



# Advanced Energy Efficiency and Net-Zero Energy Homes

“Building the homes of the future  
NOW”

Anthony Aebi, Greenhill Contracting, Inc.

# Major Projects:

- Green Acres, is a 25-Lot Subdivision in New Paltz, NY established in Sept 2008. It was the first Net-Zero Energy Development where all of the homes are designed and built to be NZE.
  - The first house completed and occupied in March 2009. Currently, 15 homes completed and 13 occupied; as of Winter 2015. (10 more to be completed)
- The Preserve, Greenhill Contracting's second NZEH Development consisting of 9 homes started in 2013 and were completed Spring 2014.
  - All homes were built within one-year. All homes occupied
- 6 Custom off site homes first one completed in 2007 last in 2016.
- Scenic Meadows, is an 11-lot Subdivision planned as Greenhill contracting's third NZEH Development to begin in 2017

# What is a Net-Zero Energy Home?

- Means that once the home is built, the occupants consume no more energy than the home itself produces on-site, inclusive of all fuels, and utilizing the utility grid for an interactive energy storage.
- Greenhill Contracting 's Approach to NZE:
  1. **High Performance Thermal Enclosure**
  2. **High Efficiency Heat Recovery Ventilation**
  3. **Ground-source Heat Pumps for Heating, Cooling and DHW**
  4. **High Efficiency Lighting and Appliances**
  5. **Solar PV Grid-Tied System**

# Learning Objectives


At the end of the this course, participants will be able to:

- ◆ 1. Utilize the principles of high performance buildings in their design concepts, specifications and construction strategies.
- ◆ 2. Recognize some of the challenges and opportunities involved in the design and construction of Net-Zero Energy Homes.
- ◆ 3. Design for optimum Indoor Environmental Quality including material selection, air-pressure boundary and ventilation strategies.
- ◆ 4. Develop and integrate resiliency strategies into high performance building projects.

# Green Building Certifications

- ◆ All houses are qualified and rated to the following green program standards:
  - ◆ ENERGY STAR Homes
  - ◆ EPA Indoor airPLUS
  - ◆ US DOE Zero Energy Ready Homes
  - ◆ USGBC LEED-H Rated Silver or Gold

# EPA ENERGY STAR Home







## ENERGY STAR® CERTIFIED NEW HOME

ENERGY STAR


**Builder Name:** Greenhill Contracting  
**Permit Date/Number:** 6-16-14 / 14-066  
**Home Address:** 20 Cooper Street  
**New Paltz, NY 12561**

**Rating Company:** Integral Building & Design  
**Rater Identification Number:** 2562038  
**Rating Date:** 10/2/14  
**Version:** 3.0

**Standard Features of an ENERGY STAR Certified New Home**  
 Your ENERGY STAR certified new home has been designed, constructed, and independently verified to meet rigorous requirements for energy efficiency set by the U.S. Environmental Protection Agency (EPA), including:

<p><b>Thermal Enclosure System</b>                  A complete thermal enclosure system that includes comprehensive air sealing, quality-installed insulation and high-performing windows to deliver improved comfort and lower utility bills.</p> <p style="text-align: center;"></p> <p><b>Air Infiltration Test:</b> Htg: 135 Cfg: 135 CFM50</p> <p><b>Primary Insulation Levels:</b>  <b>Celling:</b> R-63.3    <b>EndWall:</b> R-22.0  <b>AGWall:</b> R-22.0    <b>Slab:</b> R-52.2</p> <p><b>Primary Window Efficiency:</b>  <b>U-Value:</b> 0.200, <b>SHGC:</b> 0.230</p>	<p><b>Water Management System</b>                  A comprehensive water management system to protect roofs, walls, and foundations.</p> <p style="text-align: center;"></p> <p>Flashing, a drainage plane, and site grading to move water from the roof to the ground and then away from the home.</p> <p>Water-resistant materials on below-grade walls and underfoot slabs to reduce the potential for water entering into the home.</p> <p>Management of moisture levels in building materials during construction.</p>
<p><b>Heating, Cooling, and Ventilation System</b>                  A high-efficiency heating, cooling system and ventilation system that is designed and installed for optimal performance.</p> <p style="text-align: center;"></p> <p><b>Total Duct Leakage:</b>  <b>81.00 CFM25.</b></p> <p><b>Duct Leakage to Outdoors:</b>  <b>0.00 CFM25.</b></p> <p><b>Primary Heating (System Type • Fuel Type • Efficiency):</b>  <b>Ground-source heat pump, Electric, 5.9 COP, w/DSH.</b></p> <p><b>Primary Cooling (System Type • Fuel Type • Efficiency):</b>  <b>Ground-source heat pump, Electric, 47.2 EER, w/DSH.</b></p>	<p><b>Energy Efficient Lighting and Appliances</b>                  Energy efficient products to help reduce utility bills, while providing high quality performance.</p> <p style="text-align: center;"></p> <p><b>ENERGY STAR Qualified Lighting: 99%</b></p> <p><b>ENERGY STAR Qualified Appliances and Fans:</b>  <b>Refrigerators: 1      Dishwashers: 1</b>  <b>Ceiling Fans: 0      Exhaust Fans: 0</b></p> <p><b>Primary Water Heater (System Type • Fuel Type • Efficiency):</b>  <b>Ground source heat pump, Electric, 1.20 EF, 50.0 Gal.</b></p>

**HERS® Index**



3  
 This Home

The certificate provides a summary of the major energy efficiency and other construction features that contribute to this home earning the ENERGY STAR, including its Home Energy Rating System (HERS) score, as determined through independent inspection and verification performed by a trained professional. The Home Energy Rating System is a nationally-recognized uniform measurement of the energy efficiency of homes.

Note that when a home contains multiple performance levels for a particular feature (e.g., window efficiency or insulation levels), the predominant value is shown. Also, features may be certified to meet the ENERGY STAR using a sampling protocol, whereby one home is randomly selected from a set of homes for representative inspections and testing. In such cases, the features found in each home within the set are intended to meet or exceed the values presented on this certificate. The actual values for your home may differ, but offer evidence of better performance.

This certificate was printed using REMRate - v14.5.1  
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LEARN MORE AT [www.energystar.gov/certification](http://www.energystar.gov/certification)

# EPA Indoor airPLUS

Indoor  
airPLUS  
**Qualified Home**

This home built at  
**20 Cooper Street**  
**New Paltz, NY 12561**  
was verified by  
**Pasquale Strocchia**

to meet Indoor airPLUS construction  
specifications as established  
by the  
U.S. Environmental Protection Agency.



Indoor airPLUS qualified homes are  
designed to contribute to improved  
indoor air quality.

10/2/14



## Indoor airPLUS Features

- Moisture and Mold Control
- Radon Resistant Construction
- Pest Barriers
- Effective Heating, Ventilating, and Air-Conditioning Systems
- Safe Combustion
- Healthier Building Materials

Not all features are required in all cases. To learn more about indoor air quality features in your home, ask your builder to review the Indoor airPLUS verification checklist with you, or visit [www.epa.gov/indoorairplus](http://www.epa.gov/indoorairplus).

# DOE Zero Energy Ready Home



YOUR HOME WAS DESIGNED, ENGINEERED,  
AND CONSTRUCTED IN CONFORMANCE TO  
U.S. DEPARTMENT OF ENERGY (DOE)  
GUIDELINES FOR EXTRAORDINARY  
LEVELS OF EXCELLENCE AND QUALITY.

This home built at *70 Copper Street*  
By *Greenhill Contracting*  
Verified by *Annalee Simons*  
an independent professional  
organization, to meet or exceed  
strict home performance  
guidelines set by  
The U.S. Department of Energy  
on 10/15/2014



THIS HOME MEETS OR EXCEEDS THE MINIMUM  
CRITERIA FOR THE FOLLOWING:  
DOE Zero Energy Ready Home Quality Management Guidelines

REM/Rate - Residential Energy Analysis and  
Rating Software v14.5.1

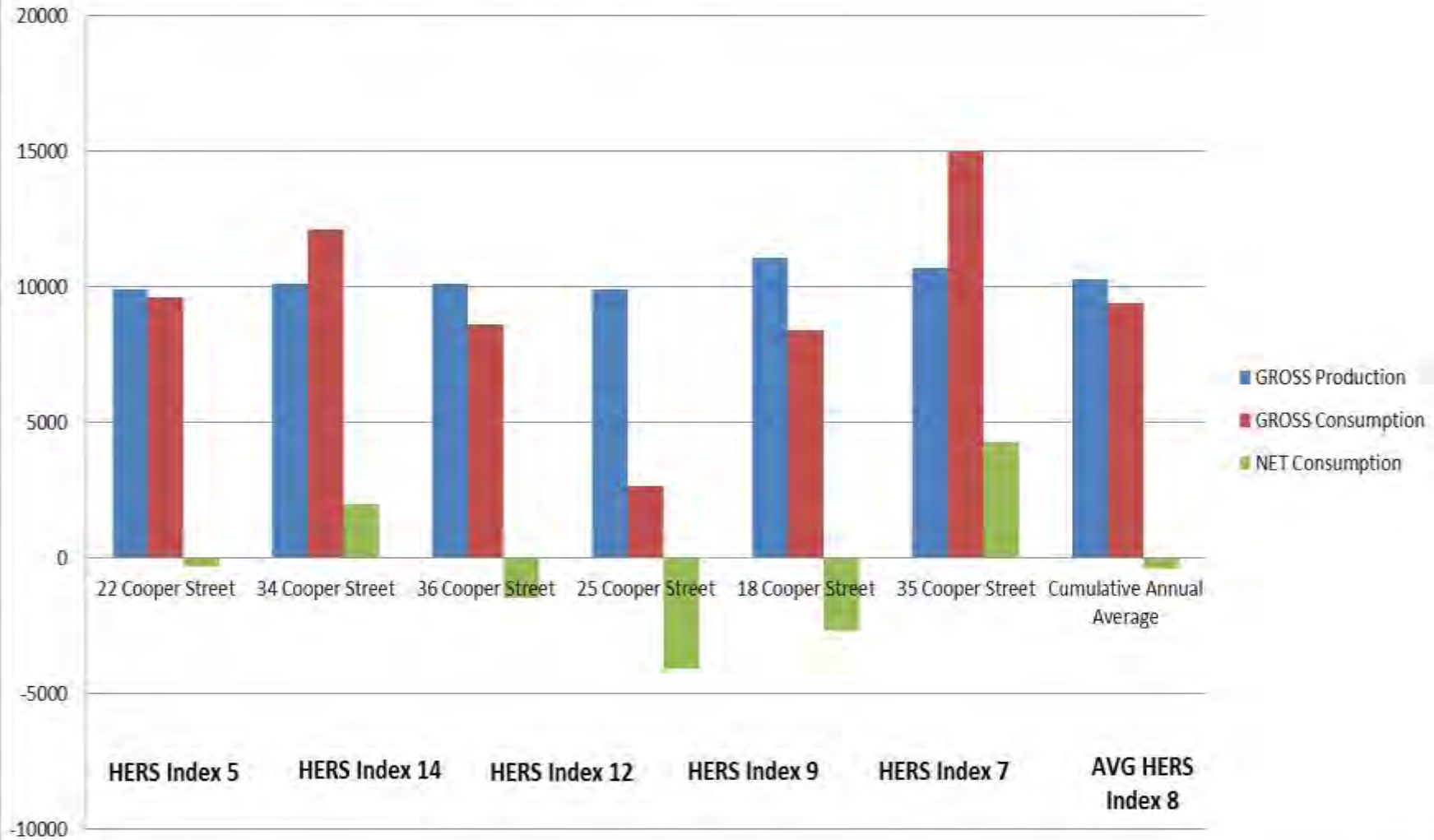
SAM RASHKIN, CHIEF ARCHITECT  
BUILDING TECHNOLOGIES  
U.S. DEPARTMENT OF ENERGY



# USGBC LEED for Homes - Silver



## Comparison of Homes at Green Acres Development Average Annual Energy Production and Consumption May 2009 thru August 2014









# Resiliency: Soil Gas Mitigation and In-House Drainage



# High Performance Thermal Enclosure: Under-Slab Insulation

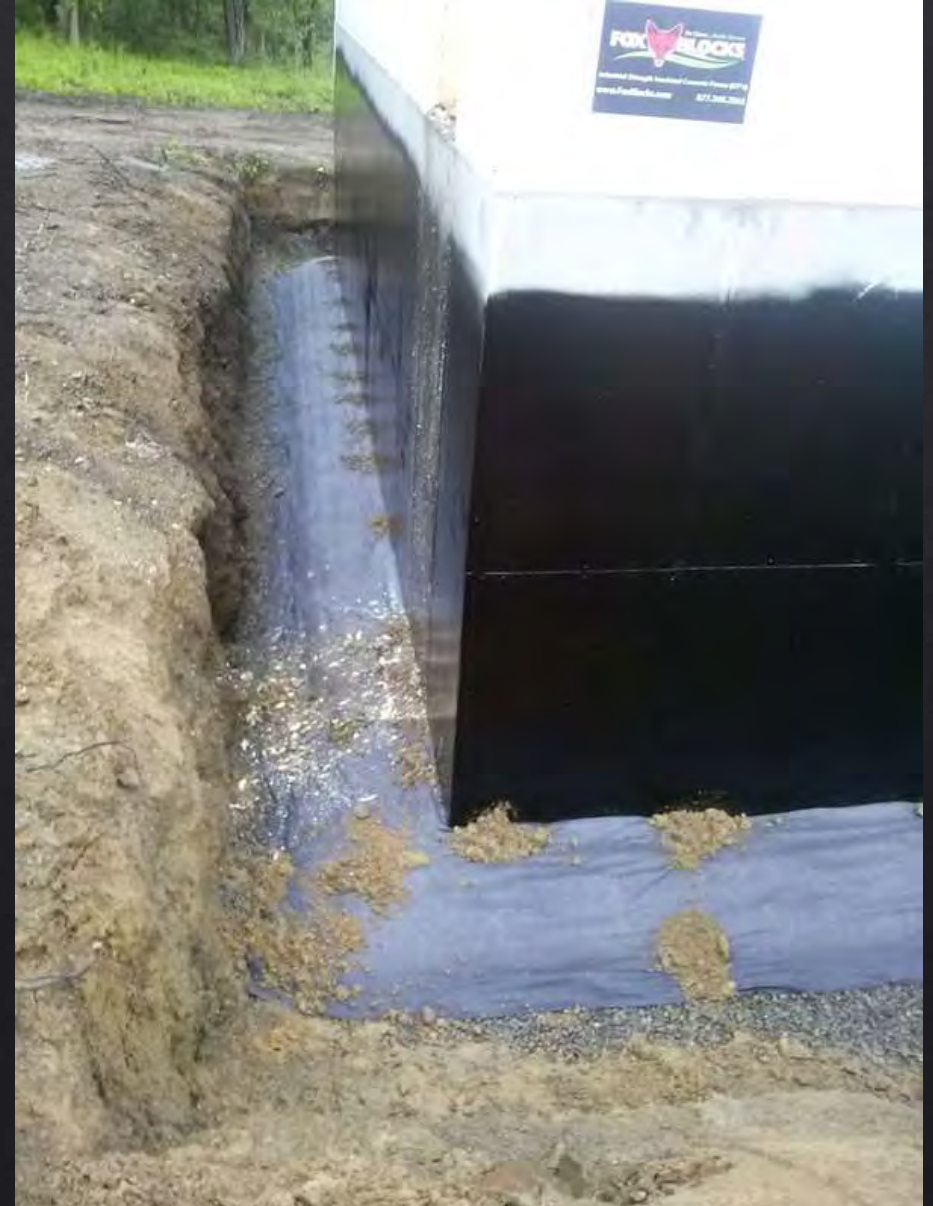








# High Performance Thermal Enclosure: Foundation Walls











# High Performance Thermal Enclosure: Above-Grade Walls















# High Performance Thermal Enclosure: High Performance Windows U-Factor – 0.17 (R-5.9)

ENERGY STAR certificado en registros

ENERGY STAR

Map of the United States with a star in the West Coast region.

Certified/Certificado 44354322

NFRC  
National Fenestration Rating Council®  
CERTIFIED

**JELD-WEN**  
WINDOWS & DOORS  
Premium Vinyl Casement  
Triple-glazing with LowE  
and Argon fill  
JEL-A-595-11282-00001

ENERGY PERFORMANCE RATINGS  
EVALUACION DE RENDIMIENTO ENERGETICO

U-FACTOR (U-Factor)	SOLAR HEAT GAIN COEFFICIENT (Solar Heat Gain Coefficient)
0.17 (U.S./IP)   0.97 (Metric/SI)	0.15

ADDITIONAL PERFORMANCE RATINGS  
EVALUACION SUPLEMENTARIA DE RENDIMIENTO

VISIBLE TRANSMITTANCE (Visible Transmittance)	AIR LEAKAGE (Air Leakage)
0.29	≤ 0.3 (U.S./IP)   ≤ 1.5 (Metric/SI)

www.nfrc.org

AA  
MA  
American Architectural  
Manufacturers Association  
Manufacturer of Certified Products

Manufacturer stipulates conformance to the applicable standards:  
**JELD-WEN Windows & Doors**  
Premium Vinyl Casement  
Class LC-PG50 - Size Tested 36x72 in  
Design Pressure = +50/-50 psf  
Conforms To: AAMA/WDMA/CSA 101/I.S.2/A440-08

WARNING: Drilling, sawing, sanding or machining wood products may release wood dust, a substance known to the State of California to cause cancer. Use a respirator or other adequate protection to avoid inhaling wood dust.















# High Performance Thermal Enclosure: Insulated Roof



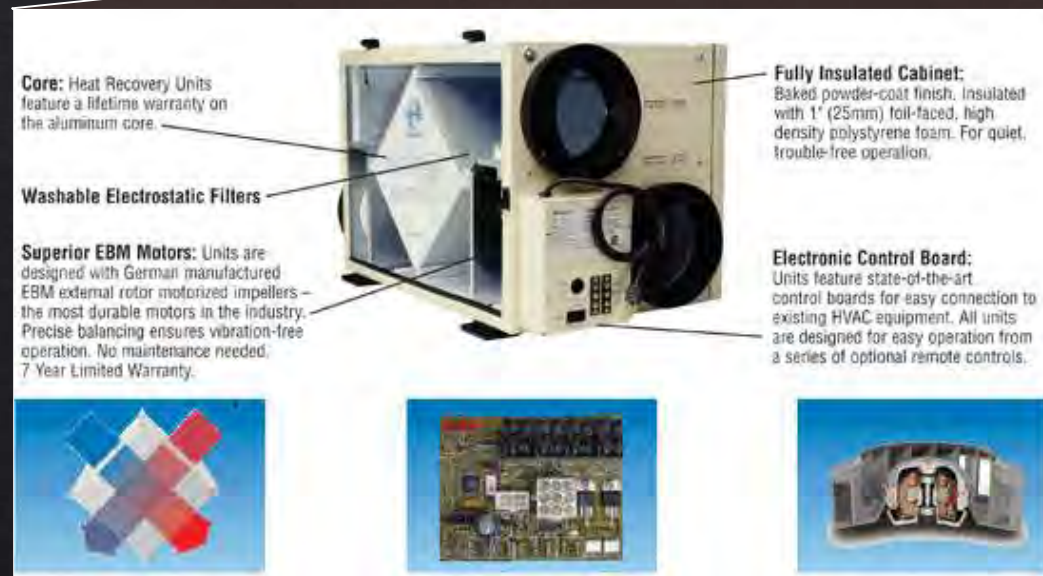
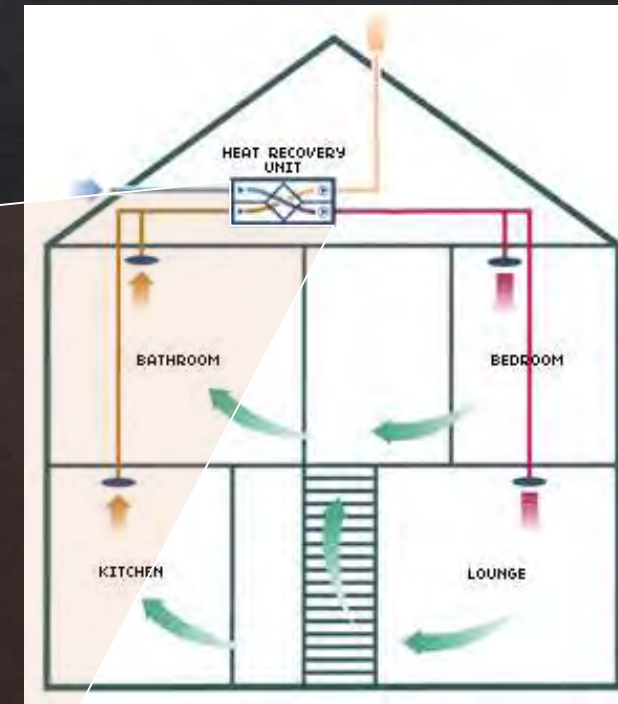
# High Performance Thermal Enclosure: Minimizing Thermal Bridging





# Energy Recovery Ventilation

- ◆ Exchanges energy from indoor, conditioned air to incoming outdoor air
- ◆ Recovers 60-80% of energy
- ◆ Also provides superior ventilation – when installed properly!



# Ground-Source Heat Pump for Heating, Cooling & DHW



Geothermal Heat Pump



Pre-tempered water tank

Pipes to closed-loop standing column well



# Solar PV System

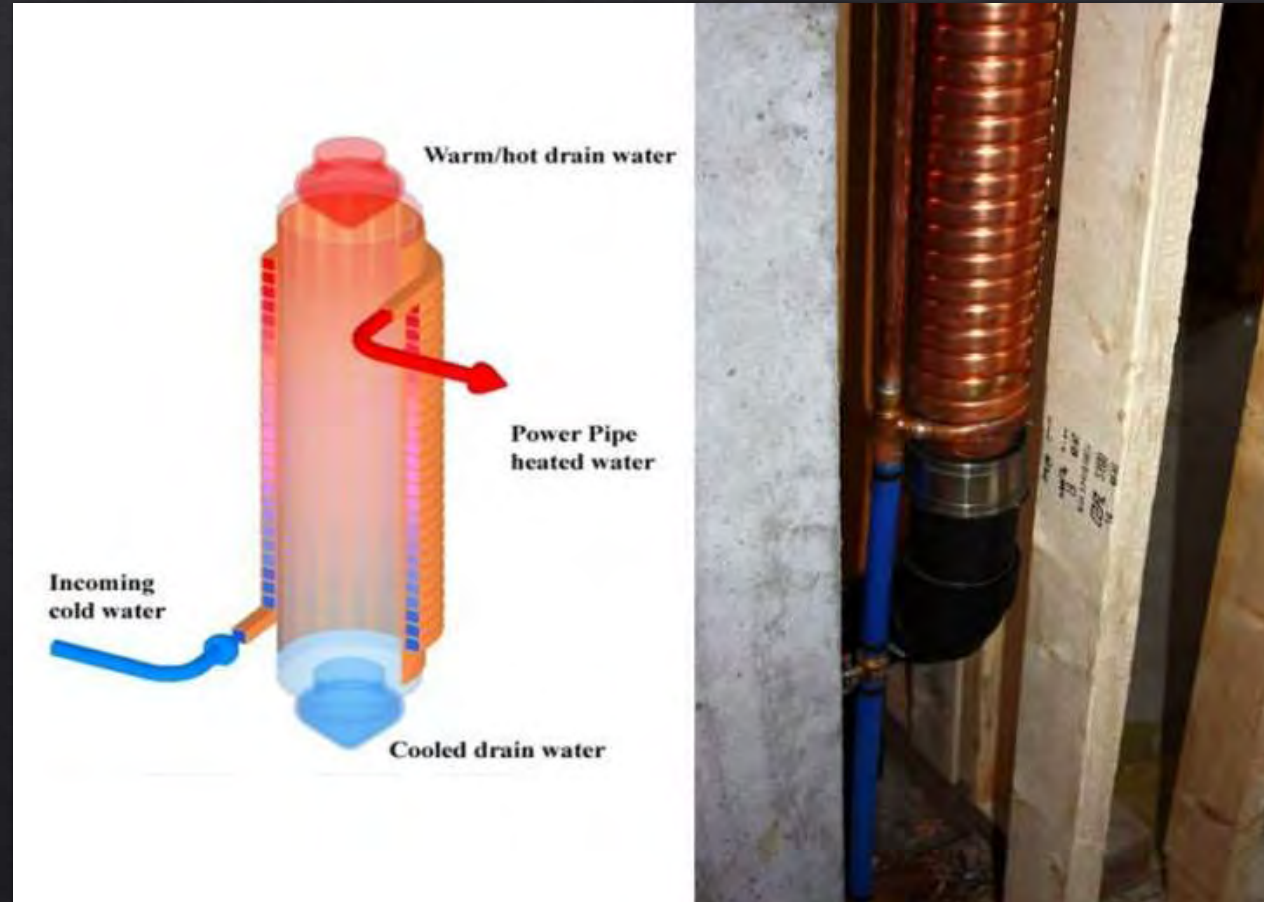


Web-based home power monitoring system

# Domestic Hot Water (DHW) Use of 3/8" Piping



# Domestic Water Heating Drain Water Heat Recovery



# Net-Zero-Energy Building: What's Working

- ✓ Demonstrating that Net-Zero Energy buildings are feasible and have proven results for typical homeowners
- ✓ Exceeding Net-Zero-Energy: Delivering Net-Positive Energy in some homes
- ✓ Systems approach is critical:
  - ◇ High Performance Envelope + Heat Recovery Ventilation + Geothermal + Solar
  - ◇ Can build NZE homes with “off-the-shelf” HVAC equipment with customized design
- ✓ Occupants of these NZE Homes enjoy better creature comforts as with traditional homes

# Ventilation

## Whole House:

- ◆ Importance of balancing of Fresh Air Supply and Exhaust flows.
  - ◆ Slight negative pressure may cause increased intrusion of soil gases into home.
  - ◆ However, excessive positive pressure is likely to cause moisture problems at the thermal boundaries (in cold climates).
    - ◆ Though for a concrete structure not such a problem and might be a goal.

# Ventilation

## Local Exhaust:

### ◆Kitchen Exhaust:

- Not optimal to use HRV/ERV to provide required flow rate, but necessary to consider the tighter the envelope.
- Exhaust fans in a super-tight house will need make-up air and pressure-relief.

### ◆Bathrooms:

- If using HRV/ERV, need to use smooth rigid ducting ; upsize the trunk and branch lines, and size the unit to provide the minimum ventilation rate required at lowest possible speed.

# Ventilation

- ◆ Eliminate all exhausting appliances.
- ◆ Unless you are going to design a system to replace the exhausting air (Make-up Air)
- ◆ Then consider where that replacement air is coming from and how you are going to treat it.

# High Performance Thermal Enclosure: Air-Tightness When I didn't know what I was doing.



25 Cooper Street 3,395sf  
CFA  
(Completed 2010)

Building Air Tightness: 236  
CFM-50pa =  
0.45 ACH@50pa



2014 Game Changer:  
33 Evergreen Ln, New Paltz (3,733sf CFA)



Building Air Leakage  
 $96 \text{ CFM}@50\text{pa} = 0.15 \text{ ACH}@50\text{pa}$

# Problems when you know what you are doing

- ◇ Homes with 0.1 ACH-50 and lower are the direction I have reached.
- ◇ You can't consider a venting appliance when the exhaust can be more than double what you used to perform a blower door test.
- ◇ Can Make up air be considered, when you will require as much, or more air than home needs for whole house ventilation?
  - ◇ Why build a high performance home with John Tooley's desired tightness and then poke holes in his balloon??
  - ◇ So if you want to poke holes in the balloon, now you will have to design your HVAC system to deal with the load the holes created.
  - ◇ How are you going to treat this make up air?
    - ◇ Design another system to condition it?
    - ◇ Filter it?
    - ◇ Now what is the use of your energy recovery ventilation system?







Rating Date	Address	CFA (SF)	Volume (CF)	Enclosure Area (SF)	HERS Index: Pre-PV	HERS Index: Post-PV	PV Peak Power (kW)	CFM-50	ACH-50	CFM-50/100SF Enclosure	WCD (Pa)
4/17/2008	590 Swar	6148	61996	11293	35	16	10.75	233	0.28	0.021	
2/17/2011					36	17	10.75	1165	1.13	0.103	
4/17/2008	592 Swar	4296	40171	8044	40	0	15.48	52	0.15	0.006	
2/8/2011					41	-1	15.48	92	0.14	0.011	
9/18/2009	34 Coop	3161	28007	6056	32	7	8.1	451	1.05	0.074	
2/8/2011		3161	28007	6056	39	14	8.1	670	1.44	0.111	-2.7
9/18/2009	36 Coop	2621	24903	5042	39	11	8.1	365	0.90	0.072	
2/8/2011					42	14	8.1	611	1.47	0.121	-4.5
9/19/2009	18 Coop	3237	30568	6429	43	6	10	448	0.88	0.070	
2/8/2011		3237	30755	6126	43	8	10.12	555	1.08	0.091	-2.4
7/14/2010	22 Coop	2710	29402	6515	36	7	8.1	322	0.66	0.049	-23
8/10/2010	25 Coop	3395	30689	6088	41	12	8.1	230	0.45	0.038	-17.5
12/12/2011	12 Misty	3015	27674	5730	36	7	9.00	251	0.54	0.044	-76
3/22/2012	35 Coop	3395	31847	6531	41	12	8.1	462	0.87	0.071	
4/12/2013	21 Coop	3256	34741	7150	37	9	8.1	395	0.68	0.055	-18.6
10/2/2013	29 Ever	3509	31215	6007	30	6	7.42	157	0.30	0.026	-34
10/22/2013	15 Ever	2488	27572	5233	35	5	7.42	130	0.28	0.025	-47
10/22/2013	35 Ever	3733	37936	6824	29	7	7.42	155	0.25	0.023	-68
11/19/2013	19 Ever	3792	36435	6936	29	7	7.42	104	0.17	0.015	-101
4/24/2014	23 Ever	3733	37936	6547	29	7	7.42	106	0.17	0.016	-96
5/7/2014	21 Ever	3733	37936	6547	28	6	7.42	88	0.14	0.013	-185
5/22/2014	33 Ever	3733	37936	6548	29	6	7.42	96	0.15	0.015	-238
5/22/2014	17 Ever	2488	27572	5233	34	3	7.42	108	0.24	0.021	-177
6/3/2014	13 Ever	2550	23561	5355	34	4	7.42	58	0.15	0.011	-224
6/24/2014	12-B Misty	756	8467	2977	48	2	5.04	157	1.11	0.053	
10/2/2014	20 Coop	4454	38770	6893	26	-3	11.55	135	0.21	0.020	-59
5/14/2015	26 Coop	4208	36000	6636	27	-3	11.76	107	0.18	0.016	-43.7
5/22/2015	28 Coop	4208	36881	6799	26	-1	10.08	88	0.14	0.013	-141
6/30/2015	9 Tayl	3524	35812	6611	25	-5	9.90	104	0.17	0.016	-37.6
8/13/2015	7 Tayl	4190	35812	6565	26	-1	9.90	111	0.19	0.017	-39.6
11/24/2015	5 Tayl	3737	31222	6303	25	-5	9.90	149	0.29	0.024	-81.5
4/27/2016	69 Je	3912	40081	7124	29	-11	13.44	109	0.16	0.015	-52
5/10/2016	3 Tayl	3554	30147	5990	27	-5	9.9	139	0.28	0.023	-36
7/13/2016	10 Tayl	3200	27700	5552	25	-7	9.9	91	0.20	0.016	-23
8/5/2016	18 Hick	3912	43288	7277	32	1	10.3	80	0.11	0.011	
7/25/2016	26 Hick	4865	50705	9834	34	10	11.69	582	0.69	0.059	

# The Garage Connection



# Indoor Environmental Quality (IEQ)

- ◆ Attached Garages:
  - ◆ Critical to have a very effective air-boundary between the Garage and the House that is confirmed with Zonal Pressure Diagnostics.
  - ◆ Needed to integrate exhaust ventilation to create a continuous, though slight, negative pressure in the Garage with reference to the House.
- ◆ Minimize and eliminate other pollutants as best possible:
  - ◆ Eliminated the use of gas-fired range
  - ◆ Minimize soil gas intrusion:
    - ◆ with use of high-density spray foam under slab and installing radon-resistant construction features
    - ◆ keeping the House under slightly positive pressure with reference to the Outside.



# Detached Garages



















# Resiliency



Baseline: 3/3/14 PM

Outdoor Temp: 22.3<sup>0</sup> F

Indoor Temp: 71.1<sup>0</sup> F

Heat Turned OFF

# Resiliency



Day 1: 3/4/14 AM

Outdoor Temp: - 8.5<sup>0</sup> F

Indoor Temp: 63.7<sup>0</sup> F

# Resiliency



Day 1: 3/4/14 PM

Outdoor Temp: 22.5° F

Indoor Temp: 63.7° F

# Resiliency

Day 2: 3/5/14 AM

Outdoor Temp: 16.6° F

Indoor Temp: 59.4° F



# Resiliency



Day 3: 3/6/14 AM

Outdoor Temp: 2.3<sup>0</sup> F

Indoor Temp: 55.1<sup>0</sup> F

# Resiliency



Day 3: 3/6/14 PM

Outdoor Temp: 23.8° F

Indoor Temp: 59.8° F

END of Test

# Contact Info.

- ◆ Consultation, and Training the trades on ways to Zero.
- ◆ Anthony Aebi, President, Greenhill Contracting
- ◆ E-mail (preferred method of communication):  
[greenhillcontracting@yahoo.com](mailto:greenhillcontracting@yahoo.com)
- ◆ Web-site [www.zeronetnow.com](http://www.zeronetnow.com)
- ◆ Or [www.greenhillcontracting.com](http://www.greenhillcontracting.com)