Getting to Zero Energy Cost Effectively

March 8, 2011

BUILDING ENERGY 11
CONFERENCE + TRADE SHOW FOR RENEWABLE ENERGY AND GREEN BUILDING PROFESSIONALS

Carter Scott
TRANSFORMATIONS™ Zero Energy Homes

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TRANSFORMATIONS™ Zero Energy Homes

Learning Objectives

After attending "Getting to Zero Cost Effectively", one should be able to:

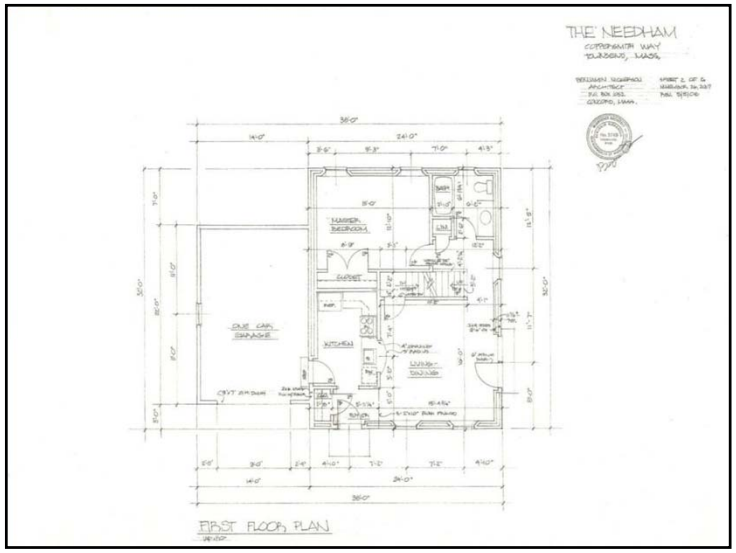
1. **Learn different techniques to reduce a homes energy usage by about 60%.**
2. **Learn how point source heating systems work.**
3. **Learn how to produce the last 40% of a home energy with solar electric panels.**
4. **Learn how to go beyond Zero Energy Homes and produce energy for electric and plug-in electric vehicles.**

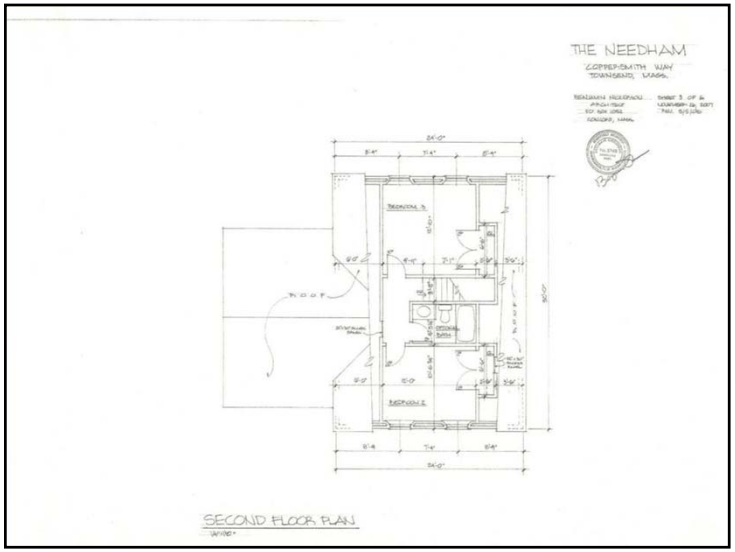
Production Home---Affordable unit (40B): "The Zero Energy Challenge Home"

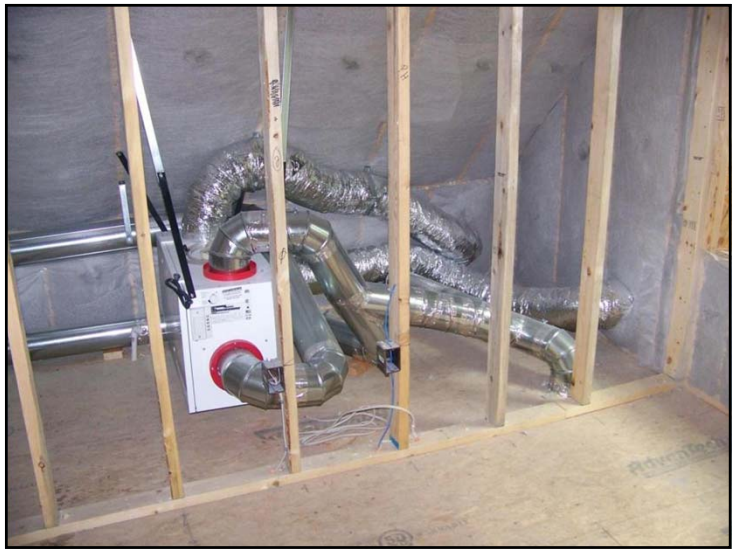
- About 1,200 square feet of living space
- 3 Bedrooms
- $195,200 sale price
- HERS Index of -4
- Currently 3 occupants
- Built in 2008 in Townsend, MA
- "The Needham" plan

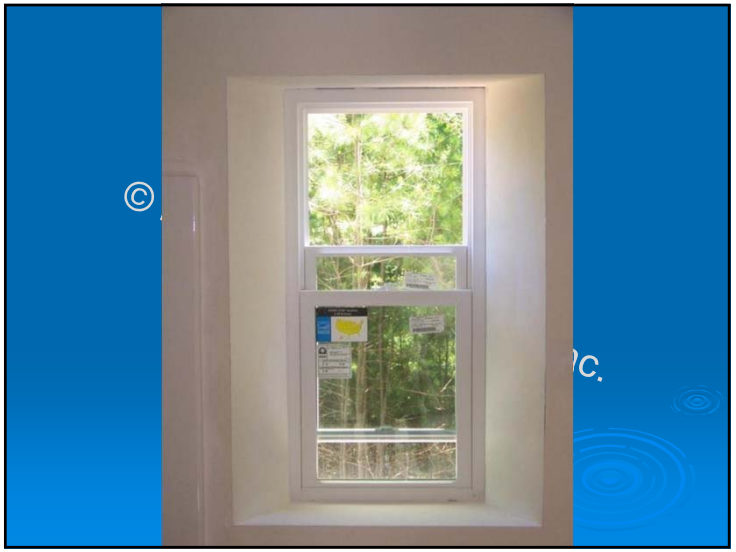
HERS Index

- The Home Energy Rating System (HERS) Index is used as the primary rating metric for utilities.
- The Index was not designed for homes approaching Zero Energy.
- After our home was built, negative numbers in the index were possible.
- The rating system has certain assumptions that drive the index.




THE NEEDHAM
SECOND FLOOR PLAN





Blower Door Test

- B-ring…
- C-ring… 175 cfm @50 Pascals
- E-ring…

Peak Heating Load

- This Coppersmith Way home has a peak heating load of about 10,500 BTU's.
- In other words, it can be heated from a design temperature of 6 degrees F outside to 70 degrees inside with two 1500 watt hair dryers and a 80 watt light bulb!

Marginal costs

- Framing double studded walls, rafters $1,670
- Super-Insulation $5,970 ($14,000 - $8,030 standard)
- PV system $5,970 ($33,000 - $25,200 MTC rebate)
- SunDrum hot water heating system $4,500
- Windows $689 ($4342 went to $5,031)
- **Total additional marginal costs $18,799**

Marginal Savings

- 1" Rigid on the outside of the house -$2,258
- Trim on the windows -$1,328
- Painting -$300
- Heating system (compared to $6800) -$1,550
- **Total savings -$5,436**

Net Marginal Cost for "The Needham"

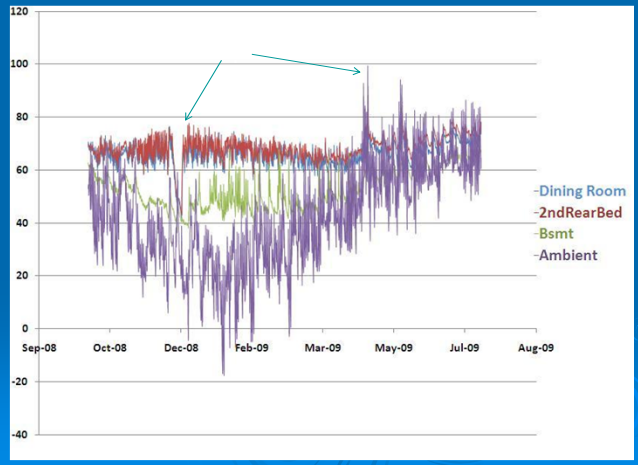
- **$13,363**
- **Less Fed. & State tax incentives -$6,000**
- **Net after tax incentives $7,363**

18 Coppersmith Way: 12 Months Electrical Usage

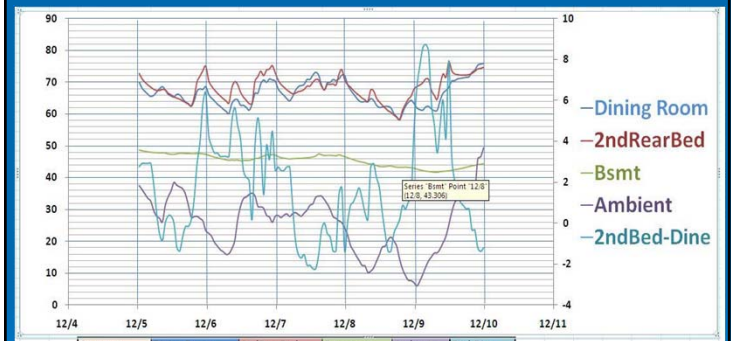
Service Period	Meter Readings Previous	Present	Usage
2/20/09 to 3/24/09	1863	2177	314
3/24/09 to 4/23/09	2177	2098	-79
4/23/09 to 5/21/09	2098	1782	-316
5/21/09 to 6/23/09	1782	1503	-279
6/23/09 to 7/24/09	1503	1309	-194
7/24/09 to 8/24/09	1309	1123	-186
8/24/09 to 9/23/09	1123	795	-328
9/23/09 to 10/23/09	795	807	12
10/23/09 to 11/20/09	807	952	145
11/20/09 to 12/23/09	952	1666	714
12/23/09 to 1/22/10	1666	2788	1122
1/22/10 to 2/19/10	2788	3478	690
Last 12 months kwh usage			1615

Temp., RH, External Temp. Probe

Full Data Set

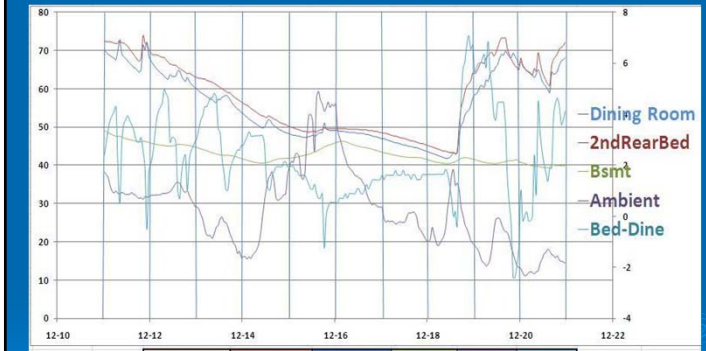


Dec. 5 to Dec. 10, 2008



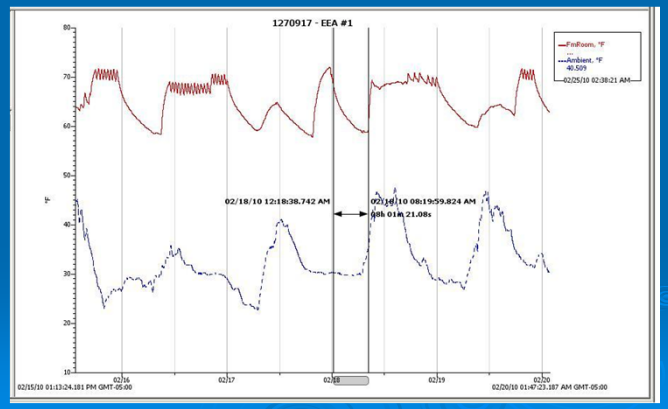
Summary	Dining Room	2ndRearBed	Basement	Ambient	Bed-Dine
Minimums	58.1	58.3	41.7	6.1	-2.2
Maximums	75.8	76.4	48.5	49.2	8.7
Average	66.3	68.0	45.4	25.1	1.7

Dec. 11 to Dec 21, 2008

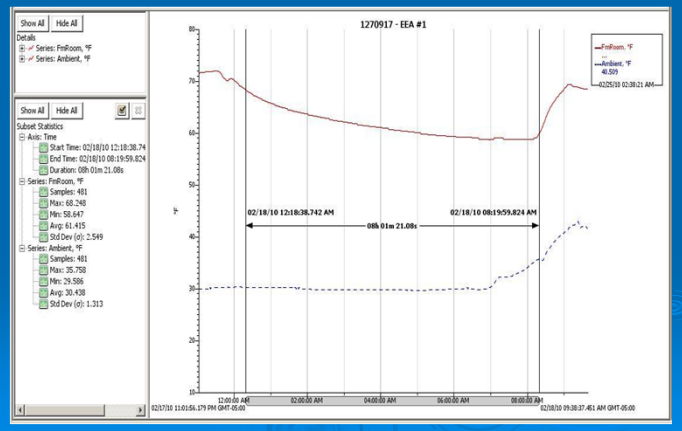


Summary	Dining Room	2ndRearBed	Basement	Ambient	Bed-Dine
Minimums	41.8	43.1	39.3	11.2	-2.4
Maximums	69.8	73.4	46.2	49.1	7.1
Average	53.7	56.0	41.7	23.8	2.2

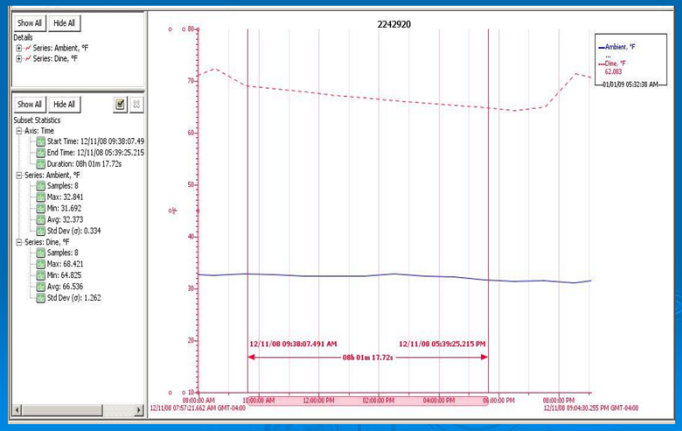
Birch Hill



Birch Hill



Needham



Passive Survivability

	Needham	Birch Hill	Delta
Start Room Temp	68.4	68.3	0.10
End Room Temp	64.8	58.6	6.20
Average Room Temp	66.5	61.4	5.10
Temp Delta	**3.6**	**9.7**	**(6.10)**
Start Ambient Temp	31.7	29.6	2.10
End Ambient Temp	32.8	35.8	(3.00)
Temp Delta	-28.1	-19.9	(8.20)
Average Ambient Temp	32.4	30.4	2.00
Ambient Delta Temp	1.1	6.2	(5.10)
Duration	481	481	0.00
Start Inside-Ambient Delta	36.7	38.7	(2.00)
End Inside-Ambient Delta	32	22.8	9.20

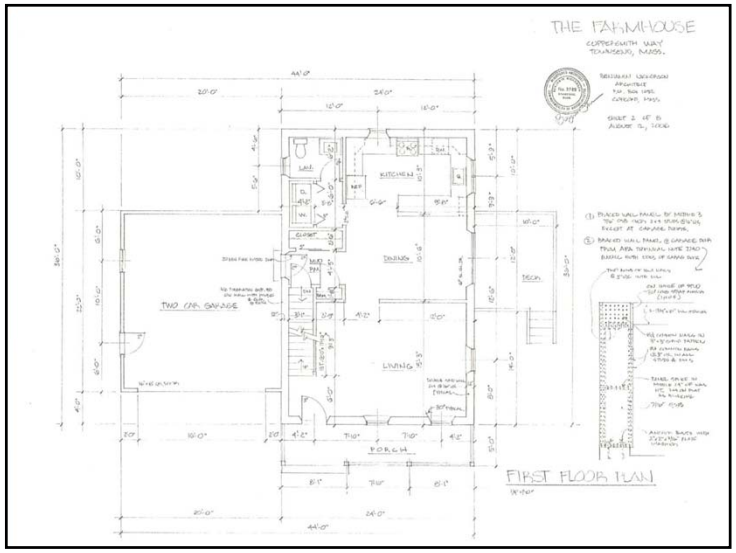
Zero Energy Challenge Home Questions?

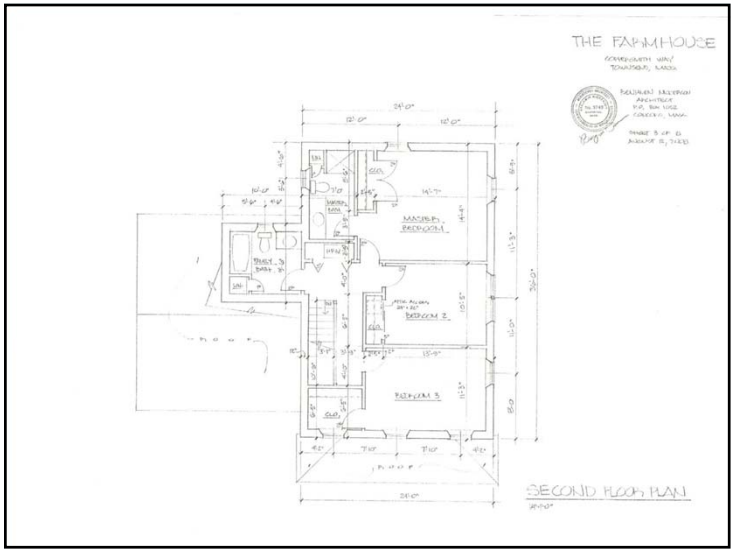
The Farmhouse

Carter Scott
Transformations, Inc.

Production Home---Market Rate "The Farmhouse"

- 1,818 square feet (169 square meters) of living space
- 3 Bedrooms
- $359,900 sale price
- HERS Index of -3
- Currently 3 occupants
- 6.435 kW PV system
- Built in 2008 in Townsend, MA





The Farmhouse cost to build:

- $186,249 or ~$102 per square foot ($9.53 per square meter)
- Excludes land, road, engineering, permits, septic, soft costs and fill
- Includes $20,000 in incentives from the Massachusetts Technology Collaborative, and $21,432 in Federal/State tax credits

20 Coppersmith Way: 12 Months Electrical Usage

	Meter reading		Metered
Service Period	Previous	Present	Usage
2/20/09 to 3/23/09	637	1006	369
3/24/09 to 4/23/09	1006	843	-163
4/23/09 to 5/21/09	843	462	-381
5/23/09 to 6/23/09	462	188	-274
6/23/09 to 7/24/09	188	999956	-232
7/24/09 to 8/24/09	999956	999671	-285
8/24/09 to 9/23/09	999671	999297	-374
9/24/09 to 10/23/09	999297	999232	-65
10/23/09 to 11/20/09	999232	999308	76
11/21/09 to 12-23-09	999308	999961	653
12/23/09 to 1/22/10	999961	995	1034
1/22/10 to 2/19/10	995	1552	557
Totals kwh per year			915

Farmhouse Questions?

Production Home---Standard Colonial "The Carlisle"

- 2,612 square feet of living space
- 4 Bedrooms
- $389,900 sale price
- HERS Index of 25
- Currently 3 occupants
- Built in 2009 in Townsend, MA

Mitsubishi SEZ Ducted Indoor units

- Provides for both heating and cooling, 17,000 BTU peak heating load
- Installed costs in the 4 BR 2,612 square foot "Carlisle" model was $7,600
- One 15,000 BTU heads upstairs, One 18,000 BTU head downstairs
- 20,000 BTU gas fireplace as back up heating system

Existing Wall Construction

- 12" thick double studded 2x4's, 16" OC outside walls, 24" OC inside walls
- R 3.9 per inch Low Density Foam (The Carlisle), R 4.89 available

Custom Homes

Carter Scott
Transformations, Inc.

Custom Home Case Study "The Solar Colonial"

- 2,964 square feet of conditioned area
- 2 Bedrooms (technically)
- $307,000 contract cost (includes overhead and margin)
- HERS Index of 7
- Currently 4 occupants
- Built in 2010 in Stow MA

Mini-Split Heating

One 9,000 BTU Mitsubishi mini-split head per floor, 4 floors total.

Solar Colonial Custom Home Questions?

Custom Home Case Study: "The Solar Ranch"

- 1,248 square feet of living space
- 3 Bedrooms
- $240,000 contract cost
- HERS Index of -8
- Currently 4 occupants
- Built in Maynard, MA in 2010

Framing

The colored Insulated slab is protected during construction.

Summer

Large overhangs protect the home from summer solar heat gain.

Solar Ranch Custom Home Questions?

Zero Energy Development
Easthampton, MA

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Transformations, Inc.

Production Building
Zero Energy Attainable Development
Easthampton, MA

- 33 units total
- Savings of about 60% in the base houses
- Optional PV as a lease, a purchase or a hybrid purchase.

Homeownership Component of Treehouse
at Easthampton Meadow

Easthampton, Massachusetts

"The Farmhouse II"
Model Home
Easthampton, MA

- 1818 square feet of living space
- 3 Bedrooms
- $120.46 psf including overhead and margin ($102.26 psf hard costs to build)
- HERS Index of -2

Slab Insulation

6” of rigid insulation was installed under the slab.
4” of rigid was installed on the slab edge

Multi-Family Housing – Georgian Colonial HERS Index of 1

Price Point

- Transformations, Inc. is able to produce these houses cost effectively---from approximately $102 per square foot for the hard costs (from about $120 per square foot including overhead and margin), depending on the design and options chosen.

Price Point

Innovations in bringing Zero Energy Homes to the marketplace contribute to this price point:

- Utilizing the Federal PV cash incentives and the new S-RECS
- Lease PV systems
- Cost effective HVAC systems

Easthampton Questions?

Planned Zero Energy Community Devens, MA

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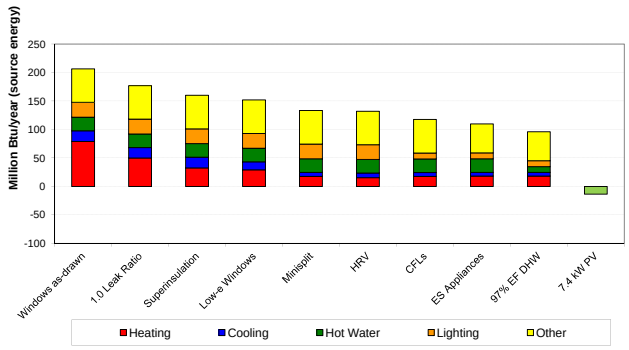
Transformations, Inc.

Planned Zero Energy Community Devens, MA

- MassDevelopment Request for Proposals
- 8 single family homes
- Sale prices between $290,000 & $350,000
- HERS Indexes of about 0 as a standard
- HERS Indexes of -20 to -30 as an option
- Site plan review obtained on January 25, 2011

Project Site Plan – 3D View

Devens Farmhouse Parametric Modeling



Single-Family Housing – Victorian HERS Index of -1


Front Elevation


Right Side Elevation


Rear Elevation


Left Side Elevation

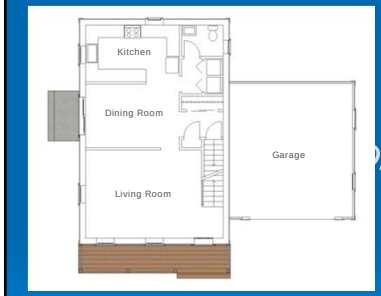
Single-Family Housing – Victorian HERS Index of -1

First Floor Plan

Second Floor Plan

Single-Family Housing – Farmhouse HERS Index of -1

Single-Family Housing – Farmhouse HERS Index of -1



First Floor Plan

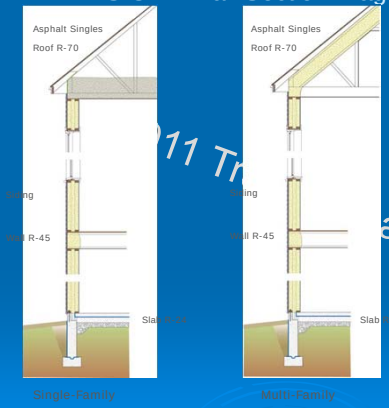
Second Floor Plan

Single-Family Housing – Greek Revival HERS Index of -1

Single-Family Housing – Large Ranch HERS Index of -3

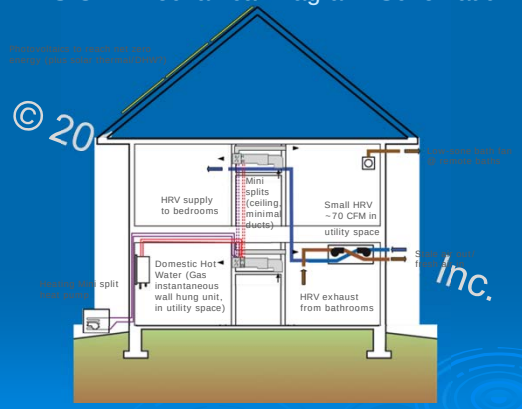
78

DESIGN: Wall Section Diagrams: Schematic



Single-Family Multi-Family

DESIGN: Mechanical Diagram: Schematic



Planned Zero Energy Community Devens, MA

Questions?

Solar Electric Installations

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Transformations, Inc.

Solar Electric Installations

- Photovoltaic: Photo (sun) voltaic (electric)
- PV for short
- Direct conversion from sunlight to electricity.
- Produces direct current (DC).
- An Inverter converts the DC to alternating current
- The AC can be either used in the house or sent into the grid with net metering

Solar Electric Installation Case Study Overview

- Typical system on a Farmhouse model
- 36 panels
- 210 watts per panel
- 3 strings of panels
- Racking
- Inverter

Solar Electric Installations
7.56 kW Case Study---Costs

- The typical cost per watt is $6.00
- For the 7.56 kW system, the cost is $45,360
- Micro-inverters add about 50 cents per watt.
- High efficiency panels (SunPower ~18% efficiency) add about $1 per watt.

Solar Electric Installations
7.56 kW Case Study---Incentives

- The Federal tax credit is 30%: $13,608 for a $45,360 system.
- Massachusetts has a $1,000 tax credit per system
- The Massachusetts Clean Energy Center (CEC) has a $4,250 incentive (with MA component adder).
- Plus S-RECS (see next slide)

Solar Electric Installations
S-REC Overview

- Massachusetts Solar Renewable Energy Tax Credits (S-RECs).
- Currently (2011) the SREC penalty is $550 for the utilities if they do not have the solar carve out percentage.
- For 2011 that is a solar carve out percentage of 5% of the Renewable Energy Portfolio Standard for 2011 of 6% of the energy sold (.05 times .06 or .003).
- The RPS is expected to go up 1% per year for several years.

Solar Electric Installations
S-REC Cash Flow YR 1

- An S-REC is 1,000 kilowatt hours or a megawatt
- A 7.56 kW system facing south, with a 10 pitch roof and no shading should generate about 1.2 time the nameplate rating over the course of a year.
- This means a 7.56 kW system will generate about 9,072 kilowatt hours in the first year (9 SRECs).
- The utilities are currently paying about $20 less than the penalty for the S-RECS and there is an aggregator fee of about 7% ($530 *.93 = $493)
- 9 S-RECs times $493 = $4,437 in year 1.

Solar Electric Installations
S-REC Cash Flow YR 2-10

- The system will likely lose about 1% efficiency per year in overall production.
- The S-RECs will likely decrease in value over the course of the rest of the S-REC life (years 2-10).
- With a averaged efficiency loss of about 5% and an averaged S-REC value reduction of about 20%, year 2-10 should average about $3,328 per year or $29,952 in years 2-10.
- Total S-REC income of about $34,389 over 10 years!!!

Solar Electric Installations
Electrical output of the system

- The 7.56 kW system will generate about 9,072 kilowatt hours in the first year, and average about 8,618 per year for the first 10 years
- At $.17 per kilowatt hour, that is $1465 per year or 14,650 over a ten year period.

Solar Electric Installations
Total Revenue over 10 years

- The Federal tax credit: $13,608
- Massachusetts tax credit: $1,000
- The Massachusetts CEC: $4,250
- S-RECs: $34,389
- Electricity: $14,650
- Total Revenue: $67,897

Solar Electric Installations
Total Revenue over 10 years

- Total Revenue: $67,897
- Total Cost: $45,360 ($6 per watt)
- 10 year return: $22,537
- 20 more years of electricity and regular RECs free and clear!

Solar Electric Installation Questions?

Beyond Zero Energy Homes

Carter Scott
Transformations, Inc.

Net Positive Homes

- A Net Positive Home is a home that produces more energy than it consumes over the course of a year.

Option 1:
Produce more renewable energy

- With higher efficiency panels (18% instead of 14%), more power can be generated on the roof.
- Our 7.56 kW example can yield 9.45 kW with SunPower panels.
- This is 25% additional power
- 1.89 kW for our home

Option 2:
Conserve more energy

- Higher efficiency windows (the Solar Ranch example)
- Thicker walls (the Solar Colonial example)
- Passive House techniques

What can we do with this extra power?

Power our Automobiles!!!

Carbon Reduction Building Sector

- With a Zero Energy home, we can reduce our share of the 40% of the carbon that is created in the United States with buildings.

Carbon Reduction Transportation Sector

- With a Positive Energy Home, we can reduce our share of the 40% of the carbon that is associated in the United States with the transportation sector.

PV Powered Automobile

- Question: How much PV is necessary to power a car for a 40 mile round trip commute, 5 days a week, 50 weeks a year (10,000 miles a year)
- Assume a Prius with a Hymotion / A123
- 5 kW battery pack.
- Assume house orientation of 196 degrees, 45 degree roof, inverter efficiency of 95.2%

PV Powered Automobile

- Answer:
- 1034 additional "Peak Watts" on the roof (1.03 kW)
- This generates about 1,262 kilowatt hours in our example.

PV Powered Automobile

Charging stations on the Street

Some of the vehicles in the pipeline for 2010-12

105

Plug-In Vehicles Enter Markets in Late 2010 - What is the Near-Term Achievable Market Penetration?

- Market penetration grows as vehicle production numbers increase, new models are introduced, and economies of scale drive down prices. (source: Southern California Edison) & Obama goal of 1 million Ev's by 2020

	2009	2010	2011	2012	2013	2014	2015
PHEV	150	250	25,000	167,100	196,700	238,000	316,000
BEV	500	5,800	31,580	73,967	97,500	126,500	181,800

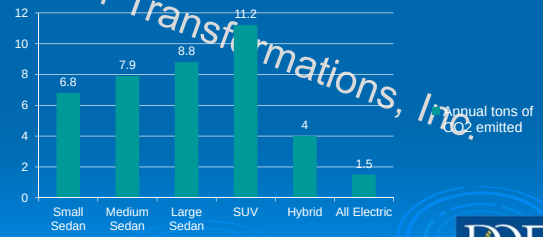
106

Creating A Greener Energy Future For the Commonwealth

DOER Massachusetts Department of Energy Resources

Electric vehicles and the environment

Annual tons of CO2 emitted
Based on ISO New England generation profile



107

Creating A Greener Energy Future For the Commonwealth

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Questions?

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