of 29 and a BA Benchmark estimated site energy savings of 63.2% and a source energy savings of 75.3%.

It should be noted that the renewable energy portions of the home design strongly compliment the efficiency measures—particularly when source energy is considered. For instance, without the 3.1 kW PV system, the HERS score rises to a 49 while site energy savings drop to 48% and source energy savings to only 55%. Similarly, with neither the PV system nor the solar water heating system, the HERS score rises to a 57 while site and source energy savings fall to 41% and 46%, respectively.

Based on the first six months of data, the home's net energy performance has been close to expectations. The PV system was sized to achieve within 70% of zero electricity use energy using TMY3 weather data for Gainesville, FL and BA Benchmark assumptions for occupant effects such as temperature setpoints and miscellaneous energy use (Hendron, et. al. 2004). The BA Benchmark represents U.S. average occupancy and behavior.

The home was occupied by two adults in July of 2008. One of the occupants work during the day and other, a retired professor, remains at home. Both occupants are interested in the energy use of their home and plan to choose appliances and equipment to reduce energy use when possible. Both also reported very actively using the installed building energy feedback system to manage loads.

The overall home performance energy related performance is given in Table 3 when averaged on daily basis. To provide best indication of long-term performance it does not including the period when the inverter was not operational:

Table 3. Six Month Performance Summary of Gainesville NZEH

	kWh/Day
Site Energy Summary	
Total site electricity consumption	12.0
Total AC site PV electricity production	8.3
Net electrical energy production	0.0
Total natural gas consumption (therms/day)	0.40
Source Energy Summary*	
Total source energy consumption	49.9
Total source energy offset	26.2
Net source energy	23.2
Total source energy (BA Benchmark)	175.4
Percent savings relative to Benchmark	**87%**

***** The site to source energy conversions are U.S. national averages based on the BA Analysis Procedures (Hendron, et. al. 2004): site-to-source multiplier for electricity = 3.365; site-to-source multiplier for natural gas = 1.02).

Site electricity use (not counting the solar contribution) has been exceedingly low, averaging only about 12 kWh/day or 2180 kWh over the six month period. By way of consumption, the typical July – December electricity use in North Florida for single family houses averages 8860 kWh or about 49 kWh/day (FPL, 2008)

The Photovoltaic system performed well producing about 70% of the site electricity required and met the design goal. While excess solar electricity production was routinely fed back into the grid, the total solar electricity produced was less than the site electricity consumption during the six month monitoring period. A total of 72 therms of natural gas was used over the half year monitoring period. Based on data, consumption for cooking and clothes drying is only about 2-3 therm/month with the totals showing that 57 therms were used for space heating – virtually all in November and December. The monthly site electricity by end uses are shown in Figure 7 and Table 4. The average diurnal demand profile over the 24-hour cycle over the extended monitoring period is shown in Figure 9.

Table 4. Six Monthly Energy Summary 2008
kWh

	July	August	Sept.	Oct.	Nov.	Dec.	Average kWh/day
Total House Electrical Demand	465	447	438	372	299	219	12.3
Cooling kWh	218	207	191	104	37	34	4.3
Air Handler kWh	16	16	15	13	20	22	0.6
Hot Water kWh	0	2	0	5	13	29	0.3
Lighting, Appliances, & Other	231	222	232	250	214	134	7.1
PV_{ac} Power Produced	283	159	176	270	237	288	8.3
Natural Gas (therms)	3	2	3	4	28	32	0.4 therms

* PV system down with failed inverter Aug. 20th – Sept. 11th.

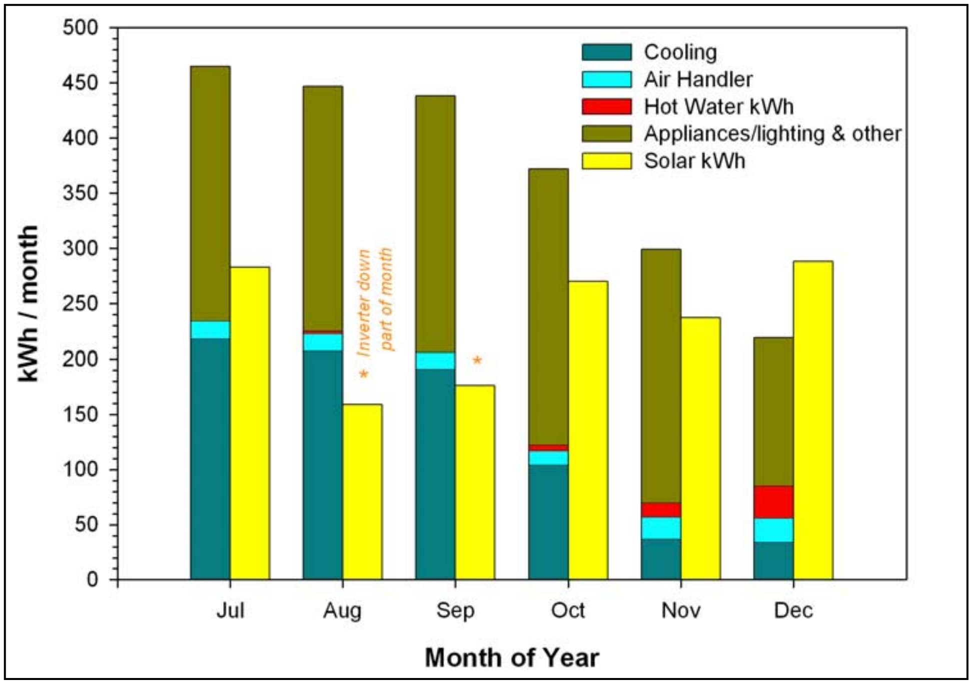

Figure 7. Monthly site electricity consumption by end use.

Overall, the PV system produced about 70% of the electricity needed over the monitoring period, but about 53% of total site energy requirement when natural gas is included. In addition, since the NZEH home produces most of the energy for its water heating and is much more efficient than a standard new home the overall savings is higher. We also compared its energy use to a typical 1993 home (the BA Benchmark) which showed a daily average source energy use of 175 kWh/day against the 23.2 kWh actually measured for the NZEH home. This represents an 87% savings in source energy. The detailed simulation results for this calculation contained in Table 5.

Table 5. Annual Energy Use and Site and Source Savings

Characteristic	Electricity* kWh	Natural Gas Therms	Site 10^6 Btu	Source 10^6 Btu
Benchmark Total Energy Use	15769	343	88.088	218.48
NZEH Prototype (simulation)	2454*	244	32.390	53.559
NZEH (actual monitored)	1360*	146	19.209	29.457
NZEH Savings: Simulated	84.4%	28.9%	63.2%	75.5%
NZEH Savings: Actual	91.4%	57.4%	78.2%	86.5%

* Net of subtracted PV power produced: 3766 kWh simulated; 3030 kWh measured.

Detailed Site and Source Energy Savings

We used the *EGUSA Version 2.8* software and monitored energy use to evaluate the source energy savings of the NZEH design. As detailed in Appendix B, the software predicted a 63% site energy savings and a 75% source energy savings versus the BA Benchmark for the installed measures. To evaluate measured performance, we assumed that the twelve month energy savings would be twice that seen in the July - December monitoring period.

In reality, the as built and as operated home did even better than predicted by the software. Our evaluation showed that the actual site and source energy savings were 78% and 87%, respectively – exceeding the predicted performance. While simulated HVAC electrical energy was somewhat higher than that simulated (measured = 4.3 kWh/day vs. 3.1 kWh predicted), non-HVAC, non DHW measured electricity use was much lower than simulated: (7.1 kWh/day vs. 13.3 kWh/day simulated). This is likely due to the careful and frugal energy use of the home owners utilizing the energy feedback system.

Figure 8. Inverter and electrical interface at NZEH house.

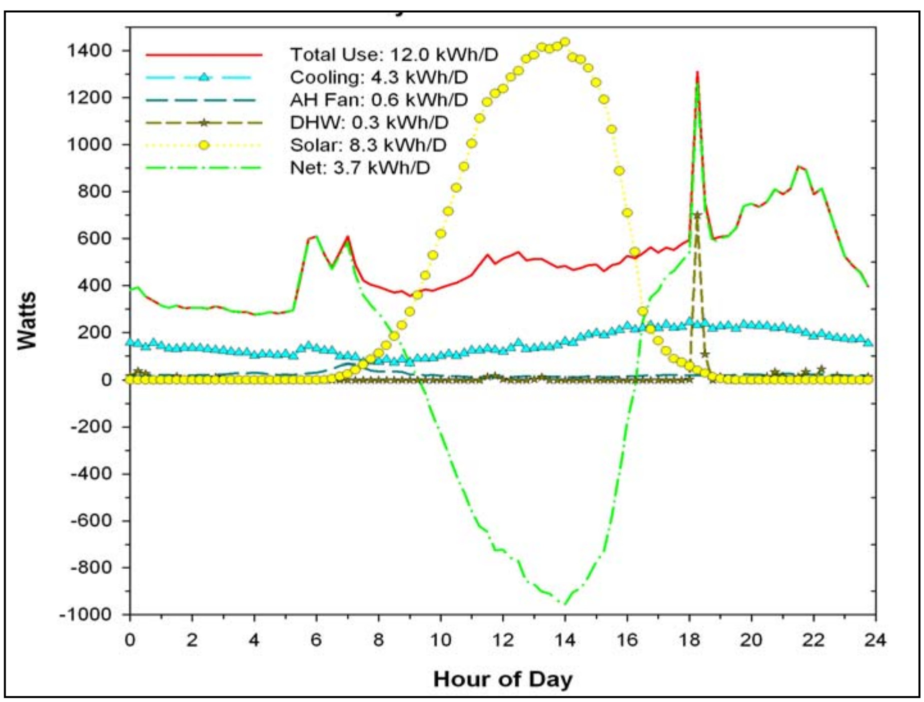

Figure 9. Gainesville NZEH average 24-hour electrical demand, July – December 2008.

Figure 10. Closeup of 3.1 kW PV system and 80 ft^2 solar water heating system.

Monthly Energy Summary by End-Use

As expected, space cooling is the largest electricity end use in summer, while natural gas is the largest energy consumer in November and December. The house design and equipment must be seen as extraordinarily successful at reducing space cooling needs. Air conditioning averaged only about 200 kWh/month in July and August while typical home in North Florida use 800 – 1000 kWh/month during summer months (FPL, 2008). Similarly, the air conditioner variable speed air handler and furnace system blower was very efficient using only about 15-20 kWh per month against standard systems which would use three times as much energy for air circulation. Moreover, the system produced very comfortable interior conditions during summer as shown in Figure 11.

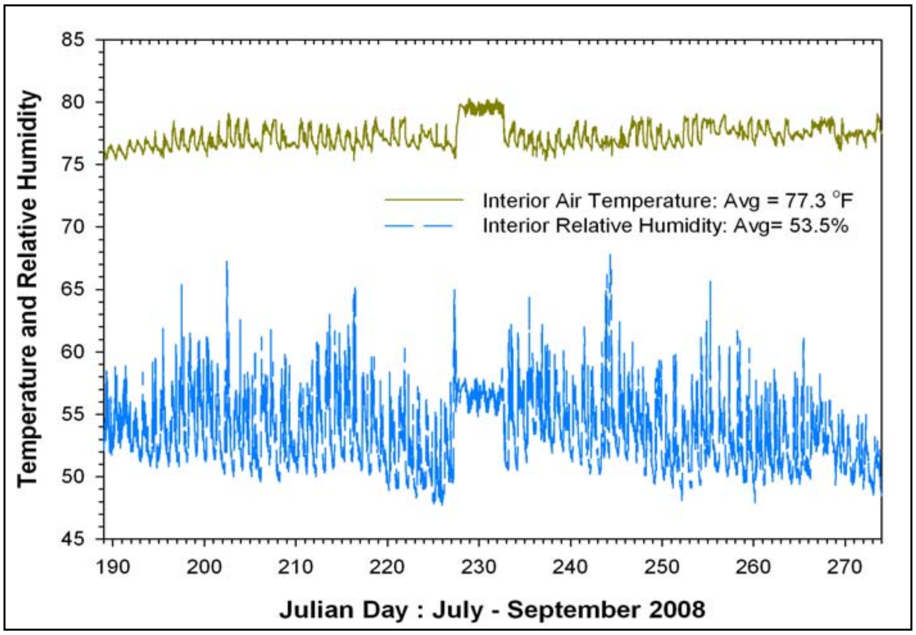

Figure 11. NZEH summer home interior comfort conditions (temperature and relative humidity), July - September 2008.

Crankcase Heater Power

Although the air conditioner has a very efficient two-stage scroll compressor, we found that crankcase heater (CCH) – a 60 Watt unit – can be a significant part of annual energy use of very low energy use homes.[2] Crankcase heaters mitigate the fact that refrigerant moves to the outside unit during cold weather and condenses. Unfortunately, refrigerant is an excellent solvent which wipes oil from bearings and can initiate slugging which shortens compressors reliability. Even scroll compressors are limited to the amount of liquid refrigerant that can pass through them without causing harm.

Below is a plot showing the crankcase heater (CCH) operation on 27 January 2008. Because of the controls, the CCH is designed to come on when the outdoor temperature is lower than 65°F and then turns off when the outdoor temperature is above 80°F.

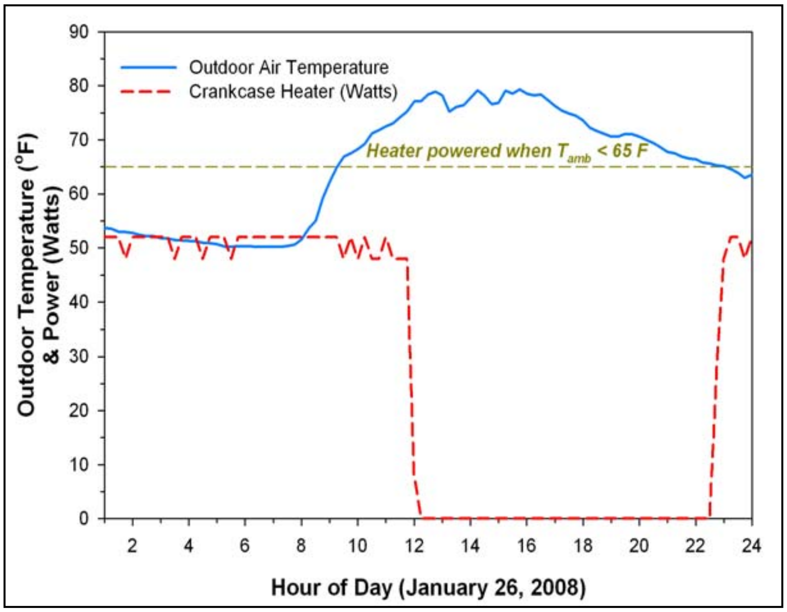

Figure 12. Crankcase heater operation at NZEH site on 27 January 2008 as varying with outdoor temperatures.

Unfortunately, the control method for CCH results in many hours, even in Florida, where the 55 Watt load is seen even though the unit is in heating mode where a natural gas furnace is used. For instance, in the NZEH, cooling was not seen from 15 November onwards. However, in the ten week period from 15 November - 28 January 2008, the CCH used 80 kWh. During that time no cooling at all was used and yet the crankcase heater was on about 80% of the time. The energy use of the CCH was nearly that expected for a refrigerator over the same period.

Also, there are many hours of crankcase heat with no prospect at all of cooling operation that would make the heat worthwhile. For instance when outdoor temperatures are 55°F or lower, there is virtually no situation where cooling would required and yet there 1677 hours when these temperatures conditions are encountered in Gainesville, Florida. This amount of potentially wasted energy would total approximately 100 kWh/year. In more northern climates, such long periods where CCH would be on without cooling being needed would be much more. For instance, in Boston, MA, there are 5,004 hours when the temperature is less than 55°F and the crankcase heater would be on with virtually no prospect of heating being needed. Given the characteristics of the CCH, this would represent a wasted use of electricity of 275 kWh/year.

Since CCH is not considered in the SEER procedures, this level of energy consumption suggests technology development with adaptive controls to reduce the incidence of crankcase heat during winter

[2] It is a common misconception that scroll compressors do not require crankcase heat. Many do require CCH as acknowledged by field experience by major manufactuers.

months when it serves no purpose. It also suggests that DOE somehow consider CCH operation in its efficiency rating procedures since CCH energy use will otherwise be a large part of annual air conditioner energy use, particularly in northern climates with only short periods of active cooling.

Other Electrical Loads

Base load lighting, refrigeration and other electrical end uses appear to be approximately 230 kWh/month. As detailed below, the solar water heating system totally eliminated water heating auxiliary energy during summer.

Even before the home was occupied in July 2008, we used an established protocol to identify miscellaneous electric loads in the home using *The Energy Detective (TED)* monitor. This was done when an energy feedback monitor *(TED)* was installed to help occupant monitor energy use. We found that the completed, but unoccupied home used 50 Watts of standby power to operate a garage door opener, HVAC control electronics, solar hot system control module, GFIs and smoke alarms.

Table 6. Measured Miscellaneous Standby Electrical Demand Prior to Occupancy

Garage door Opener	5 W
Solar hot water controls	5 W
Grid tied Inverter	5 W
Bathroom GFI	5 W
Kitchen GFI	5 W
Dishwasher electronics	5 W
HVAC electronics	20 W
Total Baseload	40-50 Watt with breakers on

Since total house electrical consumption averaged only 12 kWh/day, the pre-occupancy standby power in the home (50 Watts) amounts to to 1.2 kWh/day or 10% of total consumption! Note that this does not include any home owner installed appliances such as televisions, computers and so forth.

Figure 13. Installed *TED* energy feedback display.

Both of the occupants report employing the above energy feedback device to help control their energy use. I would appear as if they have been very successful since measured non-space conditioning and water heating energy has only averaged 7.1 kWh/day. It is worth noting that the Building America simulation Benchmark analysis predicts that typical non HVAC, non water heating energy use would typically average 12.2 kWh/day, even with the efficient appliances installed in the home. As seen before in other projects, this again highlights the critical nature of providing usable energy feedback to interested occupants.

Solar Electric Power Production

The 3.15 kW system consists of 18 *Conergy 175* Watt modules with a 3 kW SMA inverter. Photovoltaic (PV) power production was monitored beginning on 6 July 2008. Unfortunately, there was a lightning related inverter failure on 20 August which was not repaired until the unit was replaced on September 11th. Other than the inverter failure, the performance of the PV system has been as expected.

A PV performance calculator, *PVWatts*, is available on NREL's Renewable Resource Data Center website (http://rredc.nrel.gov). The *PVWatts* simulation of the 3.15 kW_p DC PV west-facing system using TMY2 weather data from Jacksonville, FL predicts the system will deliver 3418 kWh (11.7 MBtu) of AC electricity per year with no shading. The *PVWatts* default derate factor of 0.77 was used for this prediction. Similarly, the PV calculator (*PVFORM*) in the *EGUSA* software using the Gainesville FL TMY3 weater data indicated 3766 kWh/year from the PV system. The predicted PV output for the monitored period from the same software was 9.5 kWh/day. Within the project a digitized shading analysis at the site indicated approximately a 14% loss of potential solar power production due to trees on the east and north west sides of the property boundary. The detailed solar access analysis with images is shown in Appendix C. A 14% loss of solar radiation due to shading from mature trees on the site could be expected to reduce the expected annual PV production to about 8.2 kWh/day.[3] The actual solar electric energy delivered from 6 July – December 29, 2008 was 8.3 kWh/Day which is essentially identical to the predicted performance given variations in weather. The 15-minute and cumulative net electricity use over the period is shown in Figure 15.

Figure 14. Evaluation of site shading using Solmetric Sun Eye.

[3] Both PV simulation software agree that use of the west orientation for the PV system results in about a further 10-15% drop in the annual electric power produced. For instance, *PVWATTS* predicts an annual energy production of 3,418 kWh with the existing west face against 4,052 kWh had the same PV system been facing south. Similarly, *EGUSA* predicts 3,766 kWh with the west face and 4,121 kWh if it were facing south. All things equal, this means that had the PV system been facing south, the PV system would have produced about 76% of total electrical needs and 58% of the annual energy required for the home vs. the 70% and 53%, respectively, now seen. Given the expensive energy of the solar electric system offset, this means that optimal orientation and minimization of PV array shading will provide best performance for ZEH projects when evaluated on an annual basis.

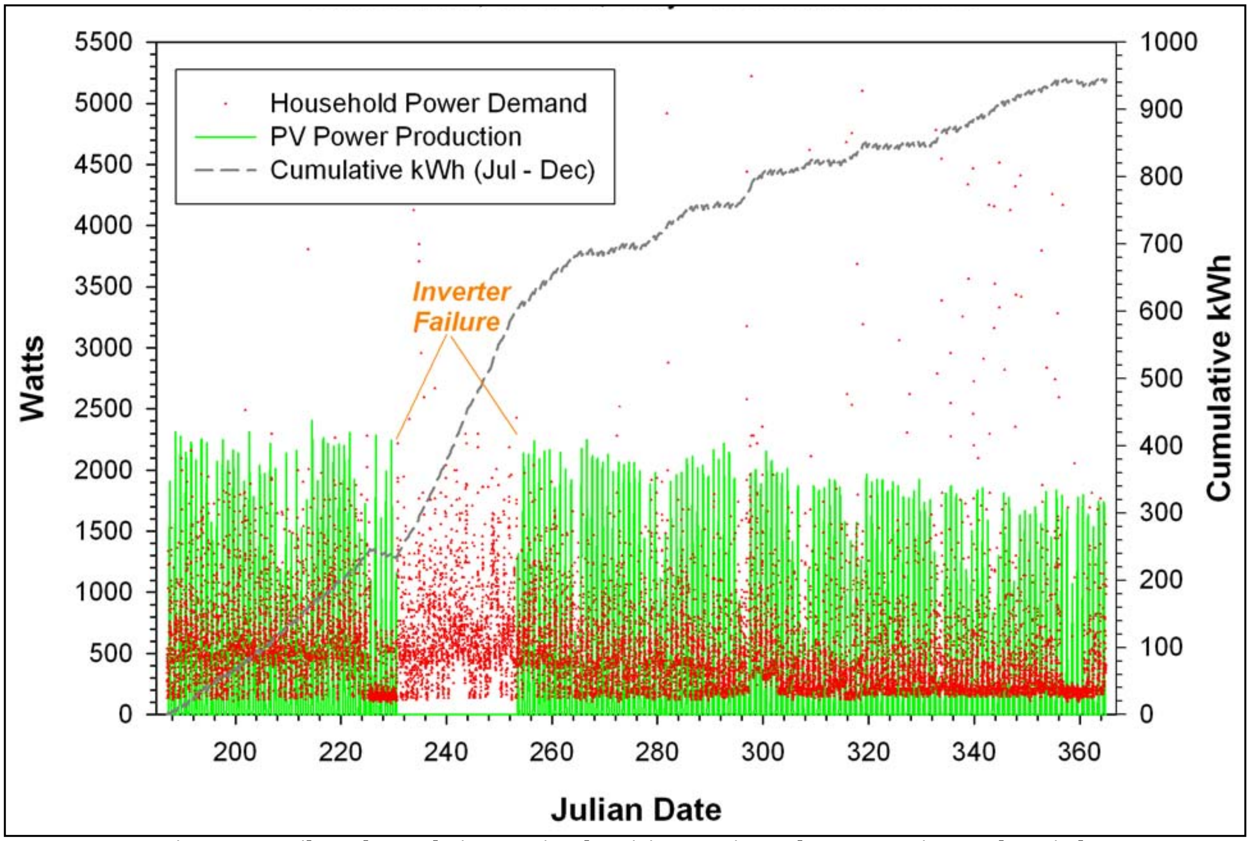

Figure 15. Daily and cumulative net site electricity 15-minute data over a six month period.

Solar Water Heating

The solar water heating system was robustly engineered with the solar installer (*ECS Solar Energy Systems, Inc*.) determined to virtually eliminate back up water heating. A pumped draindown system is used to provide function with freeze protection. Given the orientation of the house and the hipped roof, the system had to be installed on the less advantageous west face of the home. Based on experience, the installer decided on two 4 x 10 ft solar collectors (*AET-40s*) feeding a 120 gallon storage in a drainback configuration. Simulation of the solar water heating system in *EGUSA* estimated that such a system would provide 83% of typical water heating needs. However, this estimate is based on a three bedroom home with three occupants with typically more water to be heated than would be experienced in a two occupant household as monintored in this project.

Full monitoring for the solar water heating system was not yet installed during the first six months of the data obtained so that volume of the daily draws is not known. The first data include only the auxiliary electric energy use of the back up electric resistance elements in the solar hot water tank. These data showed that the home only used 0.3 kWh/day over the monitoring perioid with many days with no auxiliary electrical use at all for the solar water heating system. As showing in Figure 6, most of the auxiliary electricity use of the solar system comes in the cloudier months of November and December. However, monitoring found that the draindown solar system draws 150 watts when the system is circulated. With 7 hours of daily operation the pump energy is approximately 1.0 kWh per day. Based on a crude estimates using a very low estimated daily consumption of only 35 gallons per day, we would estimate that the solar water heating system is providing at least 90% of annual water heating energy needs. However, the high pump power observed argues for down-sized pumps, shorter pumping and lifts (85 W pump).

Later we will have data on the gallons of hot water use and the supply and inlet water temperatures to the auxiliary tank which will allow a more precise determination of the water heating load and a more exact estimate of the contribution by the solar system. We also intend to measure the hot water system pump energy.

Figure 16. 120 gallon solar water tank with monitor showing system function.

Peak Summer Electrical Load Shape

Florida electric utilities are very concerned with how homes demand energy during peak periods. Figure 17 shows the average load shape during the peak July period in summer when peak daily outdoor temperatures were sometimes greater than 95^{o}F. Note that total household electric power demand during the summer peak period (45-7 PM EDT) is only 762 W and only 422 W when net of solar power produced. This is approximately one tenth of the peak period power demand in a conventional house where utility coincident peak demand is typically about 4 kW. Also, the cooling energy use of the design was very low with a peak period demand of only 466 Watts and a daily energy use of only 7.5 kWh/day.

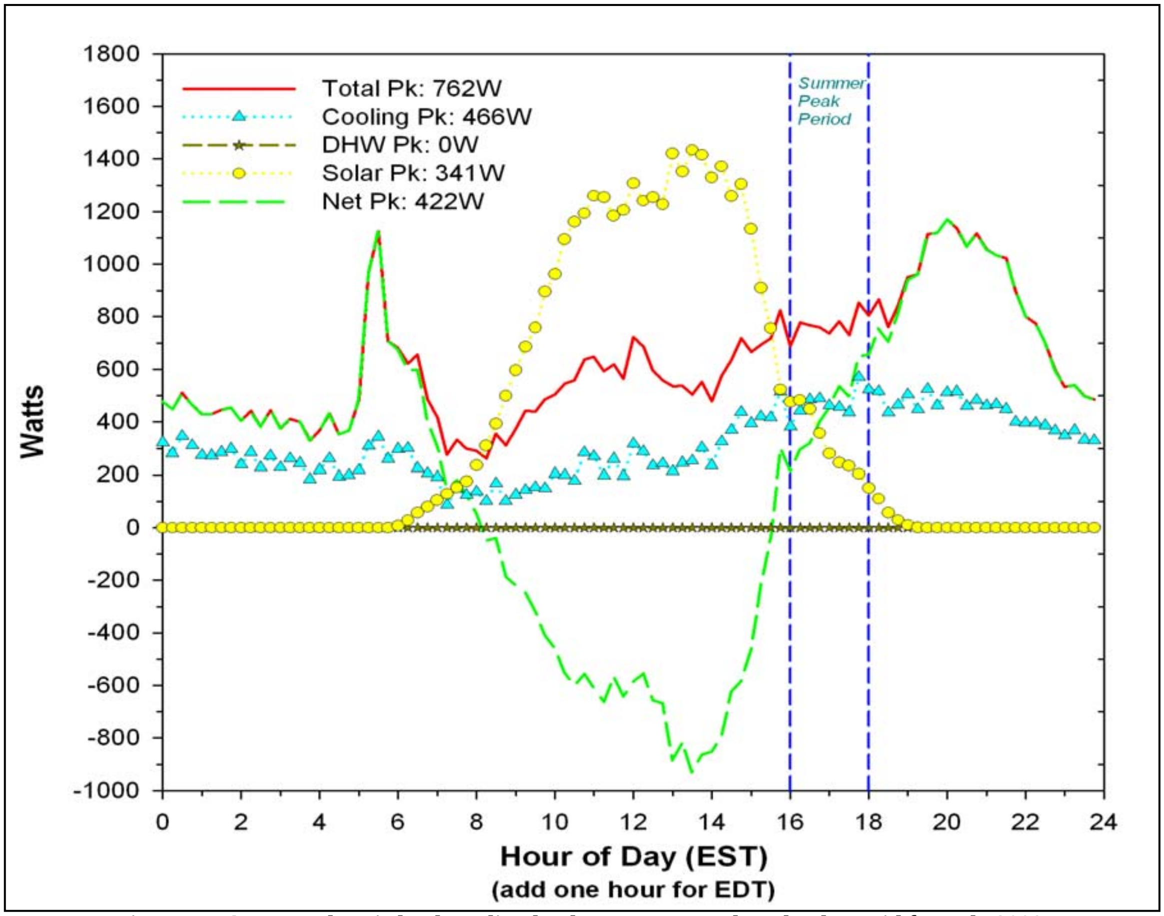

Figure 17. Average electric load, cooling load, PV output and net load to grid for July 2008.

Conclusions

We have reported on the preliminary performance data on a Near Zero Energy Home (NZEH) built in Gainesville, Florida. Featuring a battery of very efficient construction methods, appliances and equipment, the 1772 square foot home was anticipated to produce about 70% of its annual electrical energy and 63% of its required site energy from its renewable energy systems. Based on six months of monitoring, the home's energy use has been very low. Total daily electricity use has averaged only 12 kWh per day and 3.7 kWh/day when solar energy production is included. The compares to about 49 kWh per day for a typical single family home in North Florida over the same period. Thus, the home's net electricity use is less than 8% of that of a typical existing home. We also compared the home's performance against the Building America Benchmark considering all fuels. The half year Benchmark for the home indicated a daily source energy use of 175 kWh against the 23.2 kWh actually measured. This represents a savings of 87%.

Average cooling energy use averaged only 4.3 kWh/day and air handler use was only 0.6 -- exceedingly low in Florida's hot climate. The 2-ton SEER 19 two-stage cooling system appeared to work extremely well using very little electrical energy, even in the most trying conditions of summer to maintain 78^{o}F indoors with approximately a 55% relative humidity. Moreover, the occupants reported being very pleased with the even temperature conditions and low energy bills. Unfortunately we also found that energy use of AC crankcase heaters (CCH) can increase daily electrical energy by 1.3 kWh/day during winter months where there is no prospect of the need for cooling. Often during winter days the CCH was 15% of total electricity consumption. This suggests the need for future adaptive technology for low energy houses.

With a large solar water heating system with 80 ft^2 of collectors and 120 gallon storage, virtually all hot water needs were met during summer months. Over the six month period, only 0.3 kWh of auxiliary water heating electricity was used each day. However, estimated circulation pump energy (150 W when operating) was about 1.0 kWh/day, indicating that reduction to this parasitic load should be an objective for future efforts. Standby power as a part of miscellaneous electric loads from a garage door opener, HVAC and solar water heater control electronics and a dishwasher and household GFIs were found to total 50 Watts prior to occupancy. Thus, these constant standby loads (1 kWh/day) account for roughly 10% of total measured household electricity use before homeowner electronics (computers, televisions, office equipment and minor appliances) were brought to site.

Although refrigeration, lighting and other minor appliances were not monitored, they were found to be the largest collective household end use at 7.1 kWh/day or 58% of the total remaining electrical loads. The home had a very efficient *Energy Star* refrigerator and fluorescent lighting used throughout (and the owners seemingly committed to maintaining this status), however this area remained the largest energy end use load. This serves as another lesson from the project: in very efficient homes, lighting, appliance and miscellaneous loads will comprise the largest use of electricity and likely the most fruitful area for load reduction.

The house has a gas dryer, range and heating system. Total measured natural gas consumption was 72 therms over the six month period. Baseline consumption in the months of July - October showed only 2-3 therms used each month for cooking and clothes drying. However, energy use for space heating was roughly 24 therms in November and 28 therms in December.

The 3.15 kW west facing solar electric PV system operated close to expectations. We did experience one problem with the inverter, which was corrected in late summer. Not including this period, the system produced an average of 8.3 kWh/day which is similar to what is predicted with PV system simulations. We did note however, that audited site shading could be expected to reduce annual PV output by about 14%. Also, the west facing array reduces output by another 10-15% over what would be expected from a south facing system. Both these issues along with the expense of the PV installation point out the need to optimize solar access and array orientation where possible in ZEH projects.

Based on the six months monitoring, we found the PV system to produce about 70% of the electricity used on site and when natural gas use was considered, the result was about 53% of the annual site energy use. However, the NZEH is much more efficient than standard new homes. Source energy savings compared to the BA Benchmark were 87%. Based on our preliminary evaluation, approximately 5 kW of unobstructed PV facing south would produce a true net zero energy home by offsetting all electric and natural gas use. Monitoring will be continued for another full year to access long-term performance.

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Appendix A

Project Stagegate Analysis

Appendix A

Evaluation of Project Stage-gate Criteria

Within the Building America process, projects are evaluated using the Stagegate process to evaluate overall project success, potential for continuation and refinements to research and development. Within the process are “must meet” and “should meet” criteria. Each of these are examined relative to the Near Zero Energy Home in Gainesville.

“**Must Meet Criteria”**

Detailed Site and Source Energy Savings

We used the *EGUSA Version 2.8* software to evaluate the source energy savings of the NZEH design. As detailed in Appendix B, the software predicted a 63% site energy savings and a 75% source energy savings versus the BA Benchmark for the installed measures. We assumed that the twelve month energy savings would be twice that seen in the July - December monitoring period.

	Annual Energy use			
Characteristic	**Electricity***	**N. Gas**	**Site**	**Source**
	kWh	Therm	10^6 Btu	10^6 Btu
Benchmark Total Energy Use	15769	343	88.088	218.48
NZEH Prototype (simulation)	2454*	244	32.390	53.559
NZEH (Actual monitored)	1360*	146	19.209	29.457
NZEH Savings: Simulated	84.4%	28.9%	63.2%	75.5%
NZEH Savings: Actual	91.4%	57.4%	78.2%	86.5%

* Net of subtracted PV power produced: 3766 kWh simulated; 3030 kWh measured.

In reality, the as built and as operated home did even better than predicted by the software. Our evaluation showed that the actual site and source energy savings were 78% and 87%, respectively– exceeding the expectations.

While simulated HVAC electrical energy was somewhat higher than that measured (monitored = 4.3 kWh/day vs. 3.1 kWh predicted), non-HVAC, non DHW measured electricity use was much lower than simulated: (7.1 kWh/day vs. 13.3 kWh/day simulated). Given the response from the homeowners, this may mean that having energy feedback along with interested homeowners may be important to exceeding savings expectations in future projects. Similarly, automated controls to help shed miscellaneous electric loads may be helpful as well.

Prescriptive Based Code Approval

The site related construction techniques used in the Gainesville NZEH prototype were all relatively conventional and did not alter code-related approvals. The solar electric (PV) and solar water heating modules and collectors were storm rated and the electrical inspection of the PV system was completed without difficulty.

Neutral Cost Target

As seen in Table A1, incremental costs of improvements over regional standard practice are presented, along with the amortized annual cost. Incremental and amortized cost of rebates and incentives are also presented. As seen in the table, the total amortized incremental cost to the buyer, not including PV, after rebates and incentives, is $591.32 per year. Total cost including PV is $1176.05 per year. Part of these costs were softened by having supplier provide special price accommodation on the metal roof, the AC system, tile, radiant barrier, HVAC and appliances.

Table A2 presents the simulated source energy savings of the Schackow NZEH compared to both the BA Benchmark and regional standard practice. The annual utility bill reduction of the Prototype with respect to the BA Benchmark is not shown in this table, for applying local utility rates charged to the homeowner to source energy numbers would appear to artificially inflate the savings. Instead, Table A3 presents the simulated site energy savings of the Schackow NZEH compared to both the BA Benchmark and regional standard practice. In this table, using the local utility rates of $0.12 per kWh and $1.72 per therm, the annual utility bill reduction of the Prototype with respect to the two references is shown by end use and in total. When total amortized incremental cost of the Prototype over the regional standard practice, including rebates and incentives, is subtracted from the utility bill reduction over this reference the result shows a net positive cash flow of $182.48 per year when the PV system is excluded from the analysis. When the PV system is included, the result shows a negative cash flow of $30.05 per year.

The 1772 sq. foot NZEH home sale price was $306,000. However, it must be said that the premium cost of the various components and equipment, likely add about $15-$20 /square foot to the final sales price– depending on whether special price accommodation is available as within our prototype project.

Table A1. Incremental and Amortized Cost of Improvements

Measure	Regional Standard Practice	Schackow NZEH	Incremental Cost	Amortized Annual Cost
Building Enclosure				
Roofing	shingle	selective metal shingles and radiant barrier	$ 3,000.00	$ 239.40
Windows	double pane clear	Energy Star Low-E	$ -	$ -
Wall Insulation	fiberglass batts	R-13 cellulose	$ 300.00	$ 23.94
Envelope and Duct Sealing	standard	mastic and caulk	$ 350.00	$ 27.93
HVAC System				
Heating/Cooling system	SEER 13 a/c/ 80% furnace	seer 19 a/c, 95%furnace	$ 4,000.00	$ 319.20
Fresh Air Ventilation	none	runtime vent system	$ 150.00	$ 11.97
Appliances	standard	Energy Star	$ 1,000.00	$ 79.80
Lighting	incandescent	compact fluorescent	$ 110.00	$ 8.78
Total Energy Efficiency Investment			***$ 8,910.00***	***$ 711.02***
Solar Systems				
PV system and installation	none	3.15kW	$ 25,200.00	$ 2,010.96
Drainback Solar DHW	none	installed	$ 5,000.00	$ 399.00
Total with Solar			***$ 39,110.00***	***$ 3,120.98***
Ratings, Rebates and Incentives				
HERS rating and Tax Credit certification	none	received	$ 500.00	$ 39.90
Federal New Home Tax Credit	none	received	$ (2,000.00)	$ (159.60)
State of Florida PV rebate	none	received	$ (13,100.00)	$ (1,045.38)
Federal Tax Credits	none		$ (6,622.50)	$ (528.48)
Utility Rebate for Solar	none	received	$ (3,150.00)	$ (251.37)
Cost to Builder w/o Solar			***$ 7,410.00***	***$ 591.32***
Total Incremental Cost to Builder w/ Solar			***$ 14,737.50***	***$ 1,176.05***

Table A2. Neutral Cost Analysis for the Schackow NZEH Using Source Energy Savings

	Annual Source Energy			Estimated Source Energy Savings			
Description	BA Bench	Regional Standard Practice	Prototype House	Percent of End Use		Percent of Total	
End Use	Mbtu/y	Mbtu/y	Mbtu/y	vs. BA Bench	vs. Standard	vs. BA Bench	vs. Standard
Space Heating	27.3	22	15.8	42%	28%	5%	4%
Space Cooling	77.8	35.6	12.2	84%	66%	30%	15%
DHW	33.3	16.7	4.8	86%	71%	13%	8%
Lighting	25.6	26.4	8.9	65%	66%	8%	11%
Appl. & MEL	52.6	52.6	48.8	7%	7%	2%	2%
Ceiling Fan	1.6	1.6	1.6	0%	0%	0%	0%
OA Vent Fan	0.3	0.3	4.6	-1433%	-1433%	-2%	0%
Total Usage	**218.5**	**155.2**	**96.7**	**56%**	**38%**	**56%**	**38%**
Site Generation	0	0	-43.2			20%	28%
Net Energy Use	**218.5**	**155.2**	**53.5**	**76%**	**66%**	**76%**	**66%**

Table A3. Neutral Cost Analysis for the Schackow NZEH Using Site Energy Savings

	Annual Site Energy			Estimated Site Energy Savings					
Description	BA Bench	Regional Standard Practice	Prototype House	Percent of End Use		Percent of Total		Annual Utility Bill Reduction	
End Use	Mbtu/y	Mbtu/y	Mbtu/y	vs. BA Bench	vs. Standard	vs. BA Bench	vs. Standard	Prototype WRT Benchmark	Prototype WRT Standard
Space Heating	24	19.2	13.8	43%	28%	12%	7%	$177.00	$96.00
Space Cooling	23.1	10.6	3.6	84%	66%	22%	9%	$684.00	$244.00
DHW	9.9	15.3	1.4	86%	91%	10%	18%	$258.00	$173.00
Lighting	7.6	7.9	2.6	66%	67%	6%	7%	$174.00	$183.00
Appl. & MEL	23	23	21.8	5%	5%	1%	2%	$45.71	$40.00
Ceiling Fan	0.5	0.5	0.5	0%	0%	0%	0%	$0.00	$0.00
OA Vent Fan	0.1	0.1	1.4	-1300%	-1300%	-1%	0%	-$45.00	-$42.00
Total Usage	**88.2**	**76.6**	**45.1**	**49%**	**41%**	**49%**	**41%**	**$1,293.71**	**$694.00**
Site Generation	0	0	-12.85			15%	17%	$452.00	$452.00
Net Energy Use	**88.2**	**76.6**	**32.3**	**63%**	**58%**	**63%**	**58%**	**$1,745.71**	**$1,146.00**
Added Annual Mortgage Cost w/o Solar									$711.02
Impact on Mortgage from Incentives and Rebates w/o Solar									-$199.50
Net Annual Cash Flow w/o Solar									**$182.48**
Added Annual Mortgage Cost w/ Solar									$3,120.98
Impact on Mortgage from Incentives and Rebates w/ Solar									-$1,944.93
Net Annual Cash Flow w/ Solar									**-$30.05**

Gaps Analysis /Lessons Learned

A number of lessons were learned within the NZEH project:

- Two stage SEER 19 cooling equipment worked exceedingly well providing good comfort with low power.
- Advanced construction techniques in the project were successful at reducing heating and cooling loads: good insulation and windows with an attic radiant barrier and low solar absorptance metal roofing system with interior ducts
- West facing 80 ft^2 solar water heating system worked well, providing 100% of summer water heating and likely 90% for the overall year.However, pump power for the drain-down solar water heating system was large enough (~1 kWh per day) that efforts should be made to use a downsized pump, or even better, variable speed pumps for future projects to reduce this consumption.
- Occupants were able to use energy feedback device to control miscellaneous electric loads so that they were nearly half the typical consumption level.
- Pre-occupancy standby loads of the HVAC controls, garage door opener, GFI and kitchen electronics was approximately 50 Watts or 10% of total daily consumption
- Shading of PV system and solar water heating systems should be carefully evaluated for future projects.
- AC unit crankcase heater draws 55 W when outdoor temperature is less than 65^oF.In Gainesville such a system will use a lot of energy when no space cooling is needed. For instance, in an average year there are 2231 hours in Gainesville with outdoor temperatures less then 60^oF – implying a waste of 128 kWh/year.

Identified gaps within the research process:

- Need low standby energy products for hardwired items in a ZEH (doorbells, garage door openers, appliances and HVAC electronics).
- Solar access and orientation should have a priority for ZEH projects.
- Need variable speed pump for pumping drain-down water heating systems which have a high initial head capability need and then low pump power for continuous circulation.
- Home construction had an excess of wall framing that should be tackled in future projects to reduce wood use, save on first cost and improve thermal performance.
- Need high efficiency AC units that allow the crankcase heater to be deactivated when outdoor temperatures are less than 40^oF.

Quality Assurance

Quality assurance within the project has been adequately achieved. The builder, *Trunnell Construction* effectively followed up on a number of unusual construction and specification issues. The *FL H.E.R.O.* organization was available on site during the construction process to provide attention to several details that were otherwise difficult or prone to improper installation. This resulted in corrections within the construction process: proper window specification, better building air tightness and correction to several insulation details.

City arbor ordinances have made tree removal difficult in ways that were not foreseen before construction. Removal of two trees will significantly improve the PV output of this house.

Appendix B

Building America Benchmark Analysis
Simulation Runs (EnergyGauge USA)

Building Input Summary Report

PROJECT

Title:	RSfc-2-danny2-12-09	Bedrooms:	3	Adress Type:	Street Address
Building Type:	User	Bathrooms:	2	Lot #	2
Owner:	New home	Conditioned Area:	1772	SubDivision:	Forest Creek
# of Units:	1	Total Stories:	1	PlatBook:	
Builder Name:	Richard Schackow	Worst Case:	No	Street:	1650 NW 34th Ave
Permit Office:		Rotate Angle:	0	County:	Alachua
Jurisdiction:		Cross Ventilation:		City, State, Zip:	Gainesville ,
Family Type:	Single-family	Whole House Fan:			FL , 32601-
New/Existing:	New (Confirmed)				
Comment:					

CLIMATE

Design Location	Tmy Site	Design Temp 97.5 %	Design Temp 2.5 %	Int Design Temp Winter	Int Design Temp Summer	Heating Degree Days	Design Moisture	Daily Temp Range
FL, Gainesville	FL_GAINESVILLE_REGIONAL_AP	32	92	70	75	1305.5	51	Medium

UTILITY RATES

Fuel	Unit	Utility Name	Monthly Fixed Cost	$/Unit
Electricity	kWh	MyFloridaAverage	0	0.12
Natural Gas	Therm	Florida Average	0	1.72
Fuel Oil	Gallon	Florida Default	0	1.1
Propane	Gallon	Florida Default	0	1.4

SURROUNDINGS

Ornt	Type	Shade Trees Height	Width	Distance	Exist	Adjacent Buildings Height	Width	Distance
N	None	0 ft	0 ft	0 ft		0 ft	0 ft	0 ft
NE	None	0 ft	0 ft	0 ft		0 ft	0 ft	0 ft
E	None	0 ft	0 ft	0 ft		0 ft	0 ft	0 ft
SE	None	0 ft	0 ft	0 ft		0 ft	0 ft	0 ft
S	None	0 ft	0 ft	0 ft		0 ft	0 ft	0 ft
SW	None	0 ft	0 ft	0 ft		0 ft	0 ft	0 ft
W	None	0 ft	0 ft	0 ft		0 ft	0 ft	0 ft
NW	None	0 ft	0 ft	0 ft		0 ft	0 ft	0 ft

FLOORS

#	Floor Type	Perimeter	R-Value	Area	Tile	Wood	Carpet
1	Slab-On-Grade Edge Insulatio	221 ft	0	1772 ft²	0.8	0	0.2

ROOF

#	Type	Materials	Roof Area	Gable Area	Roof Color	Solar Absor.	Tested	Deck Insul.	Pitch
1	Hip	Metal	1982 ft²	0 ft²	Light	0.65	No	0	26.6 deg

ATTIC

#	Type	Ventilation	Vent Ratio (1 in)	Area	RBS	IRCC
1	Full attic	Vented	300	1772 ft²	Y	N

Building Input Summary Report

CEILING

#	Ceiling Type	R-Value	Area	Framing Fraction	Truss Type
1	Under Attic (Vented)	30	1772 ft²	0.11	Wood

WALLS

Wall orientation below is as entered. Actual orientation is modified by rotate angle shown in "Project" section above.

#	Ornt	Adjacent To	Wall Type	Cavity R-Value	Width Ft	Width In	Height Ft	Height In	Area	Sheathing R-Value	Framing Fraction	Solar Absor.
1	N	Exterior	Frame - Wood	13	45.67	0	9	0	411.03 ft²	0	0.23	0.5
2	W	Exterior	Frame - Wood	13	57.33	0	9	0	515.97 ft²	0	0.23	0.5
3	E	Exterior	Frame - Wood	13	43	0	9	0	387 ft²	0	0.23	0.5
4	S	Exterior	Frame - Wood	13	29	0	9	0	261 ft²	0	0.23	0.5
5	NE	Exterior	Frame - Wood	13	4	0	9	0	36 ft²	0		0.5
6	S	Garage	Frame - Wood	13	20		9		180 ft²	0	0.23	0.5
7	E	Garage	Frame - Wood	13	16		9		144 ft²	0	0.23	0.5
8	W	Garage	Frame - Wood	13	4		9		36 ft²	0	0.23	0.5

DOORS

#	Ornt	Door Type	Storms	U-Value	Width Ft	Width In	Height Ft	Height In	Area
1		Insulated	None	0.29	3	0	6.67	0	20.01 ft²
2	E	Insulated	None	0.29	2.67	0	6.67	0	17.81 ft²

WINDOWS

#	Ornt	Frame	Panes	NFRC	U-Factor	SHGC	Storm	Area	Overhang Depth	Overhang Separation	Interior Shade	Screening
1		Vinyl	Low-E Double	Yes	0.34	0.28	N	32.04 ft²	1.5 ft 0 in	1.5 ft 0 in	Drapes/blinds	Exterior 50%
2		Vinyl	Low-E Double	Yes	0.34	0.28	N	20.01 ft²	15 ft 0 in	1.5 ft 0 in	Drapes/blinds	Exterior 100%
3		Vinyl	Low-E Double	Yes	0.34	0.28	N	16 ft²	1.5 ft 0 in	1.5 ft 0 in	Drapes/blinds	None
4		Vinyl	Low-E Double	Yes	0.34	0.28	N	54 ft²	9 ft 0 in	1.5 ft 0 in	Drapes/blinds	Exterior 100%
5		Vinyl	Low-E Double	Yes	0.34	0.28	N	20.01 ft²	7 ft 0 in	2 ft 0 in	Drapes/blinds	Exterior 100%
6		Vinyl	Low-E Double	Yes	0.34	0.28	N	36 ft²	1.5 ft 0 in	1.5 ft 0 in	Drapes/blinds	Exterior 50%
7		Vinyl	Low-E Double	Yes	0.34	0.28	N	16 ft²	1.5 ft 0 in	1.5 ft 0 in	Drapes/blinds	Exterior 50%
8		Vinyl	Low-E Double	Yes	0.34	0.28	N	15 ft²	1.5 ft 0 in	1.5 ft 0 in	Drapes/blinds	Exterior 50%
9		Vinyl	Low-E Double	Yes	0.34	0.28	N	32.04 ft²	1.5 ft 0 in	1.5 ft 0 in	Drapes/blinds	Exterior 50%
10	S	Vinyl	Low-E Double	Yes	0.34	0.28	N	32.04 ft²	6 ft 0 in	1.5 ft 0 in	Drapes/blinds	Exterior 50%

INFILTRATION & VENTING

Method	SLA	CFM 50	ELA	EqLA	ACH	ACH 50	Forced Ventilation Supply	Forced Ventilation Exhaust	Run Time	Terrain/Wind Shielding
Tested Multi Point BD	0.00016	825	39.6	78.1	0.119	3.10	29	0	0	Suburban / Suburban

Building Input Summary Report

GARAGE

#	Floor Area	Roof Area	Exposed Wall Perimeter	Avg. Wall Height	Exposed Wall Insulation
1	447.26 ft²	447.26 ft²	56 ft	9 ft	1

MASS

Mass Type	Area	Thickness	Furniture Fraction
No Added Mass	0 ft²	0 ft	0.3

COOLING SYSTEM

#	System Type	Subtype	Efficiency	Capacity	Air Flow	SHR	Ductless
1	Central Unit	None	SEER: 19	26 kBtu/hr	780 cfm	0.75	False

HEATING SYSTEM

#	System Type	Subtype	Efficiency	Capacity	Ductless
1	Natural Gas Furnace	None	AFUE: 0.95	56 kBtu/hr	

HOT WATER SYSTEM

#	System Type	EF	Cap	Use	SetPnt	Credits
1	Electric	0.9	120 gal	60 gal	120 deg	Solar System

SOLAR HOT WATER

Collector Type	Collector Tilt	Azimuth	Surface Area	Loss Coef.	Absorp. Prod.	Trans Corr.	Tank Volume	Tank U-Value	Tank Surf Area	Heat Exch Eff	PV Pumped	Pump Energy
Flat Plate (Closed Loop)	26.6	270	7.43 m²	4.91 W/m²	0.71	0.96	454.0 L	0.700 W/m²/C	2.32 m²	0.88	No	120 W

DUCTS

#	---- Supply ---- Location	R-Value	Area	---- Return ---- Location	Area	Number	Leakage Type	Air Handler	CFM 25	Percent Leakage	QN	RLF
1	Interior	6	134 ft²	Interior	24 ft²	1	Duct Tester Results	Interior	39.00 cfm	3.48 %	0.02	0.60

TEMPERATURES

Programable Thermostat: Y   Ceiling Fans: Y

Cooling	[X] Jan	[X] Feb	[X] Mar	[X] Apr	[X] May	[X] Jun	[X] Jul	[X] Aug	[X] Sep	[X] Oct	[X] Nov	[X] Dec
Heating	[X] Jan	[X] Feb	[X] Mar	[X] Apr	[X] May	[X] Jun	[X] Jul	[X] Aug	[X] Sep	[X] Oct	[X] Nov	[X] Dec
Venting	[X] Jan	[X] Feb	[X] Mar	[X] Apr	[X] May	[X] Jun	[X] Jul	[X] Aug	[X] Sep	[X] Oct	[X] Nov	[X] Dec

Thermostat Schedule: HERS 2006 Reference

Schedule Type		Hours 1	2	3	4	5	6	7	8	9	10	11	12
Cooling (WD)	AM	78.5	78.5	78.5	78.5	78.5	78.5	78.5	78.5	80.5	80.5	80.5	80.5
	PM	80.5	80.5	78.5	78.5	78.5	78.5	78.5	78.5	78.5	78.5	78.5	78.5
Cooling (WEH)	AM	78.5	78.5	78.5	78.5	78.5	78.5	78.5	78.5	78.5	78.5	78.5	78.5
	PM	78.5	78.5	78.5	78.5	78.5	78.5	78.5	78.5	78.5	78.5	78.5	78.5
Heating (WD)	AM	66	66	66	66	66	68	68	68	68	68	68	68
	PM	68	68	68	68	68	68	68	68	68	68	66	66
Heating (WEH)	AM	66	66	66	66	66	68	68	68	68	68	68	68
	PM	68	68	68	68	68	68	68	68	68	68	66	66

Building Input Summary Report

APPLIANCES & LIGHTING

Appliance Schedule: HERS 2006 Reference

Schedule Type			1	2	3	4	5	6	7	8	9	10	11	12
Ceiling Fans (Summer)		AM	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.33	0.33	0.33	0.33	0.33
% Released:	100	PM	0.33	0.33	0.33	0.33	0.33	1	0.9	0.9	0.9	0.9	0.9	0.65
Annual Use:	652 kWh/Yr			Peak Value:	128 Watts									
Clothes Washer		AM	0.105	0.081	0.046	0.046	0.081	0.128	0.256	0.57	0.849	1	0.977	0.872
% Released:	60	PM	0.779	0.698	0.605	0.57	0.581	0.57	0.57	0.57	0.57	0.488	0.43	0.198
Annual Use:	32 kWh/Yr			Peak Value:	8 Watts									
Dishwasher		AM	0.139	0.05	0.028	0.024	0.029	0.09	0.169	0.303	0.541	0.594	0.502	0.443
% Released:	60	PM	0.377	0.396	0.335	0.323	0.344	0.448	0.791	1	0.8	0.597	0.383	0.281
Annual Use:	157 kWh/Yr			Peak Value:	48 Watts									
Dryer		AM	0.2	0.1	0.05	0.05	0.05	0.075	0.2	0.375	0.5	0.8	0.95	1
% Released:	10	PM	0.875	0.85	0.8	0.625	0.625	0.6	0.575	0.55	0.625	0.7	0.65	0.375
Annual Use:	44 Therms/Yr			Peak Value:	1 kBTU/Hr									
Lighting		AM	0.16	0.15	0.16	0.18	0.23	0.45	0.4	0.26	0.19	0.16	0.12	0.11
% Released:	90	PM	0.16	0.17	0.25	0.27	0.34	0.55	0.55	0.88	1	0.86	0.51	0.28
Annual Use:	633 kWh/Yr			Peak Value:	207 Watts									
Miscellaneous		AM	0.48	0.47	0.47	0.47	0.47	0.47	0.64	0.71	0.67	0.61	0.55	0.53
% Released:	90	PM	0.52	0.5	0.5	0.5	0.59	0.73	0.79	0.99	1	0.96	0.77	0.55
Annual Use:	1900 kWh/Yr			Peak Value:	348 Watts									
Pool Pump		AM	0	0	0	0	0	0	0	0	0	1	1	1
% Released:	0	PM	1	1	1	1	0	0	0	0	0	0	0	0
Annual Use:	0 kWh/Yr			Peak Value:	0 Watts									
Range		AM	0.057	0.057	0.057	0.057	0.057	0.114	0.171	0.286	0.343	0.343	0.343	0.4
% Released:	100	PM	0.457	0.343	0.286	0.4	0.571	1	0.857	0.429	0.286	0.229	0.171	0.114
Annual Use:	24 Therms/Yr			Peak Value:	1 kBTU/Hr									
Refrigeration		AM	0.85	0.78	0.75	0.73	0.73	0.73	0.75	0.75	0.8	0.8	0.8	0.8
% Released:	100	PM	0.88	0.85	0.85	0.83	0.88	0.95	1	0.98	0.95	0.93	0.9	0.85
Annual Use:	456 kWh/Yr			Peak Value:	62 Watts									
Well Pump		AM	0.05	0.05	0.05	0.05	0.05	0.05	0.1	0.1	0.1	0.1	0.1	0.1
% Released:	0	PM	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Annual Use:	0 kWh/Yr			Peak Value:	0 Watts									

Hours: columns 1–12

PHOTOVOLTAICS

Array Type	Azimuth	Tilt	Line Loss	Eff Coeff	Inverter Type	Battery Type	Capacity
Conergy S175mu	270	23	0.0035	0.0048	Sunnyboy	None	kWh

Building America

Site Energy Summary 2008

New home
1650 NW 34th Ave
Gainesville, FL 32601-

Project Title:
RSfc-2-danny2-12-09

Climate: FL_GAINESVILLE_REGIONAL_
2/12/2009

End Use:	Benchmark					Prototype					Savings
	kWh	Therm	Gal	MBTU	Cost	kWh	Therm	Gal	MBTU	Cost	Site
Total Space Heating:	152	234	0	23.928	420	92	135	0	13.824	243	42.2%
Heating:	0	234	0	23.409	402	0	135	0	13.510	232	
Heating Fan:	152	0	0	0.519	18	92	0	0	0.314	11	
Total Space Cooling:	6773	0	0	23.109	812	1065	0	0	3.634	128	84.3%
Cooling:	5812	0	0	20	697	826	0	0	3	99	
Cooling Fan:	961	0	0	3.279	115	239	0	0	0.815	29	
Total Hot Water:	2900	0	0	9.894	348	420	0	0	1.432	90	85.5%
Lighting Subtotal:	2226	0	0	7.595	267	776	0	0	2.647	93	65.1%
Wired Lighting:	1851	0	0	6.317	222	645	0	0	2.201	77	65.2%
Plug Lighting:	375	0	0	1.278	45	131	0	0	0.446	16	65.1%
Appliance Subtotal:	3549	109	0	22.985	604	3213	109	0	21.839	564	5.0%
Refrigerator:	669	0	0	2.283	80	455	0	0	1.552	55	32.0%
ClothesWasher:	105	0	0	0.358	13	32	0	0	0.109	4	69.5%
ClothesDryer:	76	53	0	5.560	91	76	53	0	5.560	91	0.0%
Dishwasher:	206	0	0	0.703	25	157	0	0	0.536	19	23.8%
Cooking:	0	45	0	4.500	77	0	45	0	4.500	77	0.0%
Other Appls:	2493	11	0	9.582	318	2493	11	0	9.582	318	0.0%
Ceiling Fan:	146	0	0	0.498	18	146	0	0	0.498	18	0.0%
OAVentilation Fan:	23	0	0	0.078	3	400	0	0	1.365	48	-1639.1%
Total:	15769	343	0	88.088	2454	6111	244	0	45.239	1166	48.6%
Generation(PV):	0	0	0	0	0	-3766	0	0	-12.850	-452	
Net:	**15769**	**343**	**0**	**88.088**	**2454**	**2345**	**244**	**0**	**32.390**	**714**	**63.2%**

Building America

Source Energy Summary 2008

New home
1650 NW 34th Ave
Gainesville, FL 32601-

Project Title:
RSfc-2-danny2-12-09

Climate: FL_GAINESVILLE_REGIONAL_
2/12/2009

End Use:	Benchmark					Prototype					Savings
	kWh	Therm	Gal	MBTU	Cost	kWh	Therm	Gal	MBTU	Cost	Source
Total Space Heating:	152	234	0	27.308	420	92	135	0	15.809	243	42.1%
Heating:	0	234	0	25.563	402	0	135	0	14.753	232	
Heating Fan:	152	0	0	1.745	18	92	0	0	1.056	11	
Total Space Cooling:	6773	0	0	77.763	812	1065	0	0	12.228	128	84.3%
Cooling:	5812	0	0	67	697	826	0	0	9	99	
Cooling Fan:	961	0	0	11.034	115	239	0	0	2.744	29	
Total Hot Water:	2900	0	0	33.294	348	420	0	0	4.820	90	85.5%
Lighting Subtotal:	2226	0	0	25.557	267	776	0	0	8.908	93	65.1%
Wired Lighting:	1851	0	0	21.257	222	645	0	0	7.407	77	65.2%
Plug Lighting:	375	0	0	4.300	45	131	0	0	1.501	16	65.1%
Appliance Subtotal:	3549	109	0	52.622	604	3213	109	0	48.765	564	7.3%
Refrigerator:	669	0	0	7.681	80	455	0	0	5.224	55	32.0%
ClothesWasher:	105	0	0	1.206	13	32	0	0	0.367	4	69.5%
ClothesDryer:	76	53	0	6.661	91	76	53	0	6.661	91	0.0%
Dishwasher:	206	0	0	2.365	25	157	0	0	1.803	19	23.8%
Cooking:	0	45	0	4.914	77	0	45	0	4.914	77	0.0%
Other Appls:	2493	11	0	29.795	318	2493	11	0	29.795	318	0.0%
Ceiling Fan:	146	0	0	1.574	18	146	0	0	1.574	18	0.0%
OAVentilation Fan:	23	0	0	0.264	3	400	0	0	4.593	48	-1639.1%
Total:	15769	343	0	218.48	2454	6111	244	0	96.798	1166	55.7%
Generation(PV):	0	0	0	0	0	-3766	0	0	-43.239	-452	
Net:	**15769**	**343**	**0**	**218.48**	**2454**	**2345**	**244**	**0**	**53.559**	**714**	**75.5%**

FORM FRBER-2006

Confirmed Rating

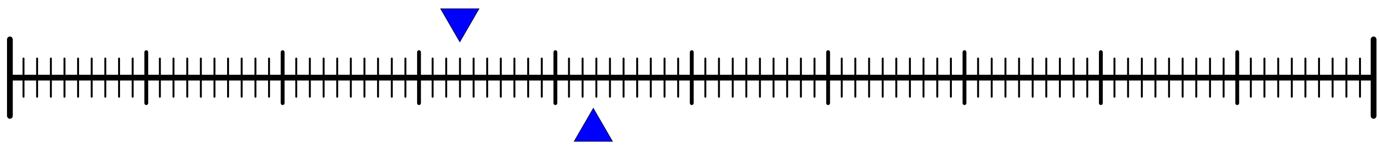
New home
1650 NW 34th Ave
Gainesville, FL 32601-

Design: Gainesville, FL
Title: RSfc-2-danny2-12-09 TMY: GAINESVILLE_REGIONAL_AP, FL

BUILDING ENERGY RATING GUIDE

$616 [3]

$0 **Reference $1868**



0 MBtu **28.7 MBtu** **67 MBtu**

▼ Proposed Home

Savings = $1252

Cost Basis:
MyFloridaAverage
Florida Average
Statewide Prices

Electric Rate: $0.120 /kWh
Gas Rate: $1.720 /Therm
Oil: $1.50/gal LP Gas: $1.75/gal

This Home may Qualify for EPA's Energy Star Label [1]

This Home Qualifies for an Energy Efficient Mortgage (EEM)

Cooling	$87
Heating	$155
Hot Water	$116
Ceil. Fan	$53
Dishwash	$19
Dryer	$76
Lighting	$106
Misc.	$360
Pumps	
Range	$41
Refrig.	$55
PV	($452)

HERS Index[2]: 29

Ken Fonorow — Certified Rater
292 — I.D. Number

Signature ______ Date ______

This Rating Guide is provided to you by a Home Energy Rater who is trained and certified to perform Ratings in accordance with the RESNET standard. Questions or complaints regarding this Rating may be directed to:

EnergyGauge Program Office
1679 Clearlake Road
Cocoa, FL 32922-5703
(321)638-1492
engauge@fsec.ucf.edu

NOTES:
[1]The home builder must have signed a Memorandum of Understanding with EPA as an Energy Star Homes partner.
[2]HERS Index calculated in accordance with 2006 RESNET standard, Section 303.2 (Reference home = 100, Zero energy use = 0).
[3]PV production assumes net metering.

Photovoltaic System Performance Summary

New home
1650 NW 34th Ave
Gainesville, FL, 32601-
Registration #:

Title: RSfc-2-Final_2_12_09
User

TMY City: FL_GAINESVILLE_R
Elec Util: MyFloridaAverage
Gas Util: Florida Average
Run Date: 02/12/2009 17:38:01

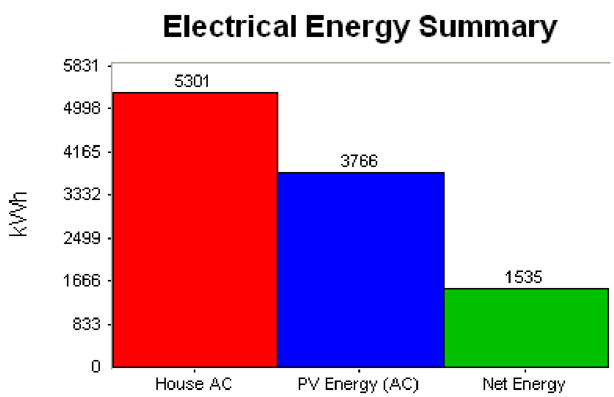
Start Date: January 1 End Date: December 31

Photovoltaic System Inputs

#	Size m² (ft²)	Orientation Degrees (N=0,E=90)	Tilt Degrees (0 = flat)	Array Type	# Modules	Array Rated Efficiency	Array Rating @STC Wp	Inverter Type	Inverter Rated Efficiency
1	22.97(247.24)	270	23	Conergy S175mu	18	0.126	3150	Sunnyboy	94 %
Total	22.97(247.24)	NA	NA	NA	18	0.12617	3150	NA	94.0 %

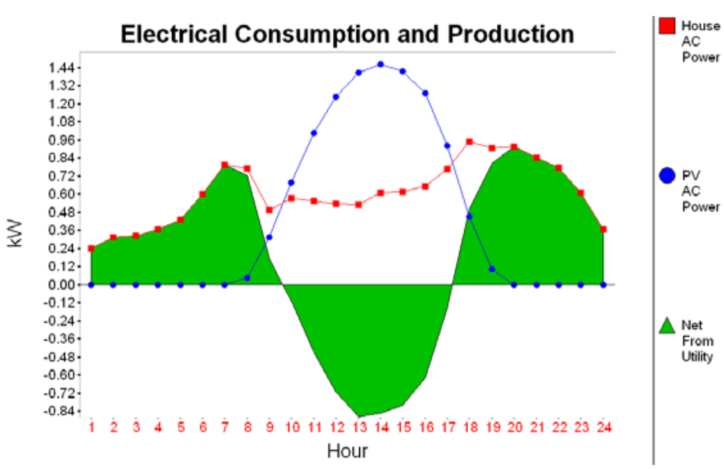
Average Meteorological Data

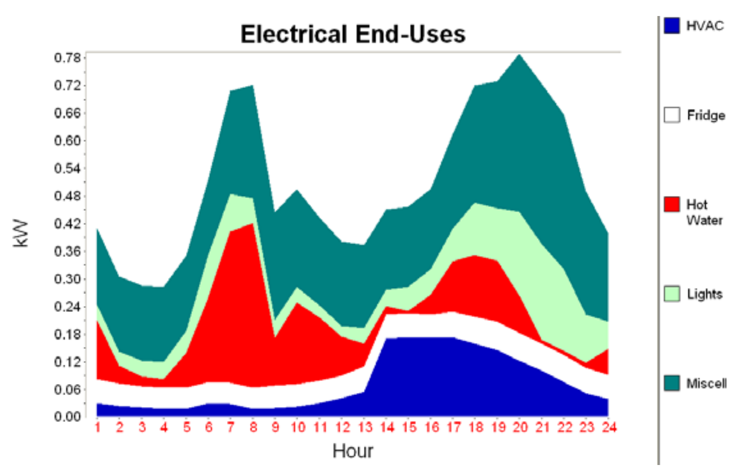
Horizontal Insolation (kWh/m²/Day)	Ambient Temp. ºC (ºF)	Wind Speed m/s (mph)	Wet Bulb ºC (ºF)
5.14	20.1 (68.1)	3.02 (6.75)	17.2 (63.0)



Average Daily System Performance

#	Solar Insolation POA (kWh/m²)	DC Energy (kWh)	Array Efficiency	AC Energy (kWh)	Conversion Efficiency	Overall AC Energy/ Rating/Sun	PV AC to House	Avg. Capacity Factor kWhAC/(24*RatedWp)	PV(AC) as % of HVAC
1	4.59	11.35	10.78 %	10.32	90.9 %	71.4 %	34.91 %	13.6 %	2009.03 %
Total	4.59	11.4	10.80 %	10.3	90.9 %	71.4 %	34.9 %	13.6 %	2.01E3 %





Appendix C

Photovoltaic System Site Shading Analysis and Report

Solar Access and Shade Report

01/28/09

For:

Danny Parker
1650
Gainesville, FL

By:

Andreas
FLorida Solar Energy Center
1679 Clearlake Rd
Cocoa, FL 32922
321-638-1000

Measurements made by **Solmetric SunEye™** -- www.solmetric.com

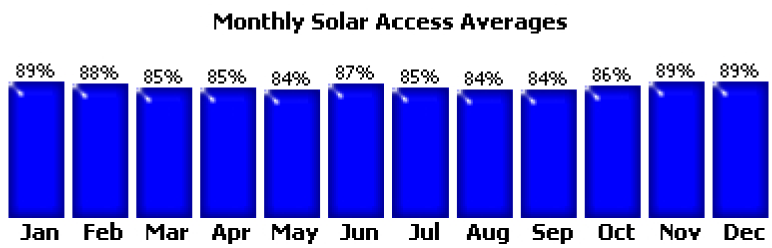
Solmetric

Session Properties

Name	1650
Creation Date	04/24/08 14:55
Note	(none)
Location	Lat: 30°, Lon: -82° Mag Dec: -5° Time Zone: GMT-5:00

Solar access averages of all skylines(4) in this session

Annual	Summer	Winter
86%	85%	87%

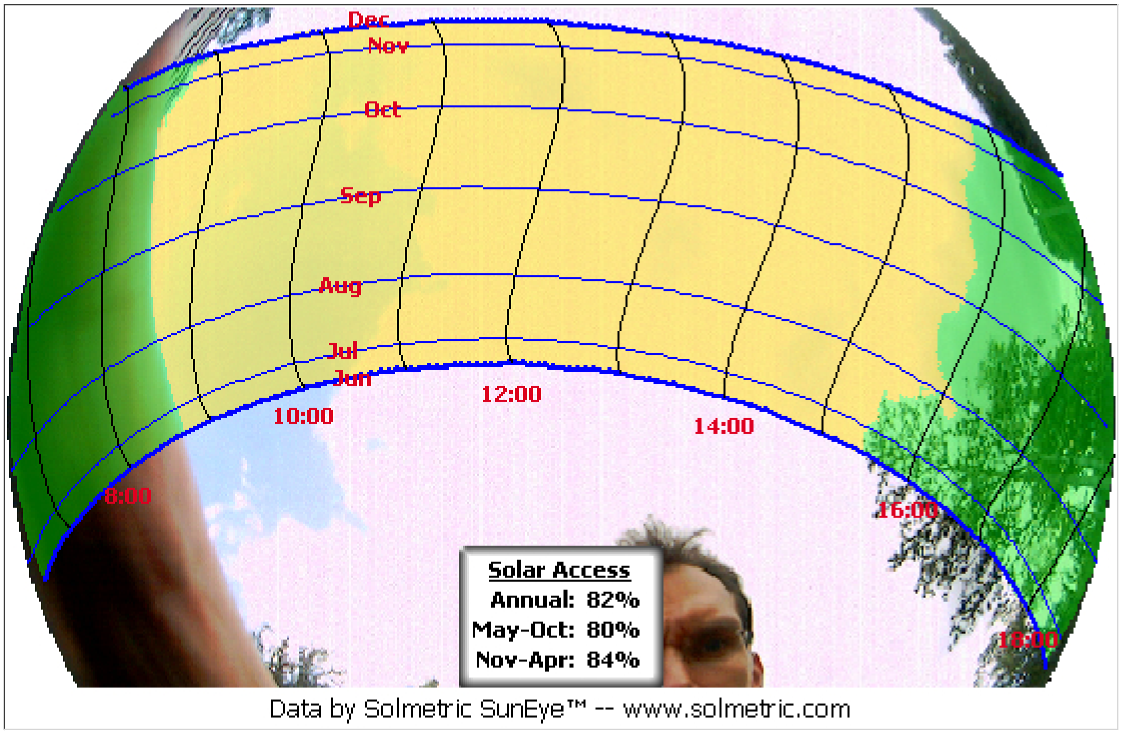


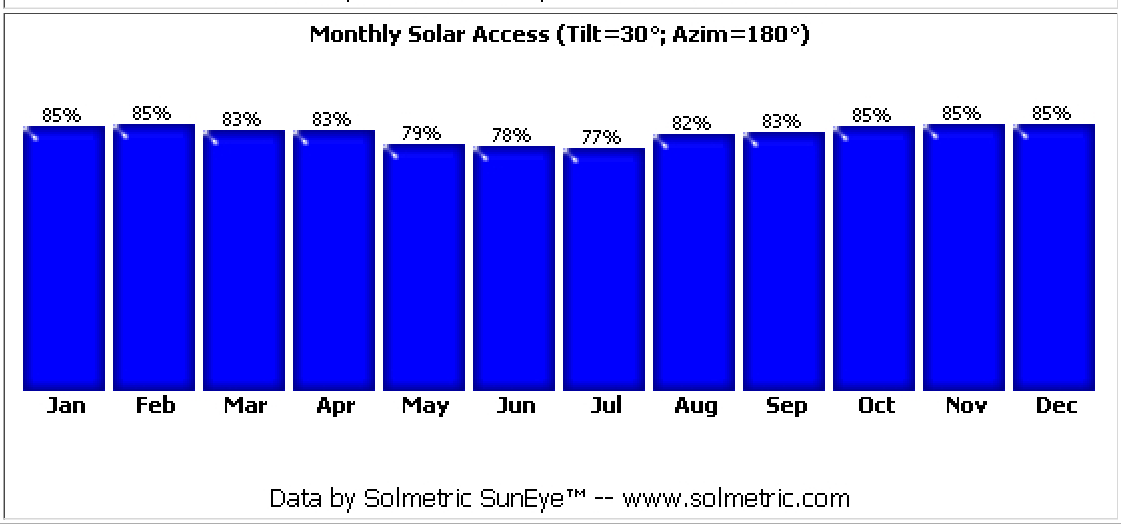
Skylines

- **Sky01 - Lower sw pv corner**
- **Sky02 - Lower middle pv**
- **Sky03 - Lower nw pv corner**
- **Sky04 - Lower sw corner v2**

Sky01 -- 04/24/08 14:59 -- Lower sw pv corner

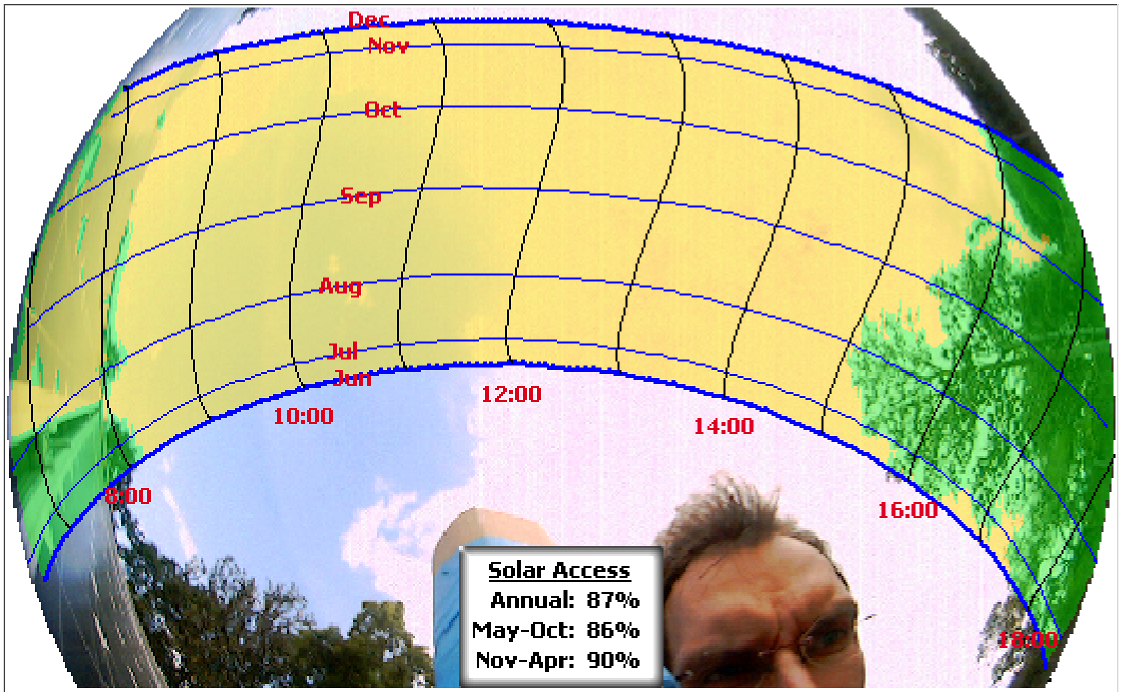
Panel Orientation: Tilt=30° -- Azimuth=180°
Solar Access: Annual: 82% -- Summer (May-Oct): 80% -- Winter (Nov-Apr): 84%



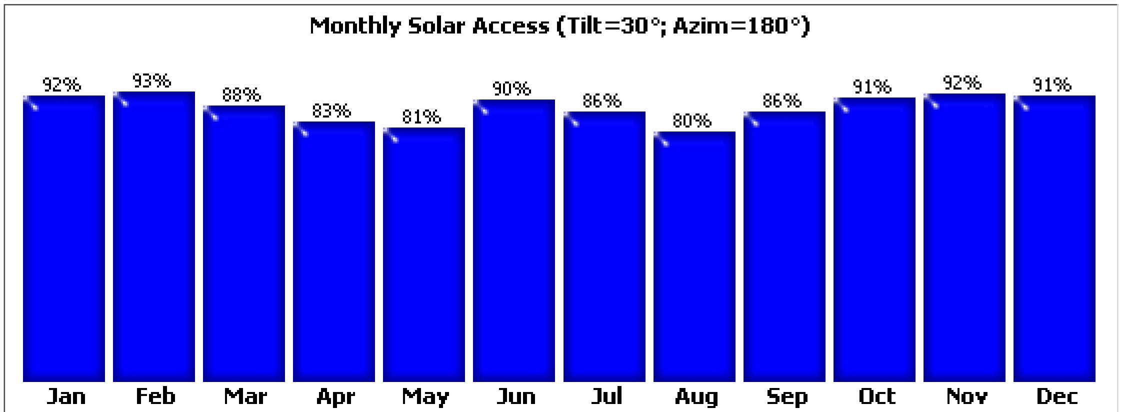


Sky02 -- 04/24/08 15:04 -- Lower middle pv

Panel Orientation: Tilt=30° -- Azimuth=180°
Solar Access: Annual: 87% -- Summer (May-Oct): 86% -- Winter (Nov-Apr): 90%



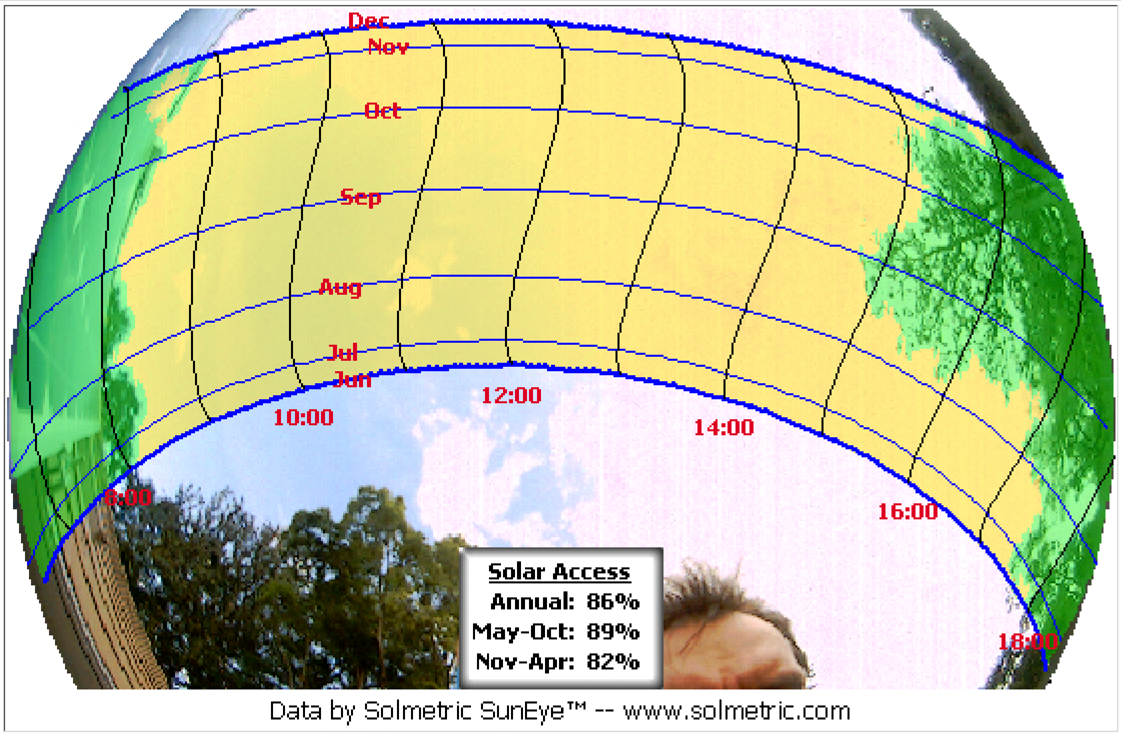
Data by Solmetric SunEye™ -- www.solmetric.com

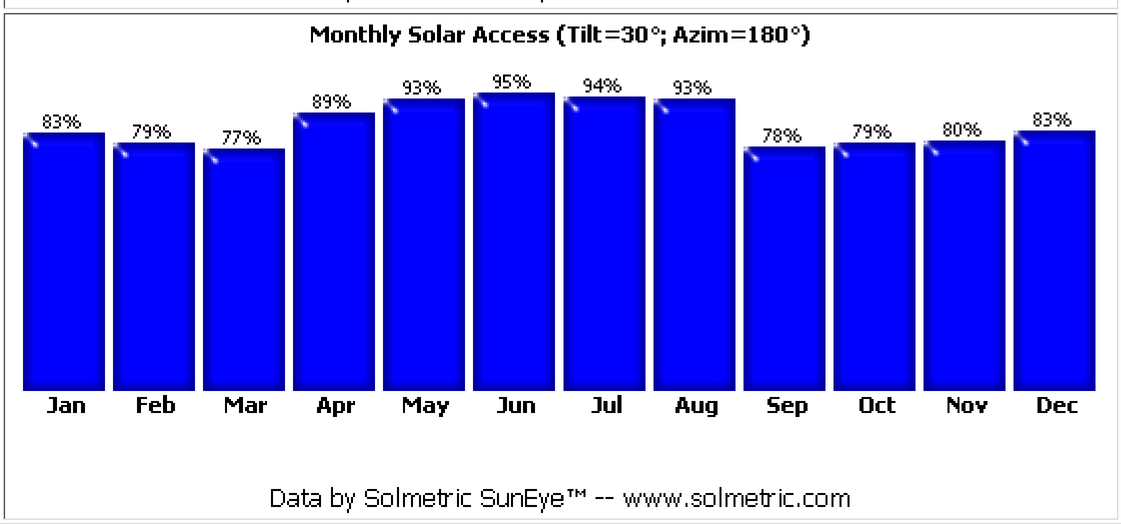


Data by Solmetric SunEye™ -- www.solmetric.com

Sky03 -- 04/24/08 15:07 -- Lower nw pv corner

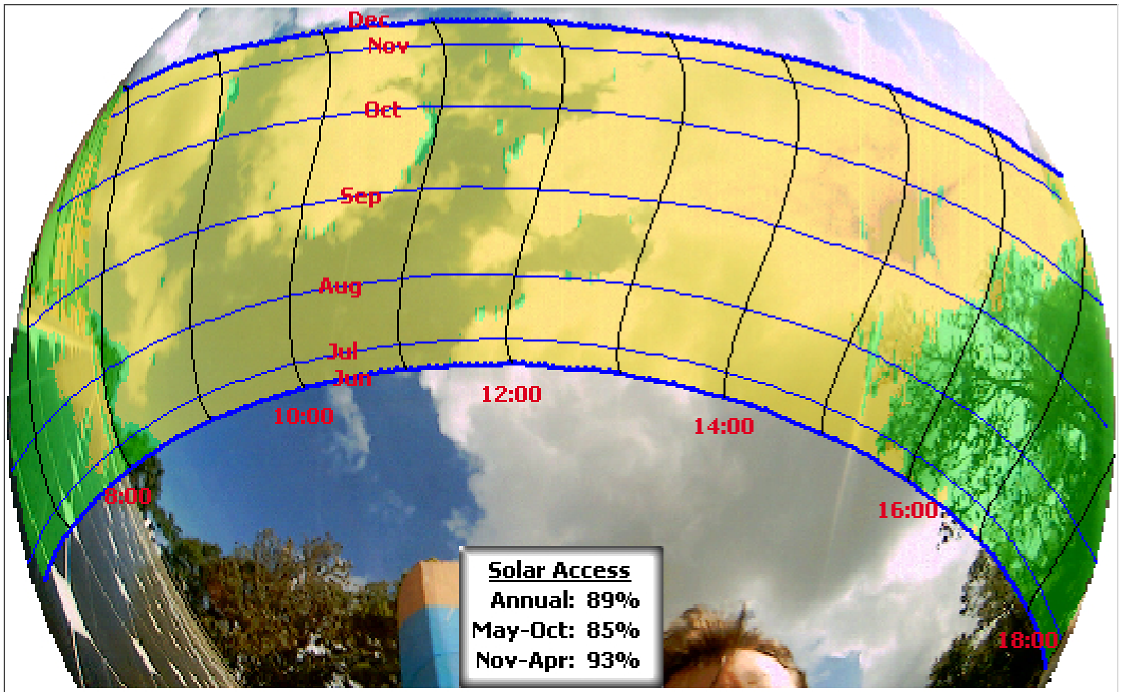
Panel Orientation: Tilt=30° -- Azimuth=180°
Solar Access: Annual: 86% -- Summer (May-Oct): 89% -- Winter (Nov-Apr): 82%



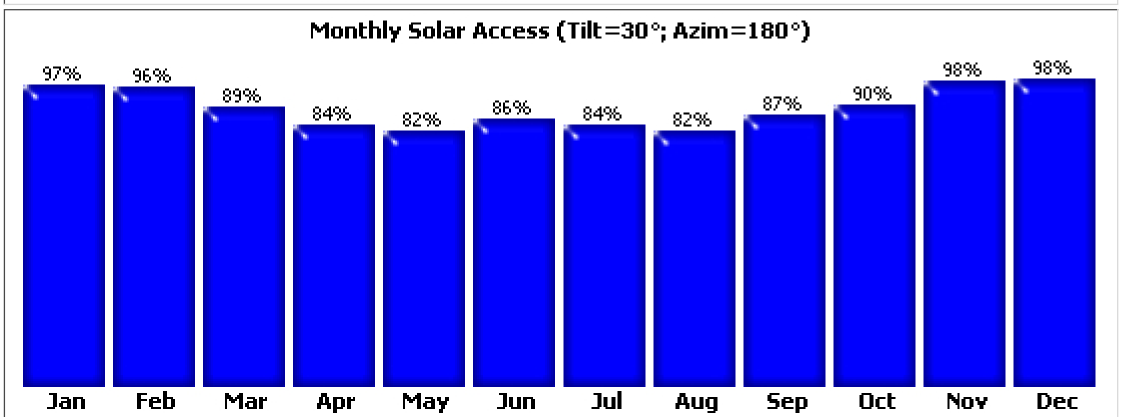


Sky04 -- 04/24/08 15:33 -- Lower sw corner v2

Panel Orientation: Tilt=30° -- Azimuth=180°
Solar Access: Annual: 89% -- Summer (May-Oct): 85% -- Winter (Nov-Apr): 93%



Data by Solmetric SunEye™ -- www.solmetric.com



Data by Solmetric SunEye™ -- www.solmetric.com