Alaska Presentation

Pathways to Zero Energy

April 25 and 26, 2014

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Zero Energy Homes

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Zero Energy Homes

Presentation Sections

- Why Zero Energy Homes?
- The Path to Zero Energy Homes
- 3 Zero Energy Homes in Townsend, MA
- Production Building for Other Developers
- Ventilation Options
- Solar Electric Installations
- Custom Homes
- Net Positive Homes
- Double Stud Monitoring
- On the Drawing Boards

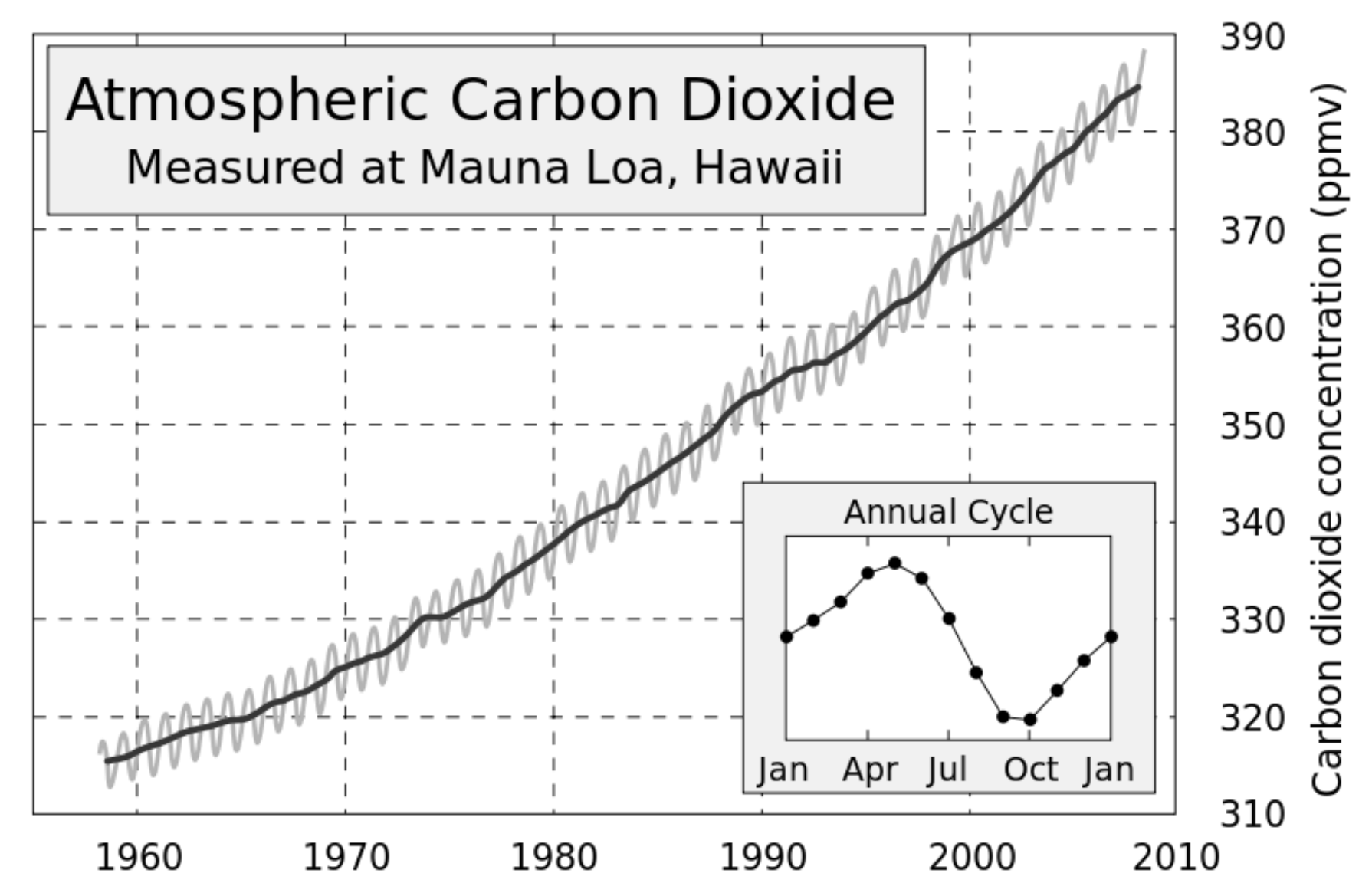
Why Zero Energy Homes?

From a Builder's Perspective…

- It's the future of housing in America.
- They can be built cost effectively in many areas of the country.
- It can be a very good business model.

and From a Global Perspective…

The Keeling Curve



Levels of carbon dioxide are rising at about 2 ppm per year

The atmosphere is relatively thin

Climate Change

- It has been suggested that to mitigate the effects of climate change we need to restore the Earth's energy balance.
- According to Dr. Hansen, recent long time director of the NASA Goddard Institute of Space Studies, to do this we will need to reduce our carbon dioxide down to a level of 350 ppm.

The Path to Zero Energy

One Builders Journey

2005 to 2008

MA Stretch Code Homes

HERS 50 Homes

HERS 40 Homes

HERS 30 Homes

HERS 20 Homes

MA Stretch Code Homes

- Home Energy Rating System (HERS) = 65 (70 if under 3000 square feet)

- Typical insulation features:
  - Floor to basement insulation: R30 fiberglass batts (Grade 1)
  - Rim and band joist insulation: R-19
  - Above grade wall cavity: R-21 fiberglass batts (Grade 1)
  - Windows: Standard double pane/low E/vinyl
  - Ceiling insulation: R38 fiberglass batts (Grade 1)

MA Stretch Code Homes

- Typical mechanical features:
  - Heating system: 96% furnace, ducts in basement and attic
  - Cooling SEER: 13 (two systems per house)
  - Domestic Hot Water: 82% instantaneous
  - Duct leakage 6% of conditioned floor area
  - Ventilation: 65 cfm const, exhaust only
  - Building tightness: 4.00 ACH50

MA Stretch Code Homes

- Typical appliance features:
  - Refrigerator: 334 kWh/yr
  - Dishwasher: 0.64 Energy Factor

HERS 50

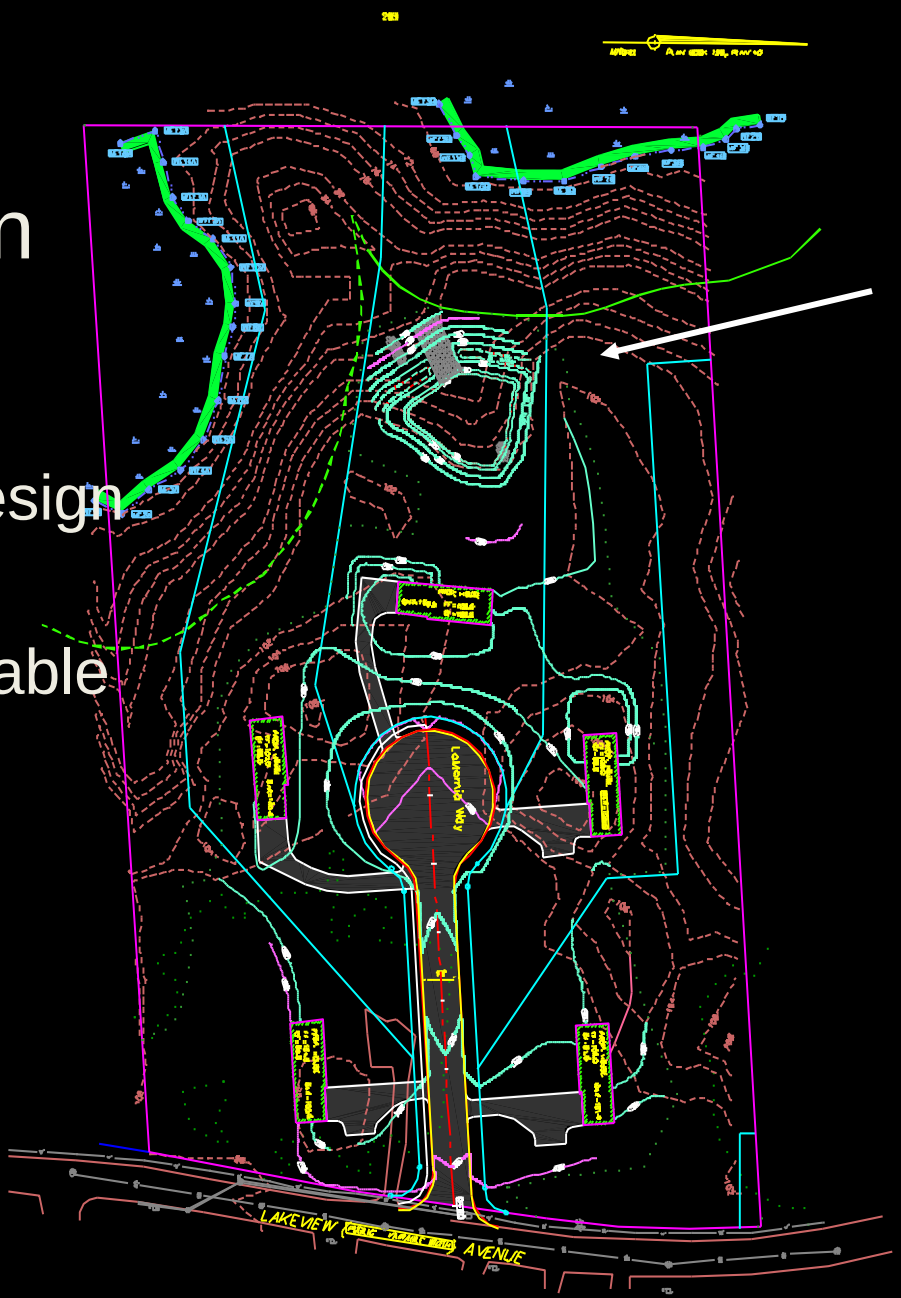
- **The 2030 Challenge 2005-2009 Goal**: Fossil Fuel Reduction of **50%** for all new buildings
- What does this look like for new homes?
- Is it easy to accomplish?

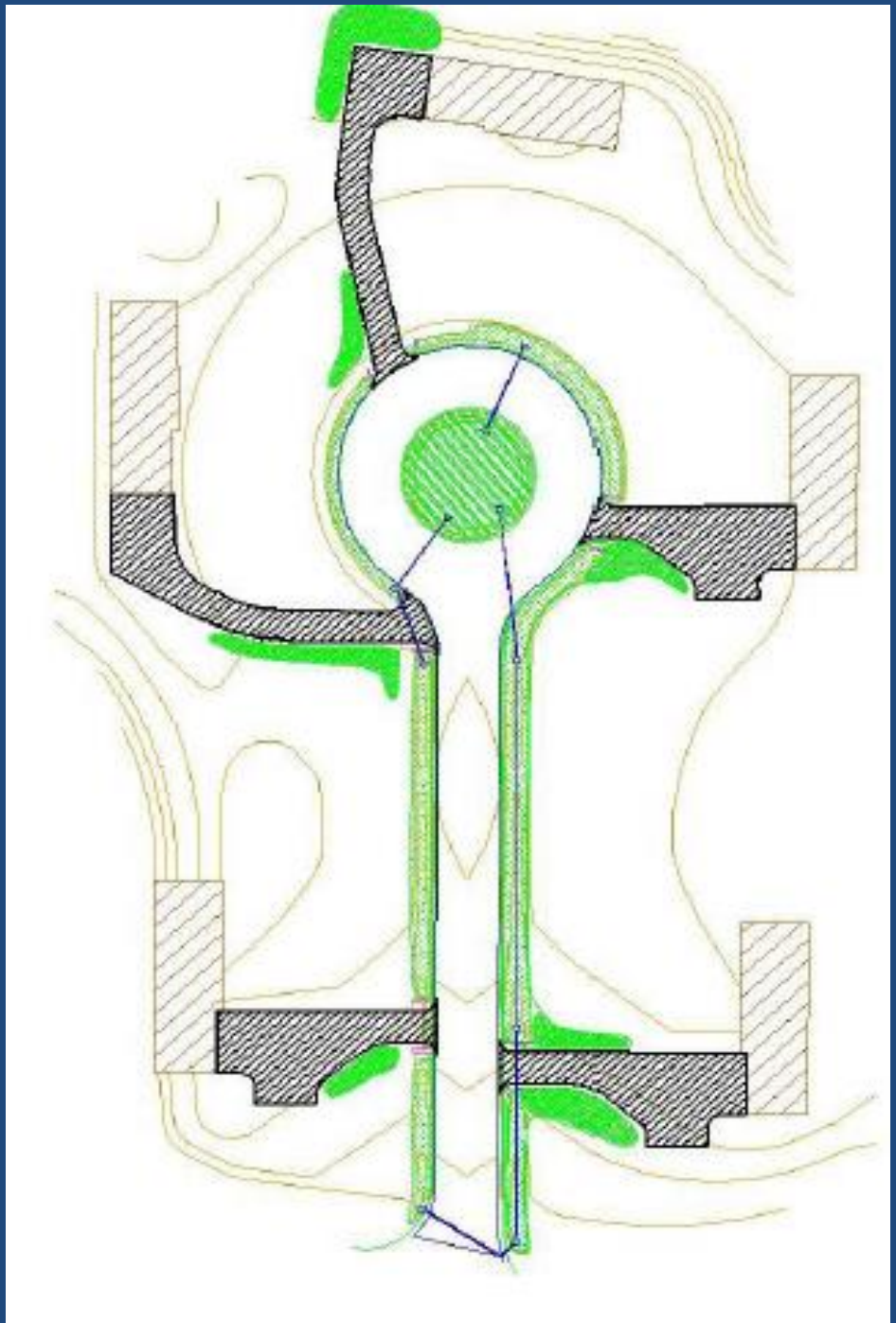
The Marla Circle Subdivision in Tyngsborough, MA

- Built in 2005 by Transformations, Inc.
- Won the 2005 Energy Star Builder Achievement Award
- 5 conventional homes
- Designed with Low Impact Development (LID) stormwater techniques
- Achieved an average of 50% savings in energy usage for the homes

Lakeview Ave Original Design

- Detention basin
- Curb and gutter design
- 28 foot roadway
- Only 4 lots approvable





Lakeview Ave Conceptual Design With LID

- Bioretention cul-de-sac
- Raingardens
- Swales
- Reduced road width to 24’
- Open section roads
- Disconnected flow paths
- Maintain existing vegetation
- Disconnected roof drainage

- Five (5) lots approved
- Extra lot very valuable to developer
- Reduced construction costs


Granite curbs set at the road elevation

Marla Circle home

Construction Details…

- *2x4 walls with 1” rigid on the outside*
- *16” on center conventional framing*
- *1.2 to 2.4 kW photovoltaic systems*
- *Hot water heater as boiler (96% efficient)*
- *Foam sealing window and doors*
- *Energy Star windows (U-value < 0.35)*
- *Garages on the North or West sides*
- *Panasonic ventilation fans*


POLARIS
Air Bear


AM
PM

Energy Star Ratings

- A 5 Star plus rating (the highest they went in the prior system) is anything over a 90.
- The Marla Circle homes ranged from 88.9 to 91.4 and averaged around 90.
- This converts to a HERS Index of 50 (a 50% reduction in energy consumed over the Code built home.
- The peak load for one of these houses was 44,000 BTU's

Marla Circle, Tyngsborough Costs

- About $95 to $100 per square foot for the hard costs of the house construction (2005 dollars)
- Town sewer; no road or soft cost included. No Builder overhead, margin or general expenses included.

HERS 40

- **The 2030 Challenge 2010 goal**: Fossil Fuel Reduction of **60%** for all new buildings

The Coppersmith Way Development in Townsend, MA

- 41 unit 40B project (includes affordable housing)
- Construction is 2006 to present.
- 27 homes completed to date.
- 16 LEED Certified homes
- 30.5 acres (8 acres of wetland and open space)

Coppersmith Way
Low Impact Development Measures

- Nitrogen Reducing Septic Systems (8.5 mg/l vs 45mg/l)
- Water Quality Swales (84% N removal)
- Wetland Stormwater Treatment Areas (30-43% N removal) vs detention basins
- Bioretention Cells (51% N removal)
- Porous Pavers on Walkways
- Phyto-Enhanced Quality Buffers
- Raingardens (51% N removal)
- Disconnected Stormwater Flow Paths
- Total Nitrogen Reduction 80% (0.13 mg/l modeled additional N Load to the well assuming no dilution or uptake in wetland)

Coppersmith Way Goals

- Using building science engineering, push the envelope in cost effective green building
- To work towards Zero Energy Homes
- To be financially profitable
- To provide aesthetically pleasing homes at a reasonable price

Saving 60% (Hers Index of 40)

- 2 x 6 walls with an inch of rigid
- Advanced construction techniques
  - 24” on center
  - Headers designed for their loads only
  - 2 stud corners
- Paradigm windows with a U-value of .28
- The same 96% efficient water heater/boiler
- 3.45 kW PV system

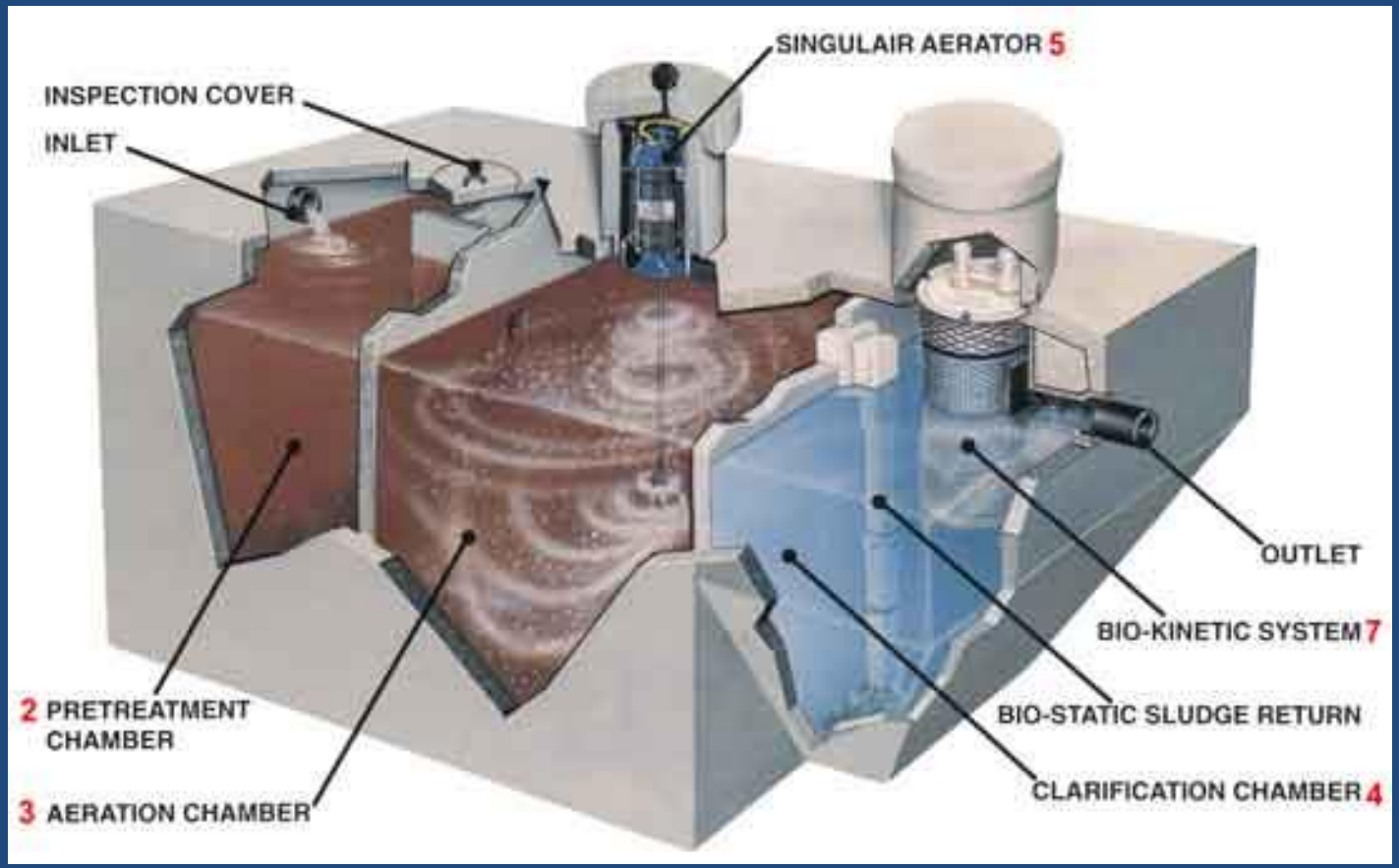
HERS Index of 37.5

HERS Index of 43

HERS Index of 39

Singulair® Residential Wastewater System

(Approved in MA Total Nitrogen <10mg/l)



HERS 30

- **The 2030 Challenge 2015 goal**: Fossil Fuel Reduction of **70%** for all new buildings

How we got to 70% savings…

- Same specifications as the 60% homes, but…
- Smaller living spaces
- Multi-family units (shared wall or floor/ceiling)
- Forced hot water baseboard heating systems
- Larger PV system per square foot of living space

Triplex Homes

Triplex home built in Townsend, MA in 2007

Under construction---note the varied entrance ways

The Greek Revival's projected performance:

- Energy Efficiency
  - •EPA Energy Star, with a HERS ratings between 24 and 28, saving over 70% of the homes energy needs
- Sustainability
  - •LEED (Leadership in Energy and Environmental Design) Certification in the works
  - •Projected to reduce greenhouse gases by over 70%
- Innovation Sells and Helps with Marketing
  - •5 out of six sold or pre-sold in the first phase
  - •One (2) bedroom unit available for $168,000 to an income qualified buyer

Duplex Homes

Duplex Barn as built in Townsend, MA in 2008

HERS 20

- **The 2030 Challenge 2020 goal**: Fossil Fuel Reduction of **80%** for all new buildings
- How did we get there?
- What does this look like for a new home?

80% Savings Home

- Added a direct exchange ground source heat pump for:
  - Hot water
  - Heating
  - Cooling
- Added a greenhouse
- Increased the PV system 4.68 kW
- Passive orientation (more glazing on the South side, almost none on the North)

Saving 80% (HERS Index of 20)

Marginal Costs

- $6,000 more to do the ground source heat pump ($23,000 vs $17,000) for a market rate home.
- $5,940 marginal cost for the larger PV system
- Greenhouse – yes, this cost a lot more (about $20,000 all said and done, after incentives)

MA Stretch Code Homes

HERS 50 Homes

HERS 40 Homes

HERS 30 Homes

HERS 20 Homes

Questions?

3 Zero Energy Homes
Townsend, MA

HERS 0

- **The 2030 Challenge 2030 goal**: Fossil Fuel Reduction of **100%** for all new buildings (using no fossil fuel green house gas emitting energy to operate)

A Massachusetts Utility sponsored "Zero Energy Challenge"

- To competition to "encourage builders to design and construct homes, which use considerable less energy than homes built with traditional practices, products and technologies".
- 6 builders were chosen.
- There is $50,000 in prize money.
- The lowest HERS Index wins!

Our first zero energy rated home (Home Energy Rating System or HERS of -4), built in Townsend, MA in 2008


SPACE PANELS
THIS SIDE DOWN
APA

HERS Index Results…

- HERS Index of -4

How we did it…

- Super insulation (R75 attic ceiling, R49 walls)
- High efficiency windows (R5 triple pane with krypton gas)
- Heat recovery ventilator (LifeBreath 155)
- Air source heat pump (Mitsubishi Mr. Slim)

How we did it, continued…

- Tight air sealing (175 CFM @ 50 Pascals after foam insulation)
- PV solar electric generation (5.7 kW)
- Solar domestic hot water with SunDrum panel inserts

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 (2008 dollars, incentives)

- 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 (2008 dollars)

- 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 “Affordable" Zero Energy Home (2008)

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

Actual Energy Usage

- 12 month of net metering came out with 1,615 kWh of electricity for total energy used in the house.
- At @.20 per kWh that's a cost of $323.00 per year for utility costs or around $27 per month.

The Farmhouse
(Built in Townsend, MA in 2008)

Applying what we learned in the “Zero Energy Challenge” to production home building.

Cost Effective Insulation

- Cellulose in the attic floor, R 3.5 per inch (18” for an R-63)
- Low Density Foam in the walls, R 3.9 per inch (12” for a cavity insulation of R-46.8).

- Note, We now mainly use ThermoSeal 500, R 3.8 per inch. It is a water based foam, reducing blowing agent off-gassing concerns.

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, fill , overhead, margin and general expenses.

- Includes $20,000 in incentives from the Massachusetts Technology Collaborative, and $21,432 in Federal/State tax credits

HERS Index and Energy Usage

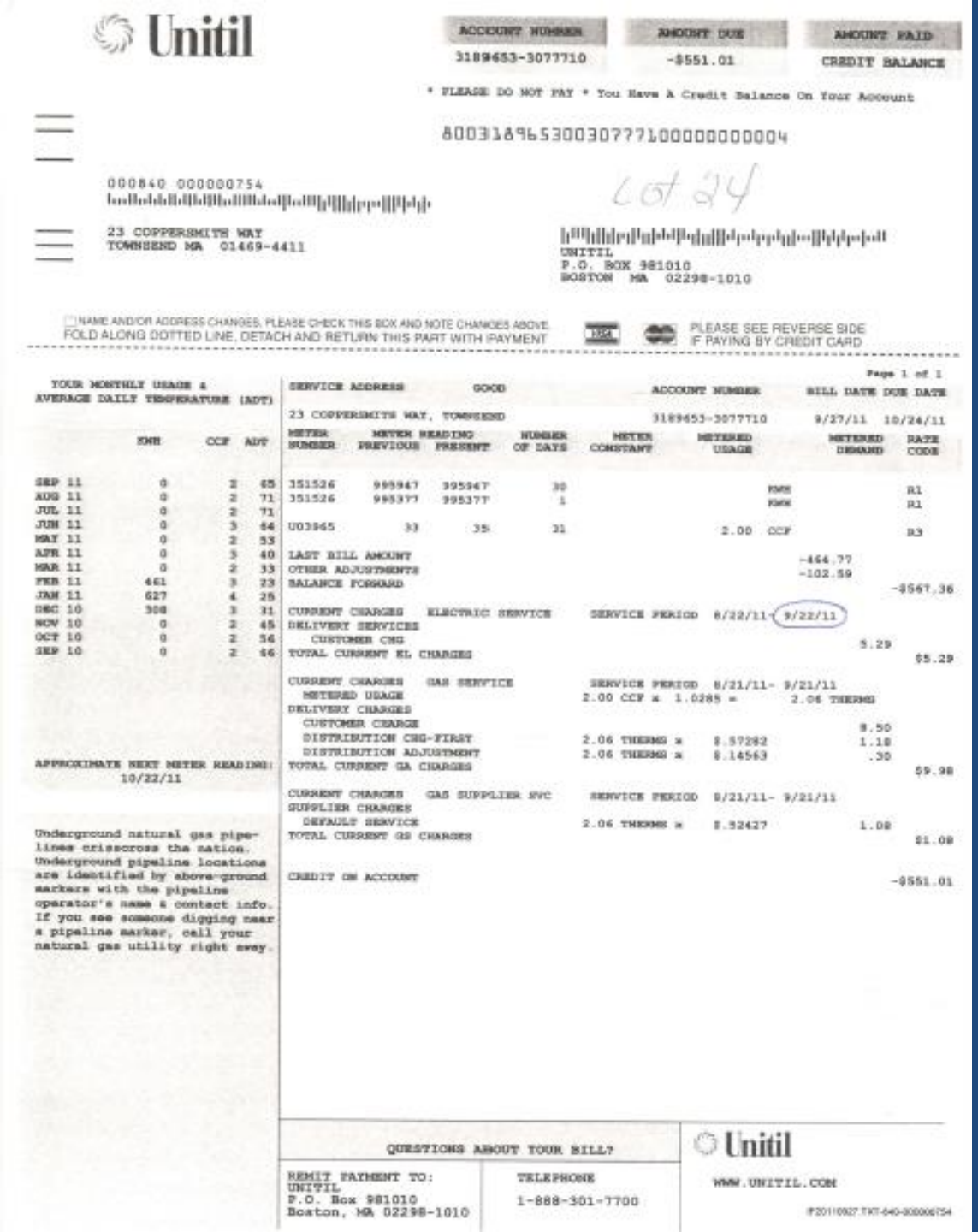
- The Farmhouse HERS Index came in at -3
- The actual energy usage came in at 915 kWh per year.
- At @.20 cents per kWh, the yearly costs were $183 or about $15 per month

The Groton
Built in Townsend, MA in 2010

(a home with 12 months of utility statements showing positive energy)

HERS Index and Energy Usage

- The Groton HERS Index came in at a 2
- The actual energy usage came in at -1574 kWh per year.
- At @.20 cents per kWh, the yearly credit built up was $315 or about $26 per month



Unitil

ACCOUNT NUMBER	AMOUNT DUE	AMOUNT PAID
3189653-3077710	-$551.01	CREDIT BALANCE

* PLEASE DO NOT PAY * You Have A Credit Balance On Your Account

800318965300307771000000000004

000840 0000000754

23 COPPERSMITH WAY
TOWNSEND MA 01469-4411

Lot 24

UNITIL
P.O. BOX 981010
BOSTON MA 02298-1010

NAME AND/OR ADDRESS CHANGES, PLEASE CHECK THIS BOX AND NOTE CHANGES ABOVE.
FOLD ALONG DOTTED LINE, DETACH AND RETURN THIS PART WITH PAYMENT

PLEASE SEE REVERSE SIDE IF PAYING BY CREDIT CARD

Page 1 of 1

YOUR MONTHLY USAGE & AVERAGE DAILY TEMPERATURE (ADT)

	KWH	CCF	ADT
SEP 11	0	2	65
AUG 11	0	2	71
JUL 11	0	2	71
JUN 11	0	3	64
MAY 11	0	2	53
APR 11	0	3	40
MAR 11	0	2	33
FEB 11	461	3	23
JAN 11	627	4	25
DEC 10	308	3	31
NOV 10	0	2	45
OCT 10	0	2	56
SEP 10	0	2	66

APPROXIMATE NEXT METER READING: 10/22/11

Underground natural gas pipelines criscrosse the nation. Underground pipeline locations are identified by above-ground markers with the pipeline operator's name & contact info. If you see someone digging near a pipeline marker, call your natural gas utility right away.

SERVICE ADDRESS	GOOD	ACCOUNT NUMBER	BILL DATE	DUE DATE
23 COPPERSMITH WAY, TOWNSEND		3189653-3077710	9/27/11	10/24/11

METER NUMBER	METER READING PREVIOUS	METER READING PRESENT	NUMBER OF DAYS	METER CONSTANT	METERED USAGE		METERED DEMAND	RATE CODE
351526	995947	995947	30			KWH		R1
351526	995377	995377	1			KWH		R1
U03965	33	35	31		2.00	CCF		R3

LAST BILL AMOUNT	-464.77	
OTHER ADJUSTMENTS	-102.59	
BALANCE FORWARD		-$567.36
CURRENT CHARGES ELECTRIC SERVICE SERVICE PERIOD 8/22/11- 9/22/11		
DELIVERY SERVICES		
CUSTOMER CHG	5.29	
TOTAL CURRENT EL CHARGES		$5.29
CURRENT CHARGES GAS SERVICE SERVICE PERIOD 8/21/11- 9/21/11		
METERED USAGE 2.00 CCF x 1.0285 = 2.06 THERMS		
DELIVERY CHARGES		
CUSTOMER CHARGE	8.50	
DISTRIBUTION CHG-FIRST 2.06 THERMS x $.57282	1.18	
DISTRIBUTION ADJUSTMENT 2.06 THERMS x $.14563	.30	
TOTAL CURRENT GA CHARGES		$9.98
CURRENT CHARGES GAS SUPPLIER SVC SERVICE PERIOD 8/21/11- 9/21/11		
SUPPLIER CHARGES		
DEFAULT SERVICE 2.06 THERMS x $.52427	1.08	
TOTAL CURRENT GS CHARGES		$1.08
CREDIT ON ACCOUNT		-$551.01

QUESTIONS ABOUT YOUR BILL?

REMIT PAYMENT TO:
UNITIL
P.O. Box 981010
Boston, MA 02298-1010

TELEPHONE
1-888-301-7700

Unitil
WWW.UNITIL.COM

IP20110927.TXT-640-000000754

$551.01 Credit Balance!

Only three months with net electric energy usage

-1,574 net electric energy usage for the year

Enough electric energy to run a plug in Prius or Nissan Leaf a majority of the year!

3 Zero Energy Homes
Townsend, MA

Questions?

Production Building For Other Developers

Easthampton, MA

31 lots

A build out project for Beacon Communities

Easthampton, MA

- Savings of about 60% in the base houses
- Optional PV as a lease, a purchase or a hybrid purchase.
- Typical retail costs per square foot were in the $120 to $145 range including site costs.

“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). Year 2000 dollars
- HERS Index of 2

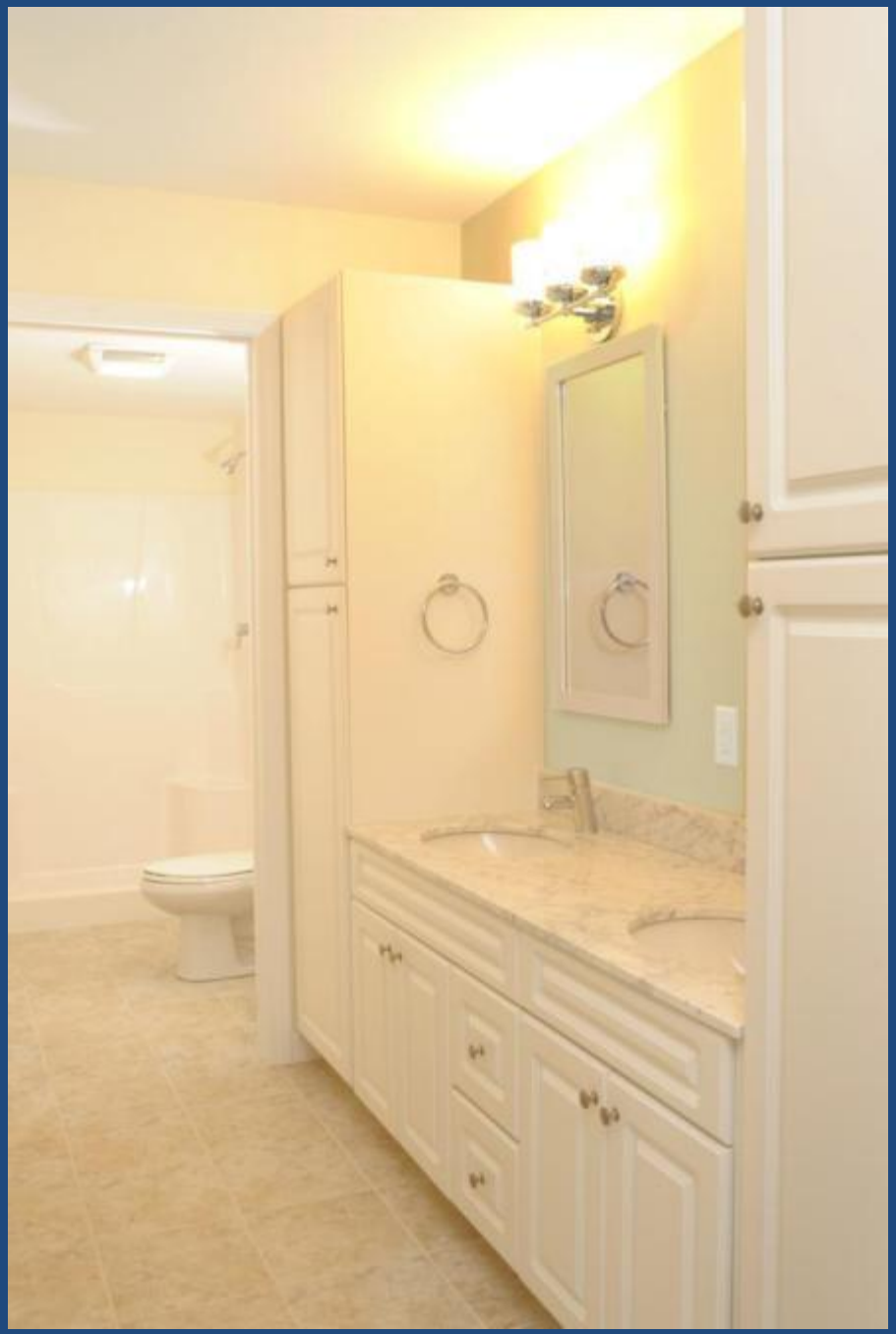
Mitsubishi inside unit

Model #MSZ-FE12NA (One 12,000 BTU head downstairs and one 12,000 BTU head upstairs)

Mitsubishi Outside Units

- Two Model #MUZ-FE12NA condensers
- Set up off the ground

Navien 180 instantaneous hot water heater



Master Bathroom

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

Building for an Affordable Housing Owner

- Lexington Housing Assistance Board (LexHAB)
- Expected construction starting in 2015
- Retail cost expected to be about $160 per square foot including expensive site costs.
- A leased solar electric system will be included.

Triplex Rentals

HERS Indexes modeled at about -15

Questions?

Production Building for
Other Developers

Ventilation Options

Ventilation Systems
(2014 Customer Pricing)

- "Basic Requirement" to meet minimum Energy Star standards: Panasonic fans with 30 CFM continuous settings with a boost option to 70 CFM for 30-45 minutes---$300 per fan.
- Assume two fans like this and one regular fan. Note that one must take precautions in high radon areas (passive mitigation system and poly over insulation that is taped well).

Ventilation Systems (continued)

- Fantech 704 HRV, exhaust one bathroom and supply three bedroom locations---Add about $1,800 to the “Basic requirement”.

Ventilation Systems (continued)

- Fantech 1504 HRV in basement, exhaust three bathrooms and supply three bedrooms---Add about $2,500 to Basic requirement.

- LifeBreath HRV in basement, exhaust three bathrooms and supply three bedrooms---Add about $3,500 to Basic requirement.

LifeBreath ventilation system

Questions?

- Ventilation options?

Solar Electric Installations

Solar Electric System
Farmhouse II Model

- 36 panels
- 250 watts per panel
- 3 strings of panels
- Racking
- Inverter

Solar Electric Installations
9 kW Case Study---Costs

- The typical cost per watt is about $4.00
- For the 9 kW system, the cost is $36,000
- Micro-inverters add about 50 cents per watt.
- High efficiency panels add about $0.50 per watt.

Solar Electric Installations
9 kW Case Study---Incentives

- The Federal tax credit is 30%: $10,800 for a $36,000 system.

Solar Electric Installations
Electrical output of the system

- The 9 kW system will generate about 10,800 kilowatt hours in the first year, and average about 10,000 per year for the first 10 years

- At $.17 per kilowatt hour, that is $1700 per year or $34,000 over a twenty year period.

Solar Electric Installations
Total Revenue over 20 years

- The Federal tax credit: $10,800
- Electricity: $34,000
- Total Revenue: $44,800

Solar Electric Installations
Total Revenue over 20 years

- Total Revenue: $44,800
- Total Cost: $36,000 ($4.00 per watt)
- 20 year return: $8,800
- 5-10 more years of electricity free and clear!

Questions?

Solar Electric Installations

Custom Homes

A Custom home in Princeton, MA
A historic looking home from the front...

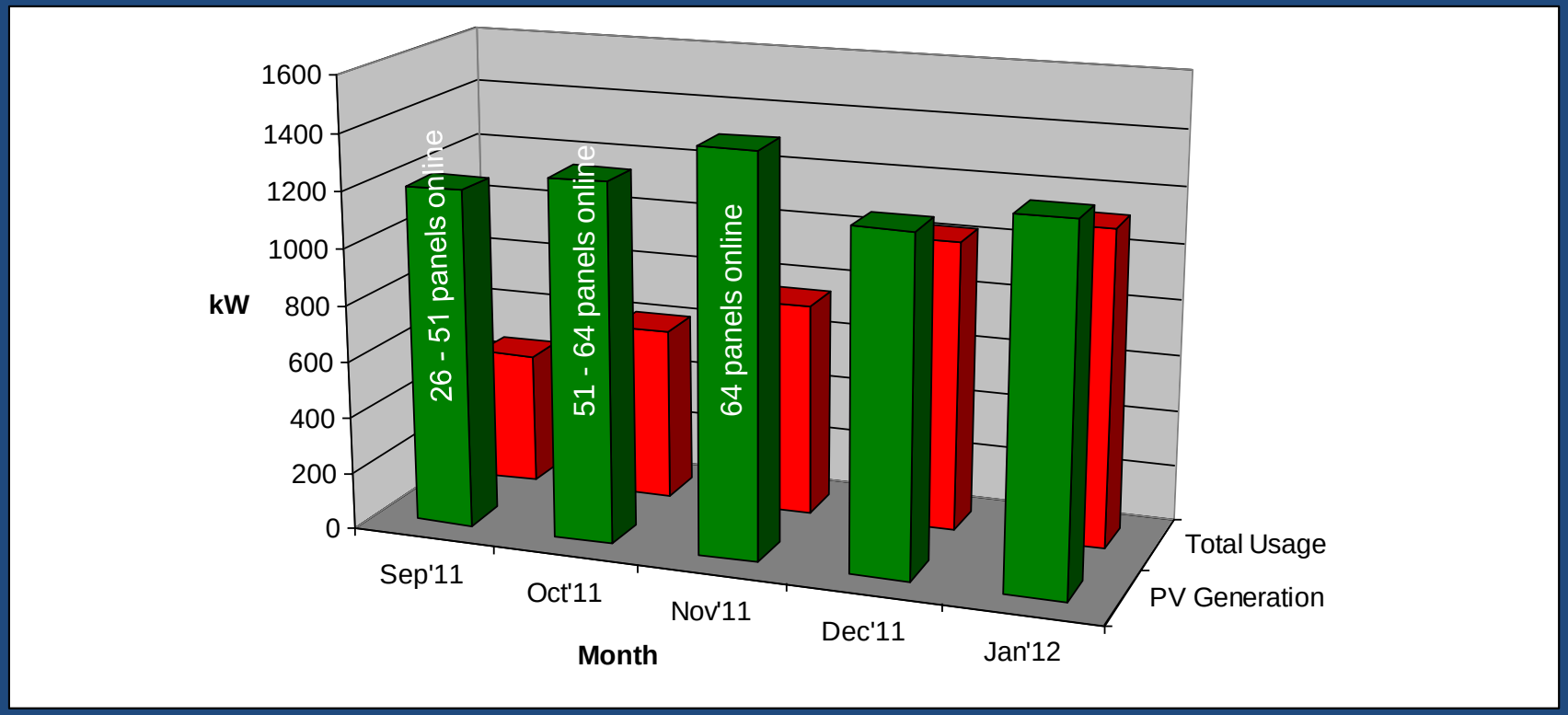
14.4 kW PV system in the back, HERS Index of -9

This all electric home generated an excess of 9,947 kwh in a year

…without sacrificing comfort

Princeton home

- Energy Positive performance…



A Custom Home is Stow, MA
15 ½ thick walls, Air infiltration of.50 ACH @50 pascals

A Custom Home is Maynard, MA

Large overhangs protect the home from summer solar heat gain.

Framing

The colored Insulated slab is protected during construction.

HERS Index of -8

A custom Home in Westborough, MA

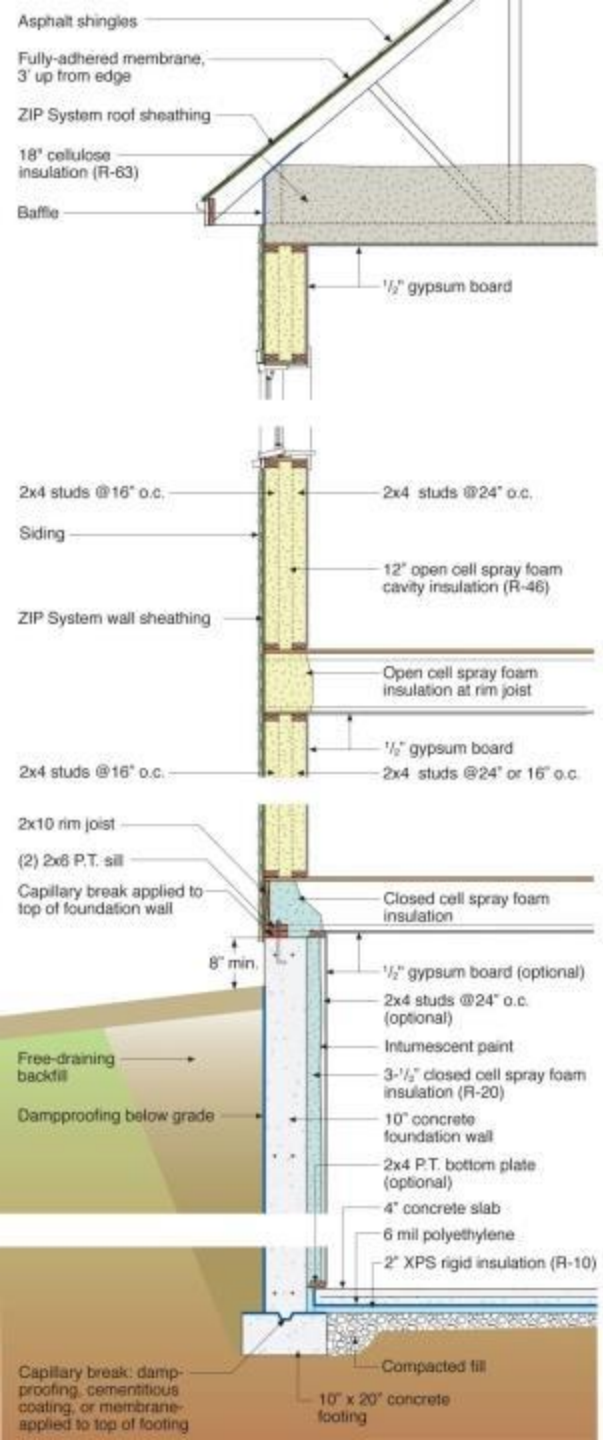
Net Positive Homes

Net Positive Homes

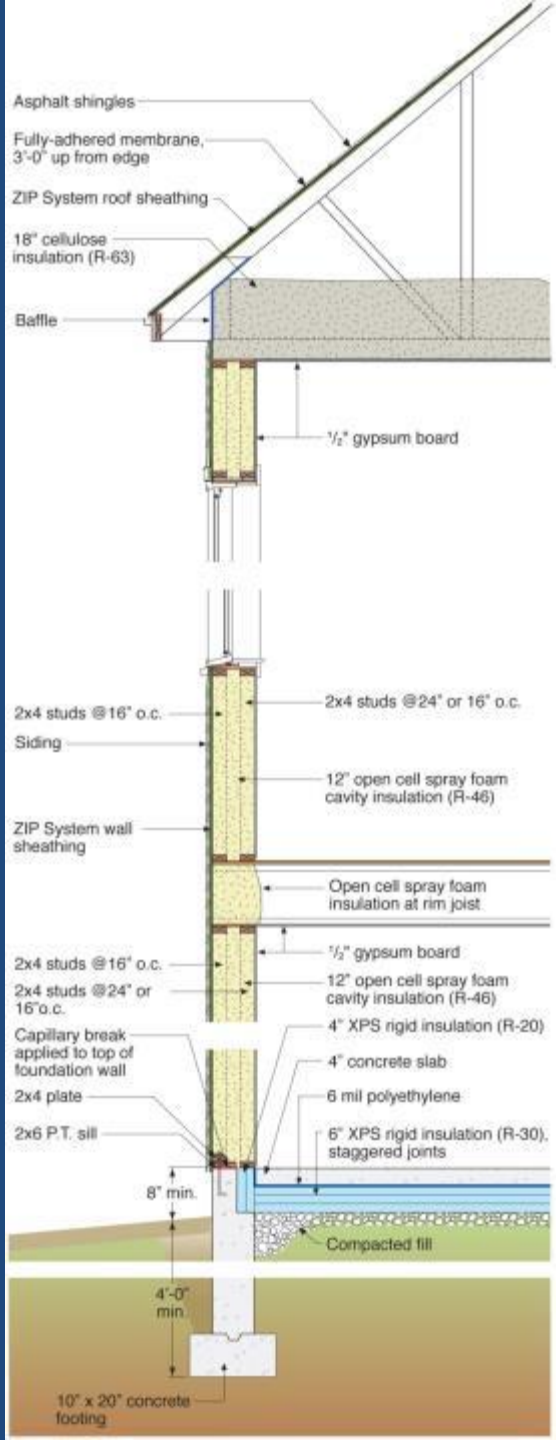
- Definition: A Net Positive Home is a home that produces more energy than it consumes over the course of a year.

2014 Transformations, Inc. Building Sections Standards

Homes with full basements

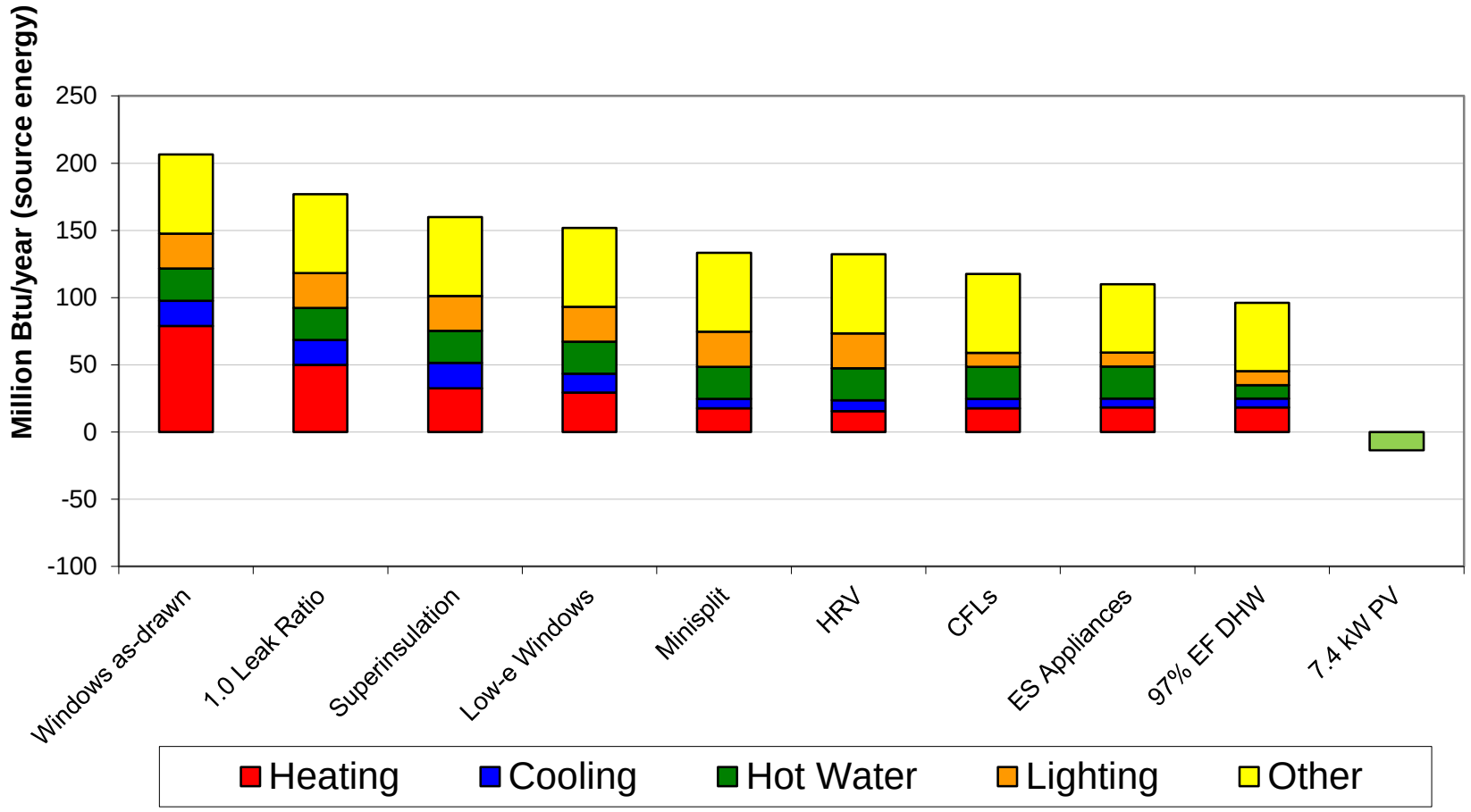


Homes with slab on grade



Drawn by
Building Science Corporation

Devens, MA Farmhouse Parametric Modeling

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A Winner in the Department of Energy Challenge Home competition, “Production House” category

HERS Index of -37

Generated 11,432 kwh more electricity than used in a year

Sold for $360,000 including the 16.32 kW solar system

A Winner in the Department of Energy Challenge Home competition, “Custom House” category

HERS Index of -21

Generated 8,586 kwh more electricity than used in a year

Very comfortable interior

HERS Index of -36

Generated 16,545 kwh more electricity than used in a year

Includes a 17.28 kW solar system

Customized Ranch

Double-Stud Wall Field Monitoring

Presented at the

Sixteenth Annual Westford Symposium on Building Science
July 30, 2012 to August 1, 2012

By Kohta Ueno of Building Science Corporation,

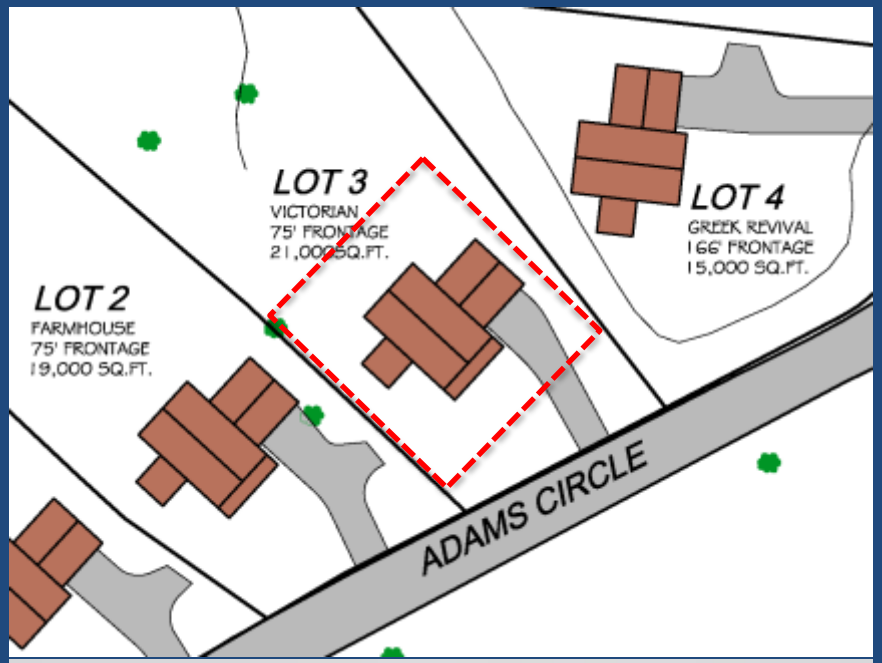
1 hour talk in conjunction with R. Carter Scott of Transformations, Inc.

Double Stud Wall Monitoring

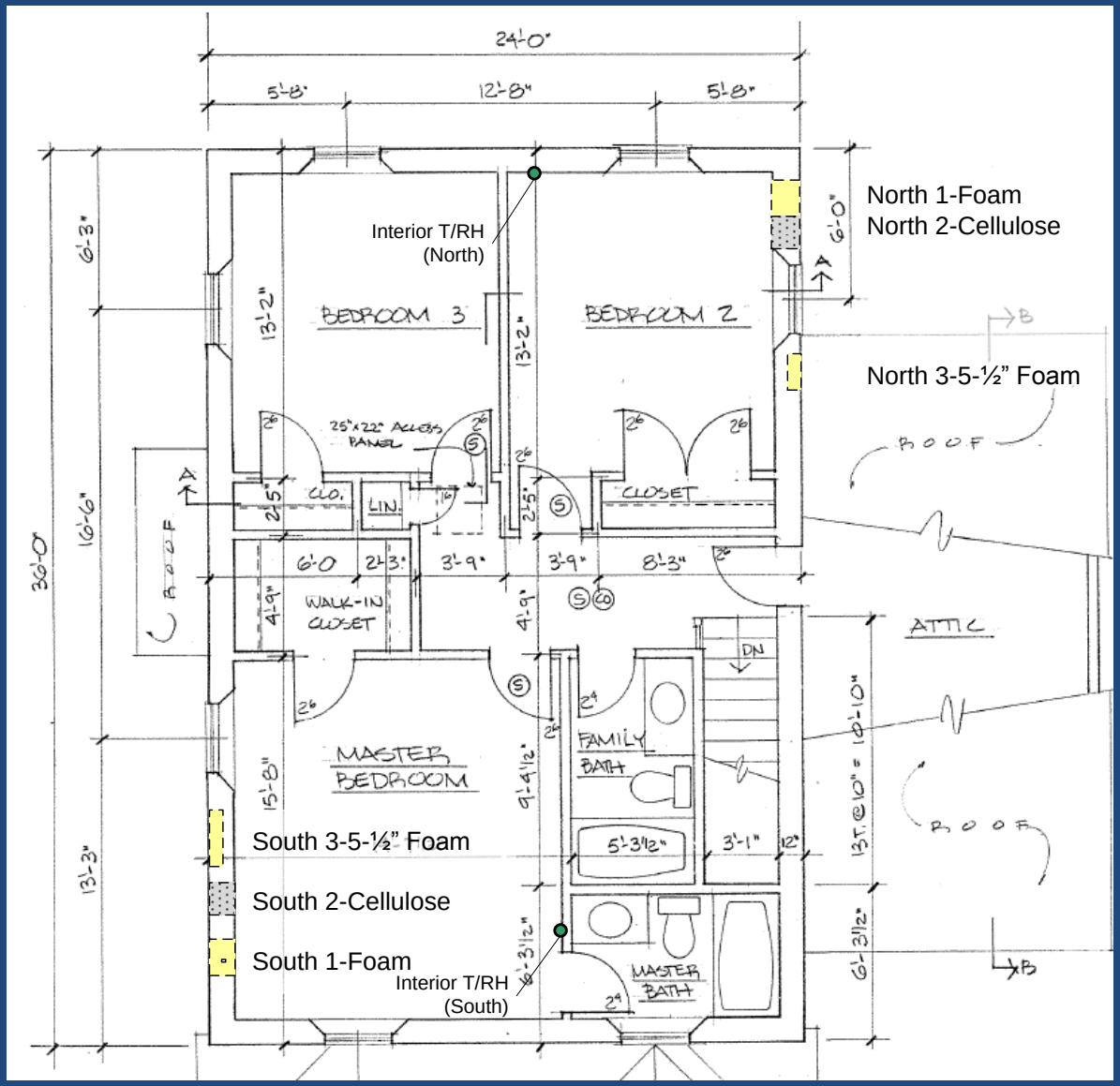
- Double stud wall advantages:
  - High R values
  - Simplifies exterior detailing (few changes to standard practice)
  - Lower cost vs. other high-R walls?

Double Stud Wall Monitoring

- Moisture risks due to interstitial condensation?
  - Most common failure, after rain control issues
  - Air barrier imperfections—increase risk
  - Air permeable low-density insulations—increase risk (including convective looping)
  - Air impermeable insulations—decrease risk
  - Reduce risk with “skim” of spray foam at sheathing?


LOT 3
VICTORIAN
75' FRONTAGE
21,000SQ.FT.
LOT 4
GREEK REVIVAL
166' FRONTAGE
15,000 SQ.FT.
LOT 2
FARMHOUSE
75' FRONTAGE
19,000 SQ.FT.
ADAMS CIRCLE

Test Wall Locations (2nd Floor)

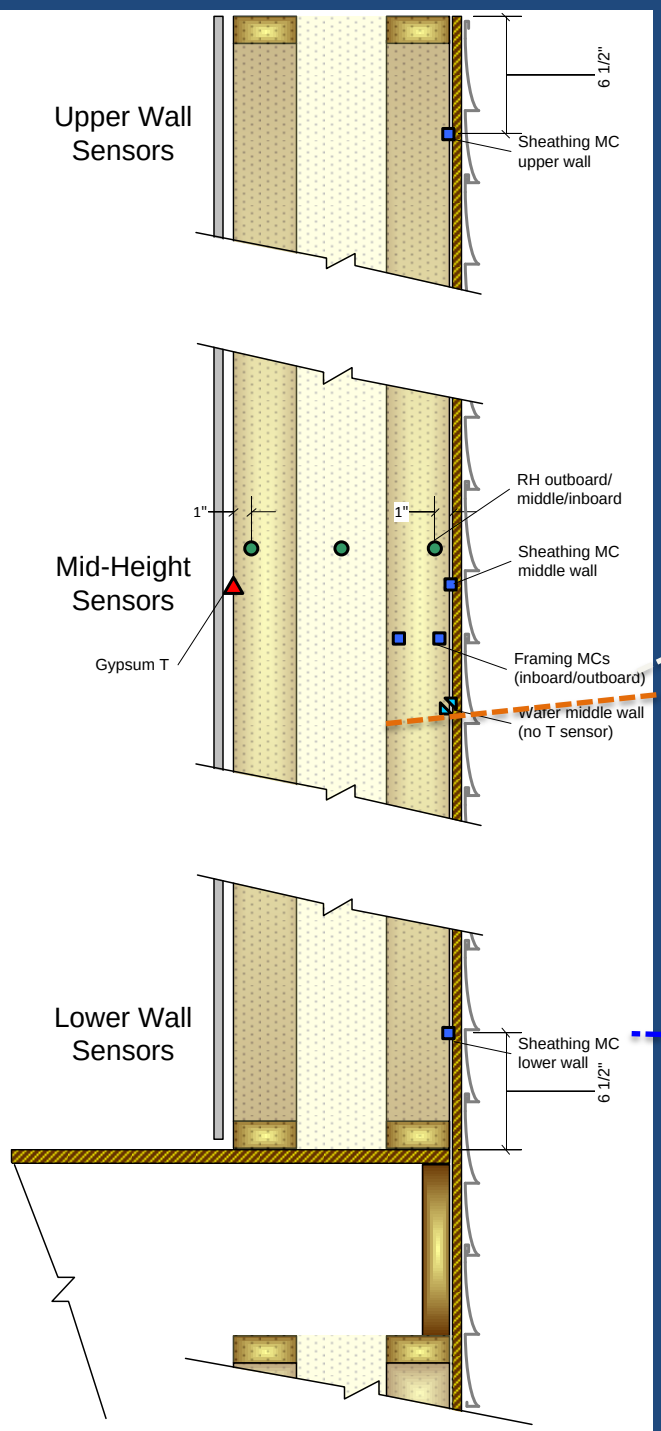


Wall 1 = 12" o.c. SPF
Wall 2 = 12" Cellulose
Wall 3 = 5-½" o.c. SPF

Wall Construction

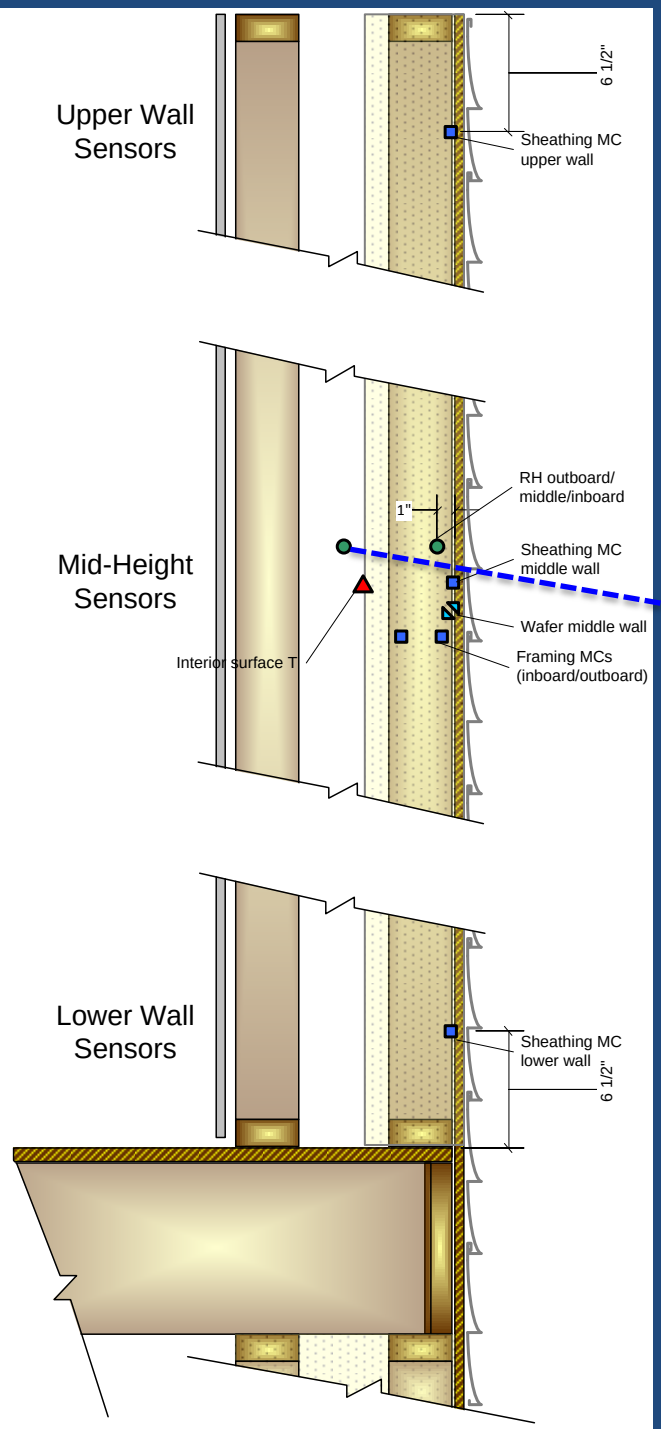
- Vinyl siding
- ZIP wall sheathing (OSB)
- Class III vapor control (latex paint)
- IRC R601.3.1—vented cladding over OSB

Test Wall Instrumentation



Sensor Key:
- Temperature
- Relative humidity/temperature
- Moisture content/temperature
- Moisture content block

Test Wall Instrumentation



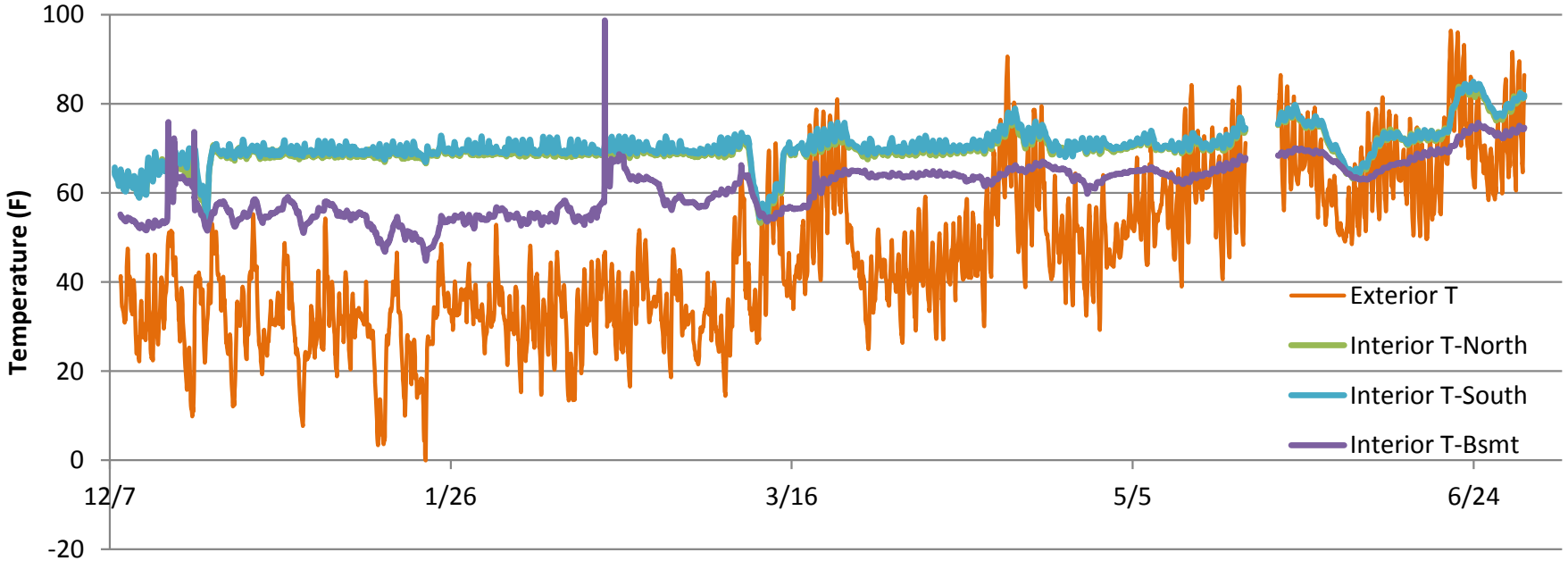
Sensor Key:

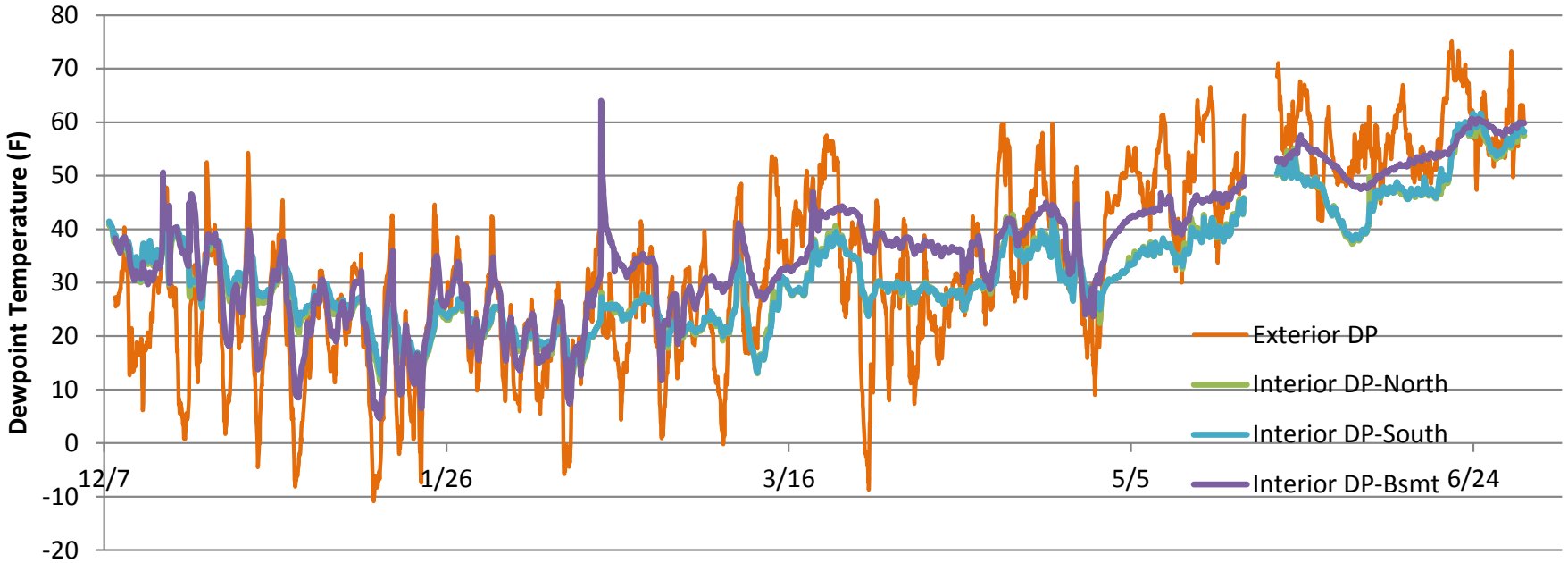
- Temperature
- Relative humidity/temperature
- Moisture content/temperature
- Moisture content block

Preliminary Results

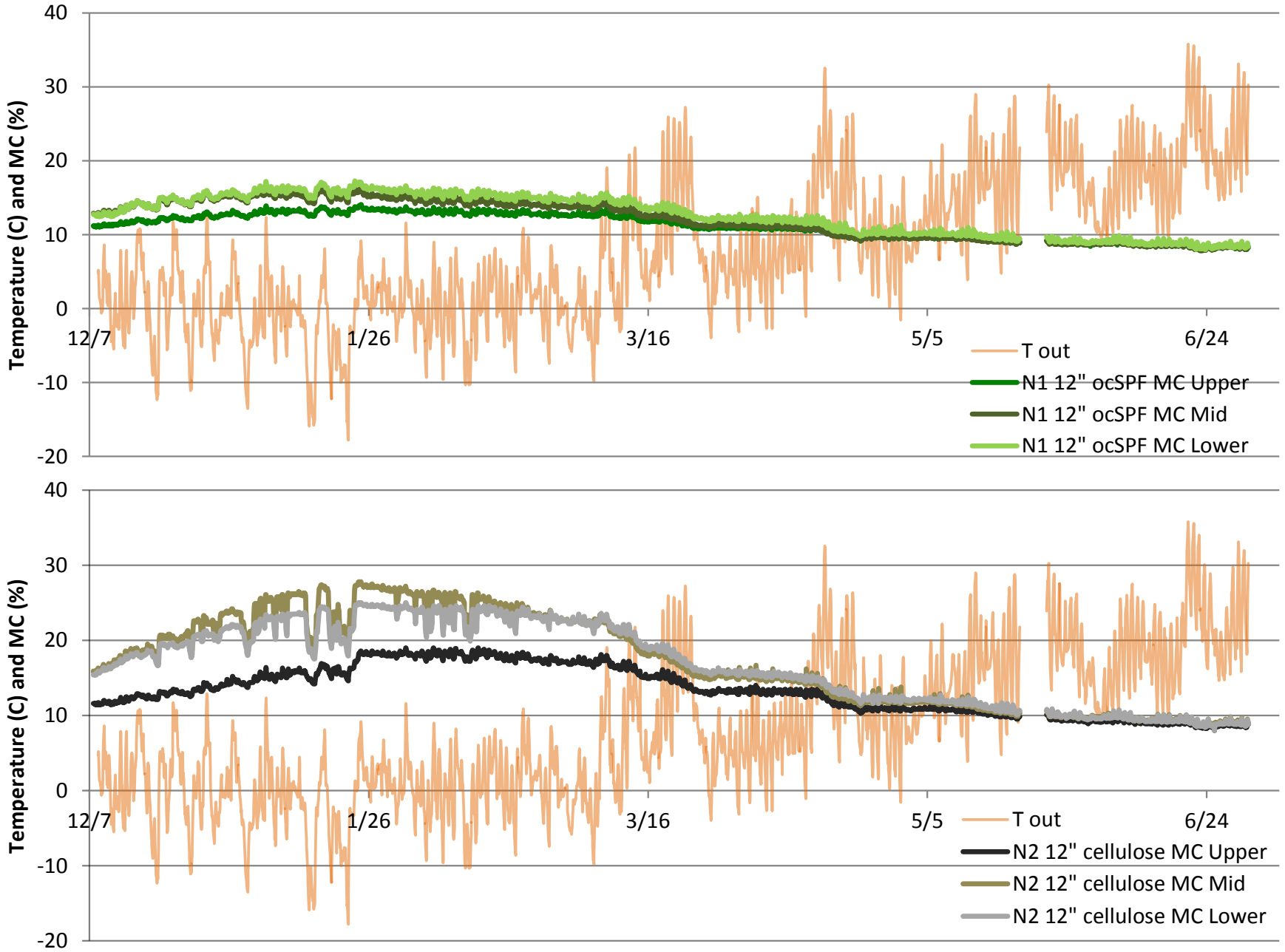
- First 8 months of data (December 2011-July 2012)
- Winter data unoccupied conditions
- No occupant moisture generation, but construction moisture drying
- Seriously weak-ass winter
- 4400 HDD Base 65 vs. 5600 HDD “normal”

Boundary Conditions

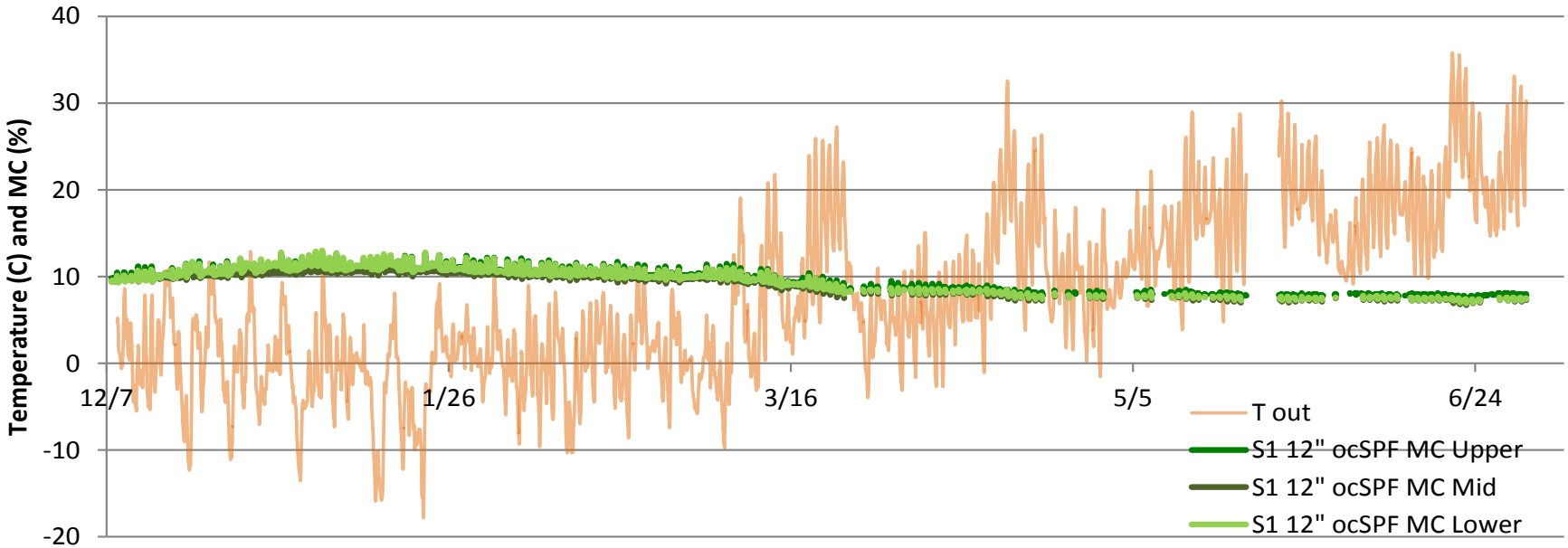


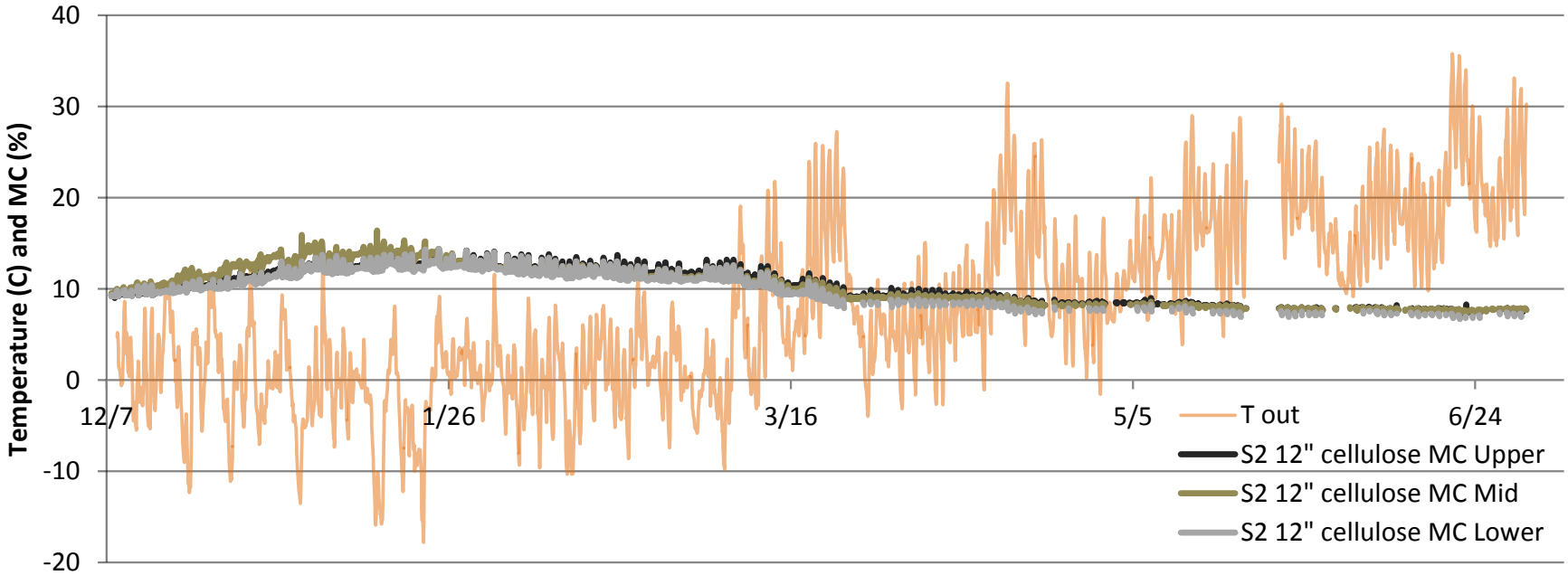


Sheathing Moisture Content (North)

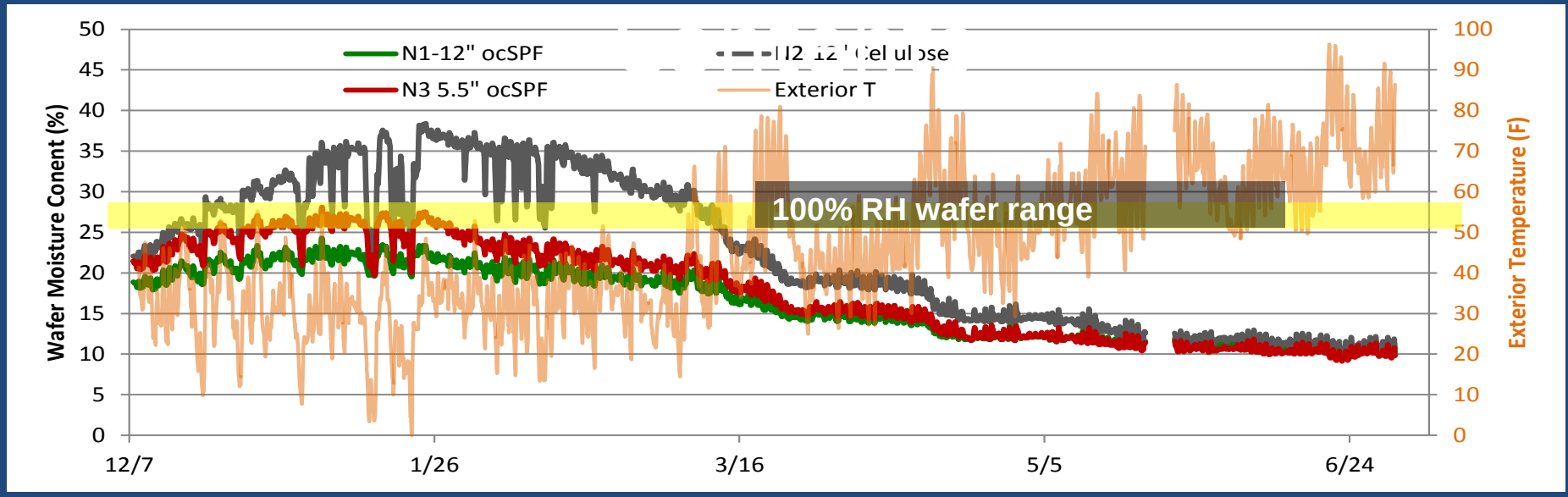


Sheathing Moisture Content (South)





Sheathing “Wafer” Moisture



30% MC wafer ≈ 100% RH

40-45% MC wafer → liquid water immersion

Data consistent with condensation at sheathing

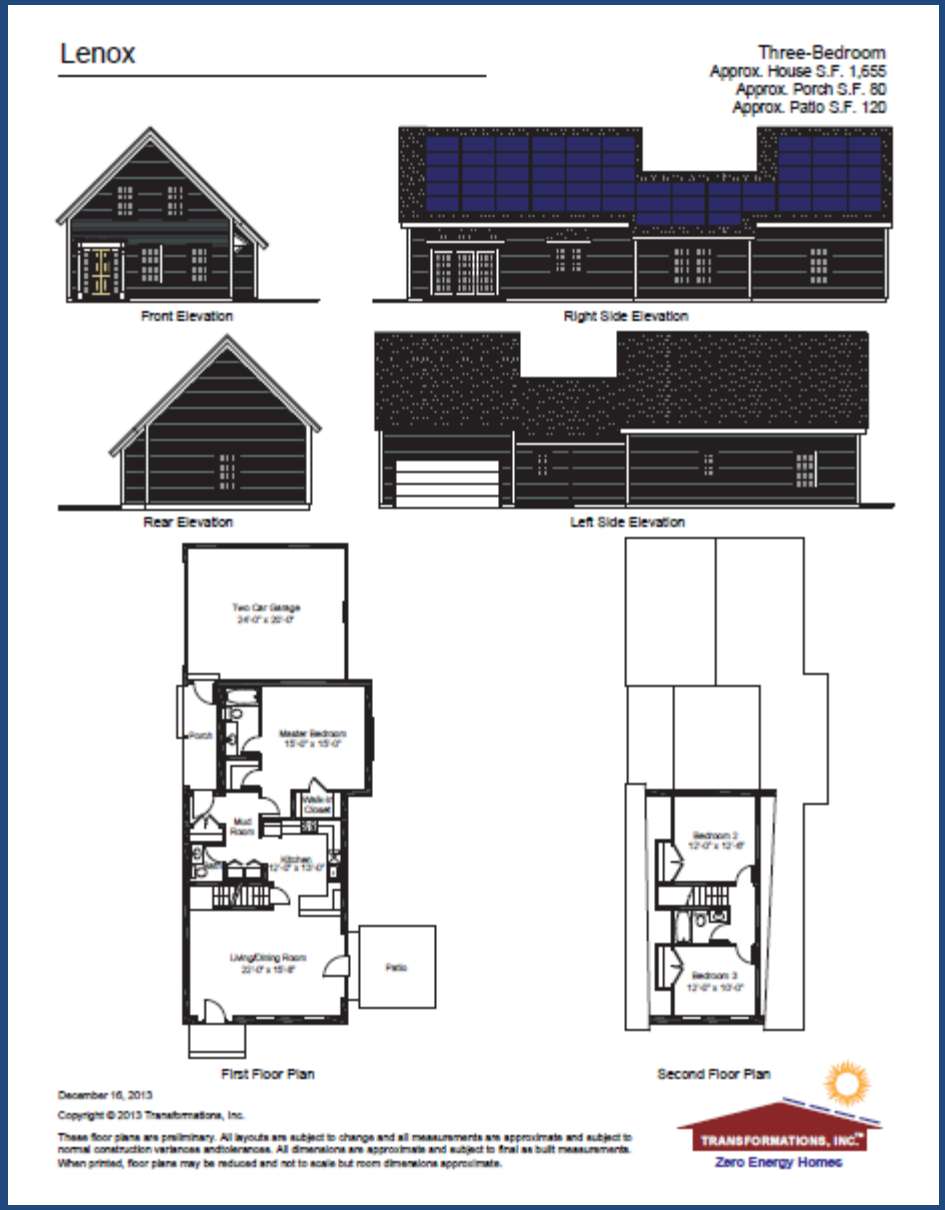
On the Planning Board…

Proposed Northampton, MA Neighborhood

A Greek Revival model with a garage in the back

This home earned a preliminary HERS Index of -25 based on the plans

The Needham has evolved to a new Lenox model with first floor master and a rear garage for expanded PV



A preliminary HERS Index of -48

The new 3 Bedroom Saltbox

Fits 26.52 kW

This is the largest residential PV system we have designed to date

A preliminary HERS of -66

Rendering looking towards the duplex homes and the solar carport

Carbon Reduction
Building Sector

- With a Zero Energy Home, we can reduce our share of the 42% (+/-) of the carbon that is associated in the United States with the building sector.

Carbon Reduction Transportation Sector

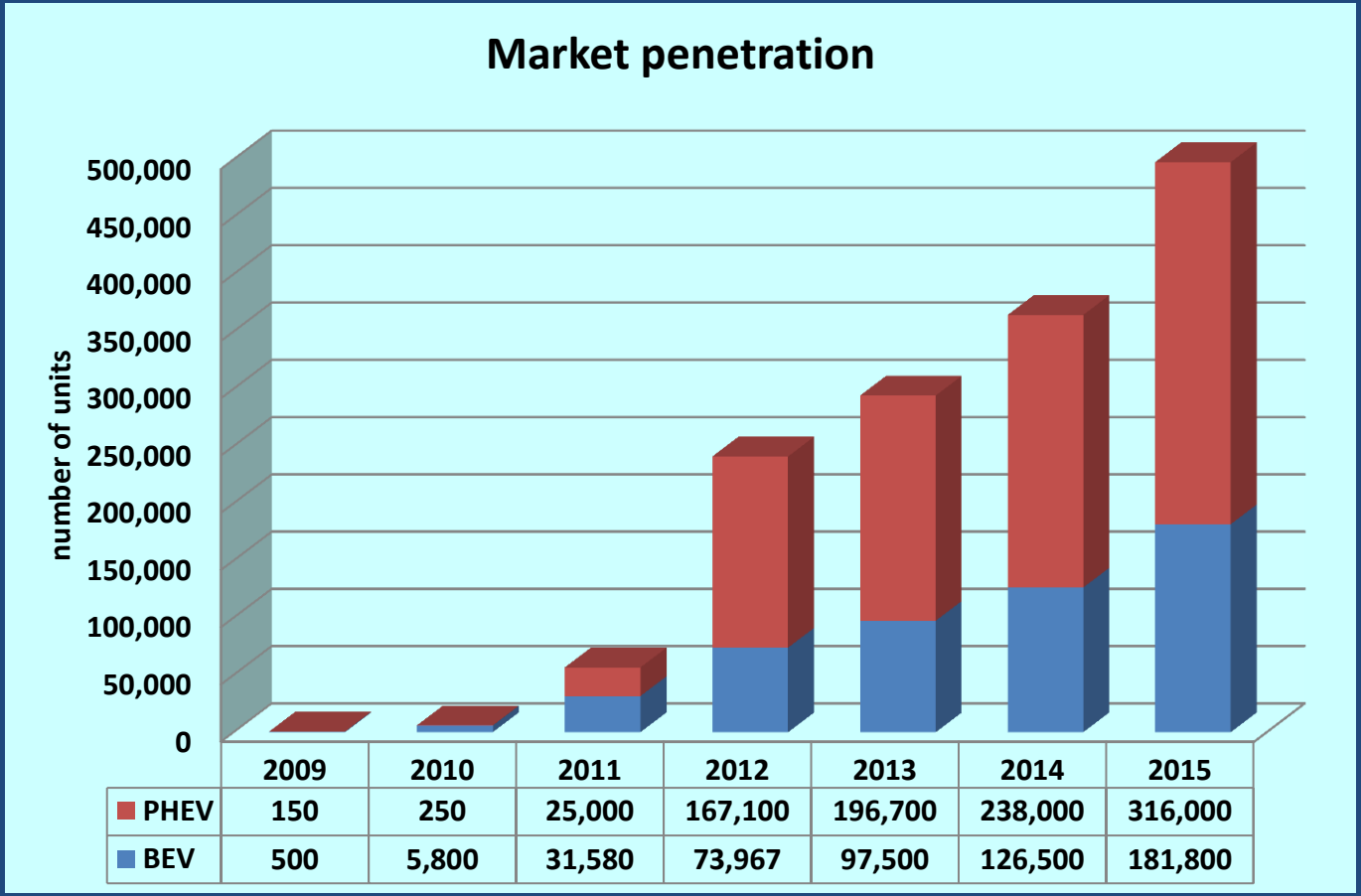
With HERS homes coming in at -21 to -37 range we can start to go after the 33% of the carbon that is associated in the United States with the transportation sector.

PV Powered Automobile

Charging stations on the Street

Some electric vehicles

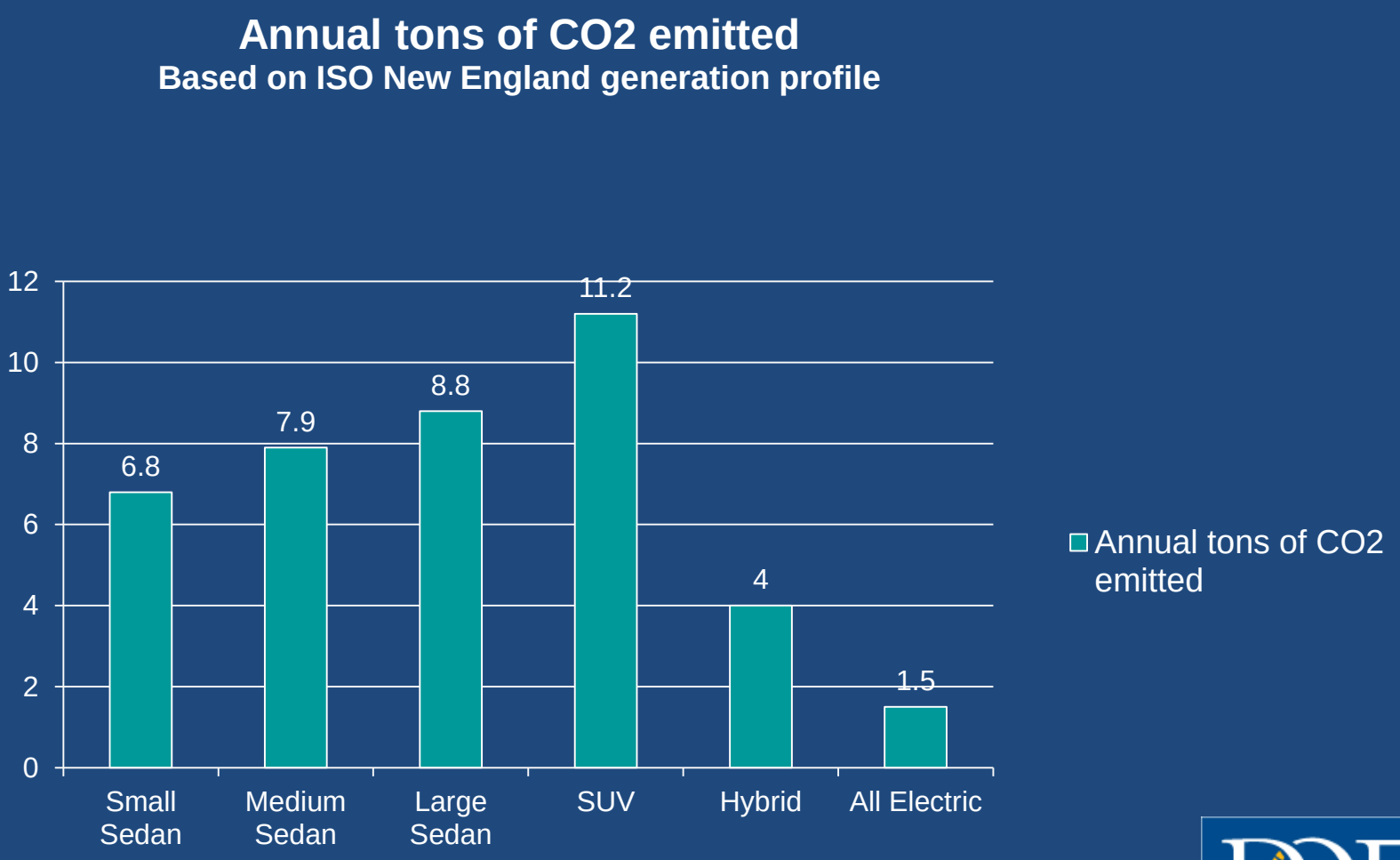
Plug-In Vehicles Enter Markets in Late 2010 - What is the Near-Term Achievable Market Penetration?



	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

•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

Electric vehicles and the environment

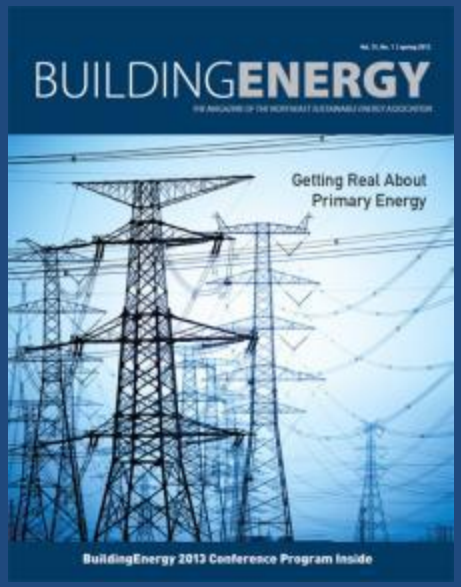


Resources…

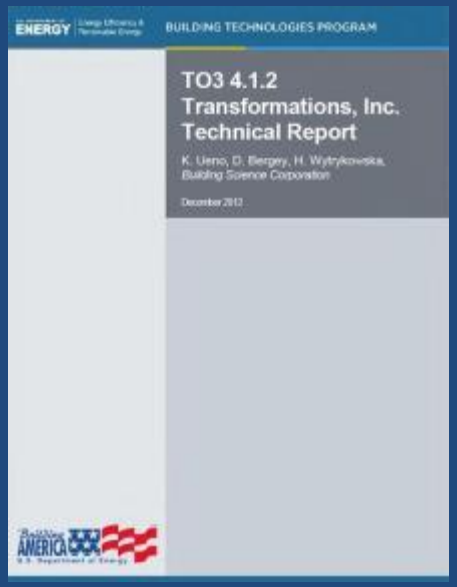
- The DSIRE website has lists of utility sponsored financial incentive programs, Mass CEC rebates, and all state and federal energy efficiency tax credits: http:/dsire.org/
- The Transformations, Inc. website: www.transformations-inc.com

Available on the website…

Solar Today and BuildingEnergy magazine article, Energy Positive Homes in Devens, MA March 2013



BuildingEnergy magazine article, Zero Energy and Beyond in Devens, MA Spring 2013



Building Science Corporation Technical Report to the National Renewable Energy Laboratory (NREL), December 2012

www.transformations-inc.com

Alaska Presentation

Pathways to Zero Energy

Questions?

Carter Scott, President, Transformations, Inc.

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