Net Zero Energy Home, Scionwood Retreat, an Alternative Approach

Project Description

It is now February of 2016 and at Scionwood Retreat, Kathryn and I have lived in a 100% sustainable sourced Net Zero Energy Home since 2006. It happened instantaneously nearly 10 years ago in September of that year. I will share our story with you and maybe it will encourage others to consider our Alternative Approach to becoming a Net Zero Energy Home. An approach that is available to all homeowners tomorrow.

In 1996 we moved into our modestly built but high performance HUD Code doublewide home built on a properly closed crawl space foundation. A building that was our private demonstration that any home can achieve a much higher percentage of its total potential if a few key elements of its building envelope and mechanical systems are actually properly completed as intended. You can read a short account of this approach to construction by reviewing, "The House that Bruce Built" at www.sivadhome.com. Additionally there is an addendum listing Enhancements to the original construction that have taken place over the years since the original construction. Yes we have lived in a very comfortable, durable, healthy, and energy efficient home now for 20 years.

With the above material as the backdrop, we arrive at September 2006 in our ten year old home. Kathryn and I had been to watch the Al Gore inspired film, An Inconvenient Truth. As we walked out Kathryn said, "I wish that we could personally do something". At that point I said well maybe we can; let me do some calculations when we get home. Once home I added up the kWh from our utility bills for the previous 12 months for our all electric home which includes an electric water well pump. In our state of North Carolina we had and continue to have a home grown sustainable energy production program called NC Green Power. The organization recruits and pays providers to produce sustainable electricity and feed it into the electricity grid. It also recruits customers who want to use sustainable energy and sells them blocks of 100kWh for $4.00 each.

We divided our total kWh needed annually by 12 months. Ten blocks would not meet our need but eleven blocks more that met our requirement. We filed our request for NC Green Power to provide us with eleven blocks of electricity for $44.00 per month and poof we were a 100% equivalent sustainable energy home. Each month the electric utility bill arrives with all the electric company's charges on it plus an additional NC Green Power charge for $44.00. We make one payment and all is done. If you want to be more technical and want to address electricity transmission and distribution losses which the U.S. Energy Information Administration estimates at an average of 6% then according to my calculations we could have been at times only a 99% sustainable home in any given year. However as you will see we addressed that in subsequent years and actually became a home providing substantially more energy than we needed even when counting line losses.

In 2011 we added onsite a 3.5KW solar electric panel array with battery backup. At that time we continued to purchase the eleven blocks of NC Green Power to help cover some of the other toes of our overall carbon footprint. In 2015 we added an additional 3.4KW array and reduced to five

our purchase of NC Green Power. On an annual basis we now produce more than 66% of our kWh needs on site. With our NC Green Power purchase we continue to provide more kWh than we need for our home. We have benefited from already having a reasonably efficient home. Some homeowners may need to start with work that improves the efficiency of their home. Others may want to start down both paths at the same time. Deciding to actually take steps toward the goal is the important element.

There are several important aspects of our initiation of this Alternative Approach to achieving a Net Zero Energy Home to consider. We did not need to have a large financial investment. We did not need to figure out what equipment to purchase. We did not need to maintain any equipment. And we did not need to find a qualified contractor. If you use a combination of fossil fuel and electricity in your home, there are conversion formulas that will provide the total equivalent amount of Sustainably produced kWh for which you will need to contract. Purchase the necessary amount of sustainable energy monthly from any number of available sources and take an important step that improves the potential for humans on this earth.

Our home could be located anywhere and be of any orientation or construction type.

It is an approach that is compatible with the realities of families that have less financial resources but who want to be a part of and help build our sustainable energy future.

Since we began in 2006 we have influenced a few others to pursue our path. We hope that our sharing in this format will encourage additional participation.

Please consider pursuing this purchased power option as a valid approach to achieve a Net Zero Energy Home for yourself. Additionally, please consider encouraging others to support and pursue this as a valid alternative approach.

Fourteen color photographs of Scionwood Retreat are at the end of this material for your viewing pleasure.

Project Team

Other Team Members

Bruce Eugene Davis, Sivad Home, Applied Building Science, Home Designer, Energy Consultant, Home Owner - 1995 to present
R-Anell Custom Homes, Builder - 1995
Jack Orum, Design Aire, HVAC Design and Installation, Owner & Installer, Service - 1995 to 2007
North Carolina Green Power, provides off-site sustainably produced electricity, billed through Electric Utility - 2006 to present
Tom Honey, Honey Electric Solar, PV Design and Installation, Owner & Installer, Service - 2011 and 2015

Ratings, Awards and Recognition

Ratings:

None

NESEA Awards:

None

Awards:

None

Published References:

The House that Bruce Built, 1997/1998, www.sivadhome.com
The House that Bruce Built: Enhancements 1.0 - 6.0, ongoing, www.sivadhome.com

Quick Facts

General

Location	Pittsboro, NC
Building Type	single family residence - HUD Code doublewide
Project Type	Zero Energy
Basis of Performance Claim	Verified
Bedrooms	3
Bathrooms	2.0
Conditioned Floor Area	1,792 sq. ft.

Energy Summary

Energy Data Type	Verified
Renewable Energy System Type(s)	Other
Ratings	none
Annual renewable energy generated	13,200 kWh/year

Envelope and Mechanicals

Foundation wall assembly	Concrete footers were poured for all the concrete block piers that carry the weight of the home from the I-Beams and for the parameter brick curtain wall that totally encloses the properly closed crawl space. Prior to pouring the concrete for the parameter footer the tie-down anchors were augured into the footer trench. The single brick width curtain wall foundation is not insulated. Its height ranges from 3.5 to 4.5 feet tall. The home is 28 feet wide and 64 feet long.
Above grade wall assembly	2x6 wall assembly with R-19 fiberglass batts. The interior surface is 1/2 inch sheetrock and the exterior is 1/2 inch OSB with vinyl siding
Door Assembly	foam core filled steel door [3' 0" x 6' 8"] with one third of its area being an insulated glass sandwich fixed window light

Completion

Completion date
Oct 01, 2006

Occupancy

Homeowners of this building and we live here full time. Two adults. At home much of the time. Retired but still active.
When we built this home in 1996 there were also 2 active teenagers living in the home.

Days per year Building is fully occupied:
365

Scope

We moved into our all electric new home June 11, 1996. It is the home to which in September 2006 we applied 100% sustainably produced power that we began purchasing monthly from North Carolina Green Power through our local electric utility. With that ongoing purchase arrangement of the necessary amount of power we became a Net Zero Energy Home. We have continued purchasing power while adding on-site 3.5 KW PV in 2011 and 3.4 KW PV in 2015. In 2015 we did reduce that amount of power we are purchasing each month. We still purchase enough extra NC Green Power to maintain our position as a Net Zero Energy Home.

Type of Construction	New
Number of buildings	1
Floor area of each building	1,792

Bedrooms	3
Bathrooms	2.0
Stories	1
Conditioned Building Volume	15,680 cu ft.
Conditioned Floor Area	1,792 sq. ft.

Location and Climate Details

Single family residence - HUD Code doublewide

Address	793 Elmer Keck Road Pittsboro, NC 27312 United States
Location Type	Rural
Climate Region	Zone 4
Köppen Climate Type	Cfb
Lat. / Long.	POINT (-79.290576 35.711467)
Elevation	400 ft.
Solar Insolation	5 kWh/m2/day
Annual CDD and Base Temp	1787 | 65 deg F
Annual HDD and Base Temp	3518 | 65 deg F

Site

Site conditions:
Previously undeveloped land
Site description:

The 16 acre site is largely mixed timber with wild brush and undergrowth but it does have two open areas near each other totaling about 3 acres that are located toward the back of the property. A driveway with partial gravel makes its way from the county gravel road to the open areas where our home is located. Flowing across the middle of the property are two separate small spring fed streams that flow year round. The front and back areas of the property are of a higher elevation than the middle area with the two streams. The driveway already had a causeway built across the wetlands with a culvert for each stream. A larger stream forms the eastern boundary of the property. Wonderful...

Materials and Design Strategy

Materials:

This home was factory built 100 miles away with no notion with regard to sustainable construction methods or materials.
Being factory built the company does work to efficiently construct and deliver the unit and the reduction of waste is in their financial interest.

Special architectural measures:

The long axis of the home was oriented east/west. The east and west walls of the home have only one window each. The long south side of the home has windows that receive full sun in winter and some shading in summer. The walls were upgraded to 2x6 lumber. The R-values were above common practice at the time of construction. The design was intentionally simple so that the workers would be much less prone to make the multiple air barrier and thermal barrier mistakes that we find in most buildings. Thus the two barriers work together and are continuous throughout the whole structure. The traditional moisture issues of crawl space homes in the south was addressed through the use of a properly closed crawl space which delivers durability, comfort, health, and efficiency benefits. The result is a home that in life achieves a higher percentage of its potential as listed on its design papers. The mechanical equipment [heat pump and ERV] are well designed and installed. Quiet, wonderful, inexpensive comfort.

LCA Description:

No Life-Cycle Analysis was used. We designed our home to be inexpensive to build, equip, and operate and to do so while meeting our high standards for health, comfort, and durability. It is the minimum home that anyone would want to build!

Indoor Environment Description:
No carpet was included. Whole house, energy recovery ventilation [protected with filtration] was included and operated at the air flow rate necessary to dilute the odors from out gassing chemicals from the standard construction materials used. The design criterion for air flow was that it had to be adequate such that when entering the home one did not smell the new building chemicals. This rate began at .62 air changes per hour, later slowed to .42 air changes per hour, and now operates at .25 air changes per hour. Plus bath and kitchen exhaust, dryer, and natural air exchange through this tight home with balanced ventilation. Air cleaning for the heat pump air flow is provided by pleated filters at the two filter return grilles plus a MERV 10 filter located at the heat pump air handler. Two 5 micron sediment water filters set in tandem and located between the water pump and the pressure tank keep the whole supply plumbing system free from debris. Two low level carbon monoxide monitors are located in the home.

General Energy Use, Strategies and Systems

Energy Use:

This home began in 1996 as an all-electric, high performance, modest cost to build home that is durable, comfortable, and supportive of the health of its occupants. In 2006 it became a Net Zero Energy Home through the use of purchased sustainable energy from NC Green Power. We purchased on a monthly basis an amount of kWh that yearly exceeded our total annual use. We could easily do this because our home was not an energy hog and an institution had been created in our state that provided this service. We have continued to enhance the efficiency of our home over the years. Plus we added a 3.5 KW PV unit with battery backup in 2011 and another 3.4 KW PV unit in 2015. With the 2015 addition we reduced our NC Green Power purchase to a total of 6000 kWh annually. Beginning in 2006 until late 2015 we annually purchased 13200 kWh [11 blocks of 100 kWh for $44.00 each mo.] This purchase power approach is our key strategy that we want to highlight.

Energy Strategies:

Start with a wonderfully comfortable, simple home that is energy efficient. Enjoy it. At ten years of use start and continue purchasing sustainable power to be put into the electrical grid in an amount that exceeds the total energy use of the home. Enjoy it a whole lot more knowing that for an extra $44.00 per month paid through the electric utility you have demonstrated the feasibility that anyone can have a Net Zero Energy Home. A personal choice to impact climate change and help secure the continued potential for human beings to have a place to live. Encourage others...

Zero Net Energy Definition Used Source Energy Use

Monthly Energy Data and Utilities

Energy Data Type:
Verified
Electric Utility:
Duke Energy Progress
Other purchased Fuels:

We are an all-electric home. Originally the utility was Carolina Power and Light. Then it became Progress Energy. Then it was purchased and now the name of the grid we are attached to is Duke Energy Progress.

Datasets and utility bills:

Electric Meter Monthly Readings for the Twelve months prior to beginning the purchase of NC Green Power*

2005	kWh
October	946
November	946
December	1698
2006	
January	1452
February	1452
March	939
April	886
May	689
June	882
July	883
August	1011
September	753

Annual kWh = 12537

Purchased Monthly from NC Green Power 11 Blocks of 100 kWh each = 1100 kWh monthly
1100 kWh x 12 months = 13200 kWh annual purchase

*These readings are for whole calendar months. The utility billings were for use through the middle of the calendar month. For some months we skipped a monthly reading and at the end of the second month we divided the two months of use by 2 and placed the same amount of kWh for the two adjoining months. The all-important total annual kWh use is correct.

In addition to reading the utility meter at the end of each calendar month we also read a second sub-meter that we privately installed that measured all the kWh use by the heat pump, the energy recovery ventilator, and the small dehumidifier that controlled the water vapor level in the properly closed crawl space. The sub-meter was installed in 1996 when we built our home.

Electric Meter Monthly Readings – 12 months ending 2016 01

2015	kWh
February	1478
March	1108
April	899
May	852
June	1021
July	1140
August	990
September	669
October	670
November	992
December	1118
2016	
January	1625

Annual kWh = 12562

PV – 2011 – 3.5KW

2015	kWh
February	316
March	386
April	451
May	482
June	458
July	455
August	434
September	358
October	358
November	269
December	214
2016	
January	300

Annual kWh = 4481

Design projection kWh = 4626

Actual kWh as a % of projection = 97%

PV – 2015 – 3.4KW

2015	kWh
September	357
October	358
November	241
December	191
2016	
January	255

To Date kWh = 1402

Design projection kWh = 4733

Projection kWh for these months = 1597

Actual kWh as a % of projection = 88%

PV1	+	PV2	+	NC Green =	Total sustainable sources
4481	+	4165	+	6000 =	14646 kWh projection for next year

Projection kWh	Actual kWh use =	Percent kWh provided by sustainable sources
14646 divided by	12562 =	117%

Datasets and utility bills sources and reliability:

We have kept a record of the monthly electricity use by reading the house utility meter monthly since 1996. We wanted calendar month data as opposed to the mid-month billing that the utility provided. However, on an annual basis they would essentially be the same and I imagine they have historical records. Once we added PV at our home to the mix we not only recorded the utility meter data, we recorded the data each month from the PV system meter. By the way, we have a net meter agreement with the utility. For the purchase power, NC Green Power will have all the records of our monthly purchases. They would have all their data with regard to contracts with producers and with purchasers.

Cogeneration

Cogeneration System Description:

None

Renewables and Energy Balance

Renewable Energy Sources:
Clean energy is imported from off-site (e.g. utility wind power), or renewable energy certificates (RECs) are purchased

Renewable Energy System Description & Details

We purchase kWh through NC Green Power. They write contracts with multiple types of producers that put kWh into the electrical grid. All the producers are providing sustainably produced electricity. It could be solar electric, landfill gas run generator, wind, or other types.

Annual renewable energy generated	13,200 kWh
Annual Renewable Energy Generated Data Type	Measured

Renewable Energy System Type(s)	Source of Annual Production Data
Other	We added up our total annual electricity use for our all electric home with electric water well pump. Divide by 12. Purchase from NC Green Power 1100 kWh per month [13200 kWh annually]. Pay them their $44.00 per month as an added charge on our monthly electric utility bill. They have all the contracts and meters. We just pay to play.

Storage and Installed Capacity

There are 8, 380ah, 6 volt lead acid L16 batteries in the battery box. They are kept charged by the system to be ready for a grid power outage.

Energy systems description:	Backup batteries [2011 system] are kept charged but are only used during those times [multiple times in our location] when the grid goes down. The transfer is automatic when the grid goes down. Sometimes we do not even realize that the grid is down. When the grid fails, the heat pump, range, dryer, and the water heater are locked out. All remaining electrical functions are available for use. With prudent use we can go for days with the grid down. Yes we have backup heating with a wonderful, sealed combustion wood stove. Plus we have an outdoor grill for cooking and heating water and lines for drying clothes. Our primary interest is keeping the water pump working and running the refrigerator and freezer, plus maintaining communications.
Energy Storage Capacity	18 kW

Walls and Roof

This is an on-frame HUD Code doublewide. It measures 28' x 64' = 1792 sq. ft. Concrete footers were poured for all the concrete block piers that carry the weight of the home from the I-Beams and for the parameter brick curtain wall that totally encloses the properly closed crawl space. Prior to pouring the concrete for the parameter footer the tie-down anchors were augured into the footer trench. Following construction below grade foundation water-proofing and a drain to daylight parameter French drain was installed. The finish grade of the soil drains all surface water away from the foundation.
The home uses 2 x 6 wall framing and a 2 x 4 roof truss system with cathedral ceilings throughout the interior and approximately a 3/12 roof pitch.
Insulation values are: Ceiling R-30, Walls R-19, and Floor R-22.
The windows are intentionally simple. Single-hung, none treated, single-pane glass in an aluminum frame plus and interior single-hung of the same materials. The two windows are separated by the wall framing leaving a 5 inch space.
Space conditioning is provided by a standard heat pump and an energy recovery ventilator. Separate airtight ducts systems were site installed for each.
The properly closed crawl space has a continuous and sealed poly vapor retarder for the ground and walls - leaving a 3 inch view strip at the top of the foundation wall. A dehumidifier with gravity drain to outside manages the minimal water vapor that migrates into the space.

Foundation wall assembly	Concrete footers were poured for all the concrete block piers that carry the weight of the home from the I-Beams and for the parameter brick curtain wall that totally encloses the properly closed crawl space. Prior to pouring the concrete for the parameter footer the tie-down anchors were augured into the footer trench. The single brick width curtain wall foundation is not insulated. Its height ranges from 3.5 to 4.5 feet tall. The home is 28 feet wide and 64 feet long.

Above grade wall assembly	2x6 wall assembly with R-19 fiberglass batts. The interior surface is 1/2 inch sheetrock and the exterior is 1/2 inch OSB with vinyl siding
Above grade wall R-value	19.0
Cathedral ceiling assembly	100% of the ceiling is a cathedral assembly using a 2 x 4 truss system Because it is HUD Code, the ceiling assembly for each half is fully constructed and then placed onto each half of the home as a unit which substantially reduces the wall to attic air leakage paths. The ceiling is 1/2 inch sheetrock and the insulation is blown cellulose.
Cathedral ceiling R-value	30.0
Roof Assembly	2 x 4 truss system The home is 28 feet wide and 64 feet long. Each section is 14 wide and 64 feet long. The attic has soffit and ridge venting and the decking is 1/2 inch OSB with shingles.

Windows and Doors

Window Assembly:

Intentionally inexpensive aluminum frame single-hung windows with non-coated single-pane glass.
Interior single-hung storm window of the same materials with the two windows separated by the wall framing leaving a 5 inch space between them

No record of U-factor, SHGC, etc.
Cheap windows

Door Assembly:

Foam core filled steel door [3' 0" x 6' 8"] with one third of its area being an insulated glass sandwich fixed window light

Door Area 20 sq. ft.

Mechanical Systems

Space cooling - Manufacturer & Model	Rheem RPRL 024JEZ 2-stage heat pump
Space cooling - capacity	7 kW
Space heating - Manufacturer & Model	Rheem RPRL 024JEZ 2-stage heat pump
Space heating - capacity	7 kW
Domestic hot water - Manufacturer & Model	Intertherm 20RTOE3JNC - electric
Domestic hot water - capacity	50 gal
Domestic hot water - efficiency	92 kW
Ventilation - Manufacturer & Model	Venmar AVS Duo 1.2 with TRE = 75%
Lighting Manufacturer and Model	multiple
Lighting Efficiency	all lighting is cfl [80%] or led [20%]
Mechanical Equipment Installation Details and Comments	Manuals J, D, S, & T were used in design and selection. With room by room calculations present, air distribution was balanced with air flow measurements. The complete air distribution system including the air handler was tested with a duct blaster and found to have less than 5 CFM25 Total air leakage. System performance was achieved by establishing correct air handler air flow and then establishing proper refrigerant charge. The 7KW heat strip is locked out until outside temperature drops to 20 degrees F. The ERV ventilation system has a separate sealed air distribution system that was tested with a duct blaster and found to have less than 5 CFM25 Total air leakage. Balanced air flow into and out of the home was achieved by using through the cabinet pressure taps and the resulting air flow measurements at the ERV and then making adjustments to the balancing dampers. There is a simplicity to using a separate duct system for the ERV that avoids a lot of installation mistakes that we find where space conditioning and ventilation equipment are connected to the same duct system.

General Process

A whole range of Applied Building Science key issues that address the structure, its mechanical systems, and the wellbeing of occupants were addressed in the design of this home. In essence I built [or bought] what I taught. See "The House that Bruce Built" at www.sivadhome.com. Also see "The House that Bruce Built: Enhancements 1.0 - 6.0 at the same site. The practical, basic principles that need to occur to ensure that a home actually becomes its potential.

Design for Adaptability:

Exterior and interior doors are 36 inches wide, with only two interior door exceptions. The height of the crawl space is such that there is a comfortable amount of space to pursue revisions as desired. The crawl space is clean and dry given that it is a properly closed crawl space. The limited length hallway is 42 inches wide in place of the traditional 36 inch wide hallway.

Software Tools

Software Tools:

Tom Honey used several solar program tools for his 2011 and 2015 PV installations.

General modeling information:

During the building design phase the Elite software available in 1995 was used.
Jack Orum of Design Aire used the Rightsoft suite of programs to provide his J, D, S, and T information for the Heat Pump system and to supplement the Duct design for the ERV. Jack is known for sizing duct systems to be very quiet. You do not know if the system is on or off you are just very comfortable.

Lessons Learned

Outcome of project goals:

Very often the most important part of the construction process is the persons that you hire to perform the work. The quality of their knowledge and ability to actually perform the work as intended makes all the difference in the world. Performance standards need to be in agreement prior to work beginning. Buying say a SEER 13 piece of equipment and actually having it operate on-site as SEER 13 depends on the installer. We often refer to "Lucky 7" systems. You pay for a SEER 13 and you are lucky if it delivers SEER 7 because of the inadequate installation. The original set up contractor had to be dismissed. While there are detailed set up instructions, he followed none of them. We asked around and hired a wonderful contractor who very easily and methodically proceeded through the processes and delivered the expected work. The General Contractor had to pay for this extra subcontractor out of his specified budget, not us. What we would have received had we not insisted on correct work [we had a copy of the required set up processes] would have been horrible for years to come.

Discrepancies:

Our home has just been wonderful and actually delivered as intended. However living in it has been so much more enjoyable than we anticipated - even to this day it is so pleasant.

General Finances

In September of 2006 we started with our reasonably energy efficient 1996 home. It is not a "World Record Setter" but it is good enough. For our all electric home we calculated the total kWh used over the previous 12 months. We divided that by 12. We determined that we would need on average 1100 kWh per month to equal more than our current annual usage. North Carolina Green Power sells access to produced sustainable power from multiple sources. They sell blocks of 100 kWh for $4.00 per block. We needed 11 blocks per month for $44.00 per month. We contracted with NC Green Power for the 11 blocks. The $44.00 charge is listed on our monthly electric utility bill. We pay it. The funds are passed on to NC Green Power. NC Green Power continues to contract with providers to feed sustainable power into the grid. We are happy with our personal, direct, real commitment to addressing climate change. Repeat. Repeat. Simple. Simple for anyone. Happy. Go do it. Do not need a special home or a home with a special orientation, or solar access, or finances, or knowledge of equipment, or how to maintain equipment, and the list go on. Poof you live in a Net Zero Energy Home.

Value of Tax Credits for renewable energy systems

Cost breakdown information:

Rebates and Financial Incentives

Federal incentives	N/A except that since NC Green Power is a not for profit our total annual contributions to purchase power is a regular tax deduction
State incentives	N/A except that since NC Green Power is a not for profit our total annual contributions to purchase power is a regular tax deduction
Local incentives	none
Utility incentives	none
Other incentives	None other than our desire to work with others to help maintain the only planet where human beings can live so that our descendants will have a place to live.

Advice

Just give it a try. It is quick, direct, and easy.
Some participants may want to follow a double track. Commit to energy efficiency upgrades and to purchased power and meet in the middle over time.
There are conversion formulas for fossil fuels to kWh so that you can cover all your home energy use.
We chose to use an in state organization to help build our local infrastructure, but there are multiple organizations out there offering this power and some of it is cheaper than we are paying.

Front of Scionwood Retreat

Home entry and country kitchen

Country kitchen and Jotul wood stove

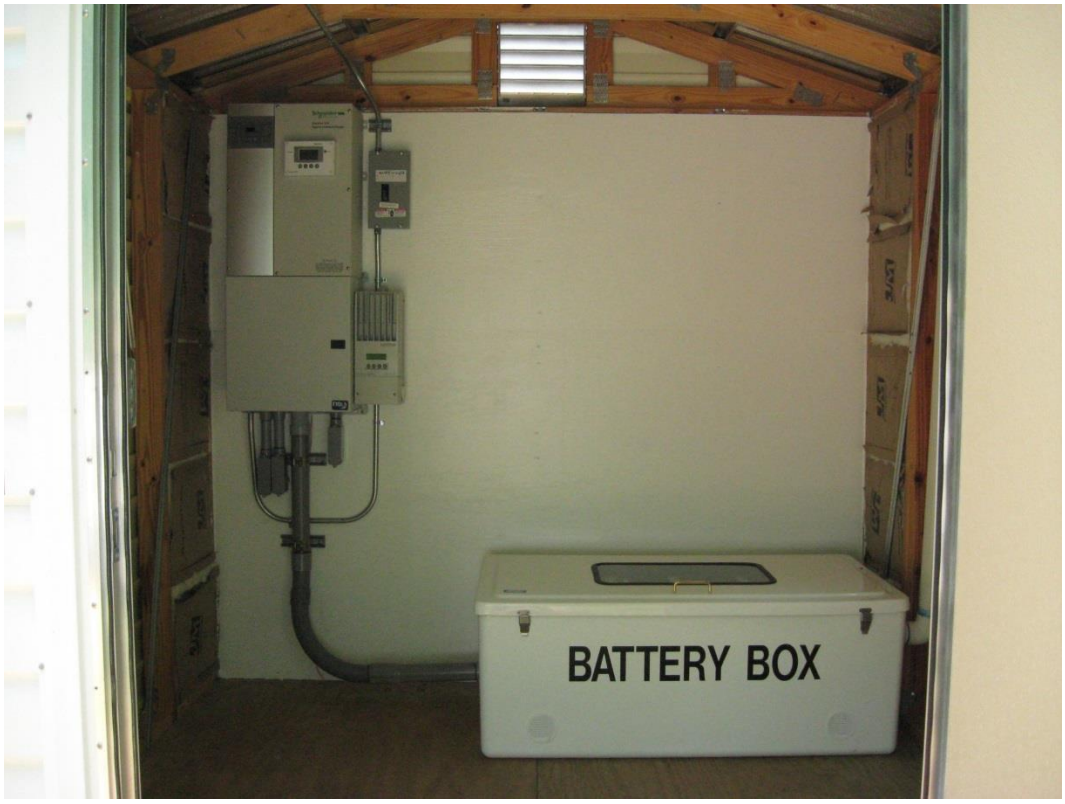
Livingroom

Venmar Duo 1.2 ERV

Inside of Venmar ERV

Thermal wheel of ERV

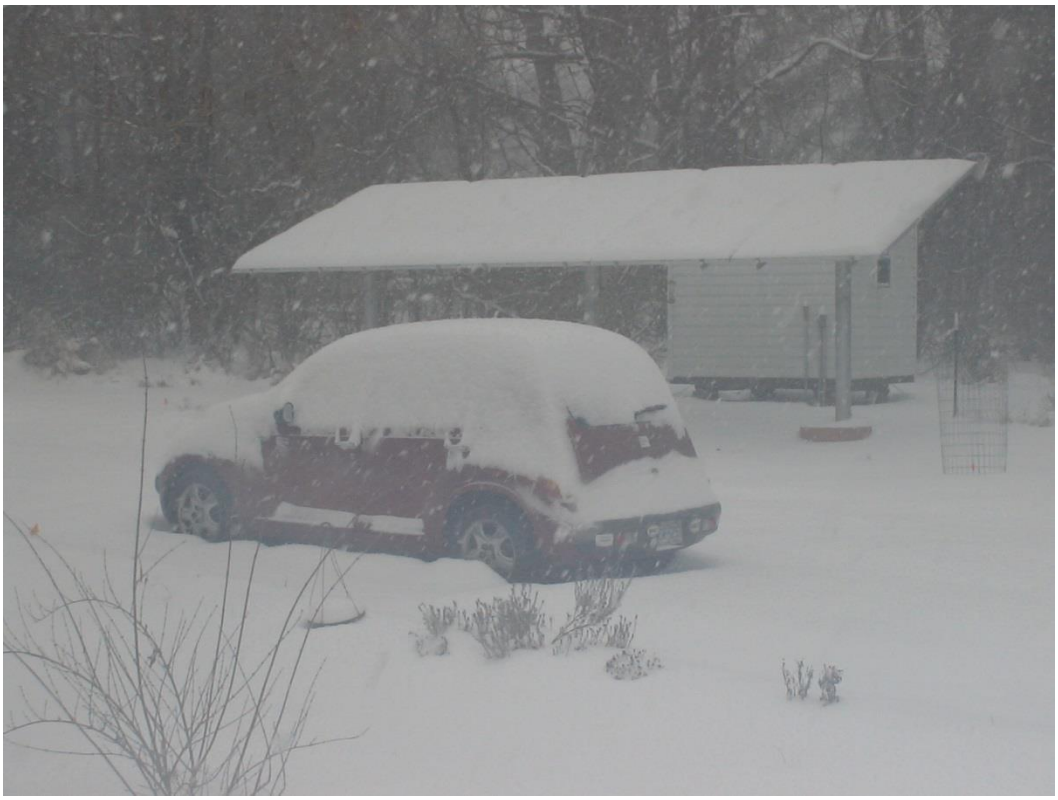
3.5KW pole mount with battery backup 2011



Solar power management system and battery storage


3.4KW roof mount 2015

Roof mount solar controller with pole mount in background



Yes, snow on PV

Jotul wood stove – heat for fun or emergencies

Jotul beautifully on fire – open to feed