Modeled vs. Measured Energy Consumption for Single Family Homes

FEBRUARY 26, 2014 | 10:30 AM – 12:00 PM

Presenter:

Brian Lieburn // Dow Building Solutions

What is Project TEETH?

A multi-home, 5 year research project, in partnership with Cobblestone Homes, to investigate the performance of building enclosures designed to meet latest energy code requirements.

Research Objectives

- Demonstrate ways to:
  - Lower the cost of home ownership
  - Improve home performance
- Produce real world data on:
  - Construction cost
  - Energy use
  - Wall durability performance
  - Occupant comfort and perception
- Create output useful in construction decisions

Experimental Design - Foam vs. Fiber

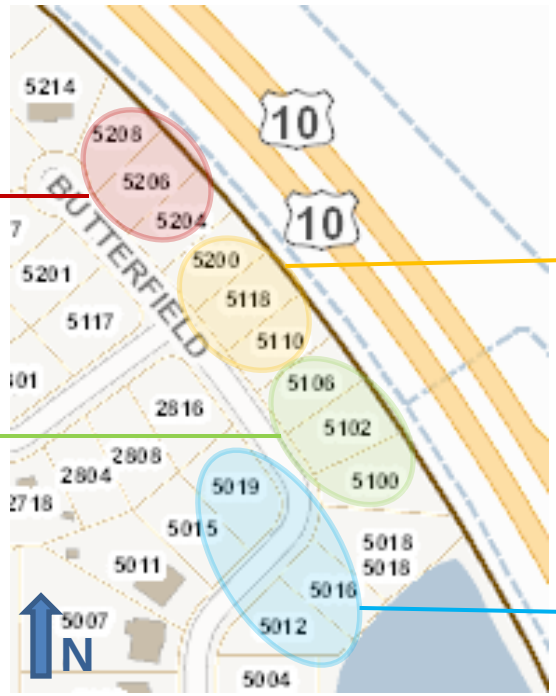
Three Homes Built For Each Energy Efficiency Design

Baseline HERS 82	Meet 2006 IECC Typical Local Practices
2012 IECC Fiber Minimum cost HERS 57	Meet 2012 IECC Least Changes & Lowest Possible Price Point
2012 IECC CI Premium Package HERS 57	Meet 2012 IECC Continuous Insulation & SPF
Beyond 2012 IECC Premium Package HERS – mid 40s	Beyond 2012 IECC Renewable Ready

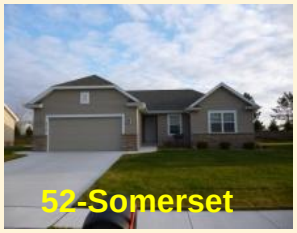
Research Neighborhood

Midland, Michigan Climate Zone 5-6

2006 IECC



2012 IECC



2012 IECC CI

Beyond 2012 IECC

Foundation & Floor Design

	Fibrous Insulation		Foam Insulation	
	2006 IECC	**2012 IECC**	**2012 IECC -CI**	**Beyond 2012 IECC**
Under Floor Slab	None	None	None	R-10 XPS
Rim Joist -Interior	R-19 FG batt	R-19 FG batt	R-16 cc SPF	R-16 cc SPF
Rim Joist – Exterior	None	None	R-5 XPS	R-10 XPS
Basement Wall – Interior Finished	R-13 FG batt	R-19 FG batt	R-5 XPS	R-10 XPS
Basement Wall - Interior Unfinished	R-10 FG vinyl faced	R-15 FG vinyl faced	R-5 PIR	R-10 PIR
Basement Wall – Exterior	None	None	R-10 XPS	R-10 XPS

Above Grade Wall and Ceiling Design

	Fibrous Insulation		Foam Insulation*	
	2006 IECC	**2012 IECC**	**2012 IECC-CI**	**Beyond 2012 IECC**
Stud Dimensions	2X6 16”o.c.	2X6 16”o.c.	2X4 16”o.c.	2X6 24”o.c.
Stud Cavity	R-19 FG batt	R-19 FG batt	R-16 cc SPF	R-31 cc SPF
Wall Exterior	OSB & Housewrap	OSB & Housewrap	R-5.5 SIS	R-5.5 SIS + R-5 XPS
Ceiling	R-38 Dry Blown Cellulose	R-49 Dry Blown Cellulose	R-49 Dry Blown Cellulose*	R-12 2”cc SPF & R-49 Dry Blown Cellulose*

Windows and Mechanical Design

	Fibrous Insulation		Foam Insulation*	
	2006 IECC	**2012 IECC**	**2012 IECC-CI**	**Beyond 2012 IECC**
Windows	U-.35	U-.32	U-.32	U-28
Furnace	80% AFUE	92% AFUE	92% AFUE	95% AFUE
AC	13 SEER	13 SEER	13 SEER	13 SEER
Water Heating	62% Electric	62% Electric	62% Electric	62% Electric
High Efficiency Lighting	0%	75%	75%	100%

Four Energy Efficiency Performance Strategies

Construction Cost Comparison

Actual Cost Complications

- Lot variations
- Elevation differences
- Material upgrades
- Weather related costs
- Price variations
  - ✓ Price fluctuations throughout the term of the project
  - ✓ Different suppliers or subcontractors
- Invoicing errors
- Quantity variations
  - ✓ Rob Peter to pay Paul
  - ✓ Different subcontractors
  - ✓ Theft
  - ✓ Damage

Isolating Energy Related Costs

- Exclude costs not related to energy levels
- Equalize all material and labor prices across the board
- Equalize or calibrate quantities
  - ✓ Use consistent areas between same house types
  - ✓ Use an actual material count across same house types
    - ❖ Make adjustments only when needed based on solid, logical and defensible judgments

Cost Summary

Somerset Model - Ranch	Framing, Insulation & Air Sealing	Windows & Exterior Doors	HVAC	Lighting	TOTAL	Premium from Baseline
2006 IECC	$ 14,888	$ 3,356	$ 6,922	$ -	$ 25,166	
2012 IECC - Fiber	$ 15,396	$ 4,545	$ 6,375	$ 100	$ 26,416	$ 1,250.27
2012 CI Dow Premium	$ 19,619	$ 4,545	$ 6,375	$ 100	$ 30,639	$ 5,472.96
Beyond 2012 IECC - Renewable Ready	$ 27,142	$ 5,477	$ 7,675	$ 350	$ 40,644	$ 15,478.09

Kendall Model - 2 story						
2006 IECC	$ 16,886	$ 3,660	$ 6,922	$ -	$ 27,467	
2012 IECC - Fiber	$ 17,215	$ 4,928	$ 6,775	$ 100	$ 29,018	$ 1,550.24
2012 CI Dow Premium	$ 21,086	$ 4,928	$ 6,775	$ 100	$ 32,889	$ 5,421.55
Beyond 2012 IECC - Renewable Ready	$ 28,789	$ 5,828	$ 8,075	$ 350	$ 43,042	$ 15,574.57

Preston Model - Ranch						
2006 IECC	$ 16,945	$ 3,447	$ 6,922	$ -	$ 27,314	
2012 IECC - Fiber	$ 17,744	$ 5,130	$ 6,375	$ 100	$ 29,350	$ 2,035.68
2012 CI Dow Premium	$ 22,297	$ 5,130	$ 6,375	$ 100	$ 33,902	$ 6,588.09
Beyond 2012 IECC - Renewable Ready	$ 29,023	$ 6,146	$ 7,675	$ 350	$ 43,194	$ 15,879.75

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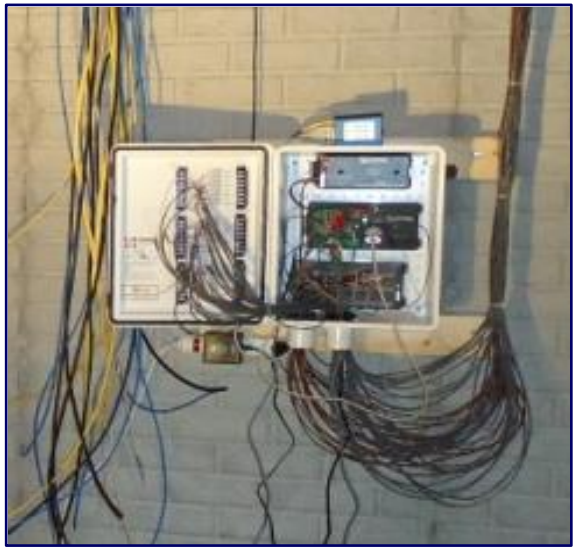
2012 IECC Fibrous vs. Foam Insulation Comparison

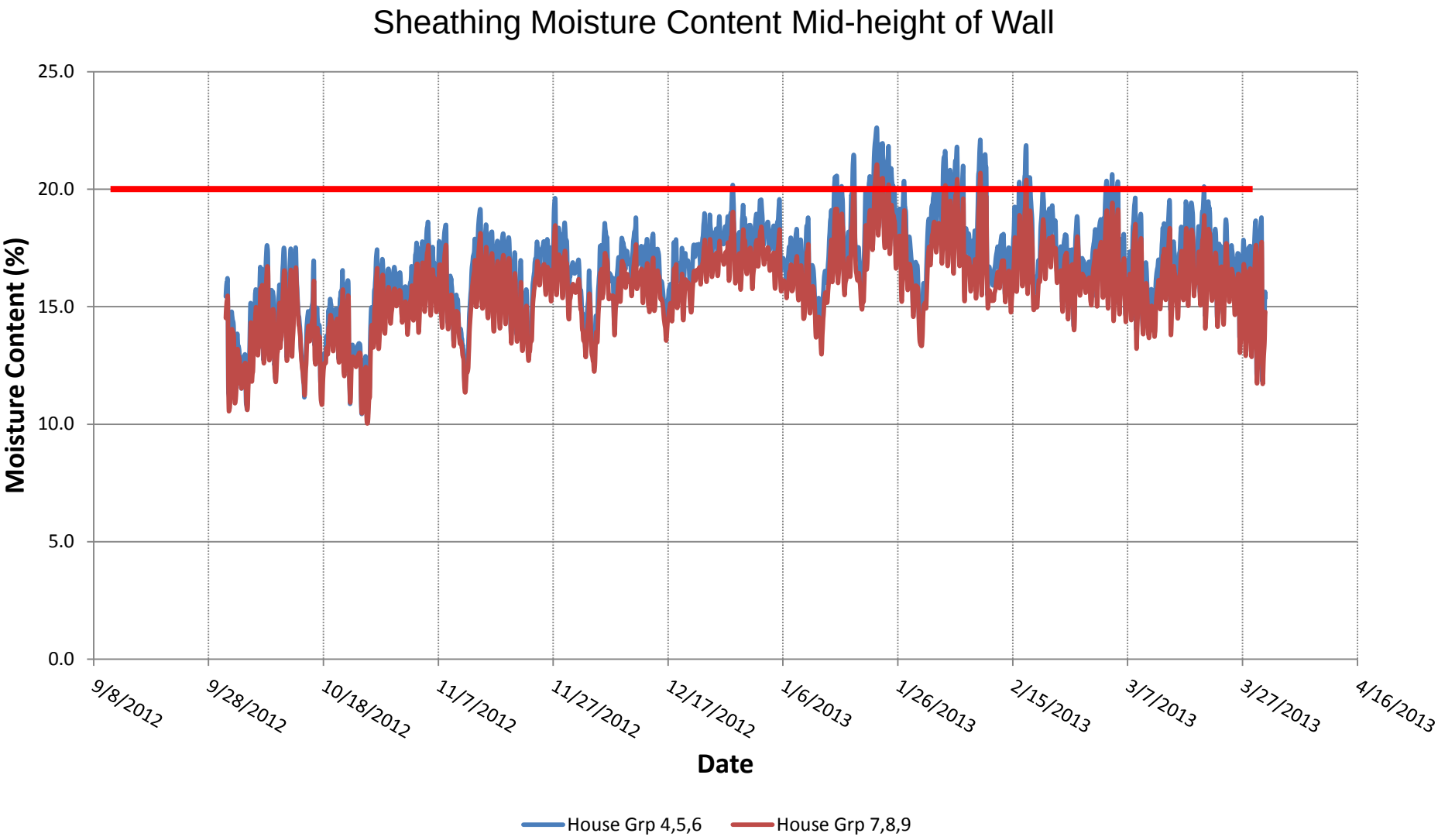
Hygrothermal Performance

Hygrothermal Instrumentation & Data Acquisition

- Moisture Content, Temperature, RH
- Inside three wall areas in each house
  - Conditioned – upstairs
  - Conditioned – downstairs
  - Unconditioned - downstairs
- Multiple measurements each measurement area
- Exterior temperature, RH



Above Grade Wall



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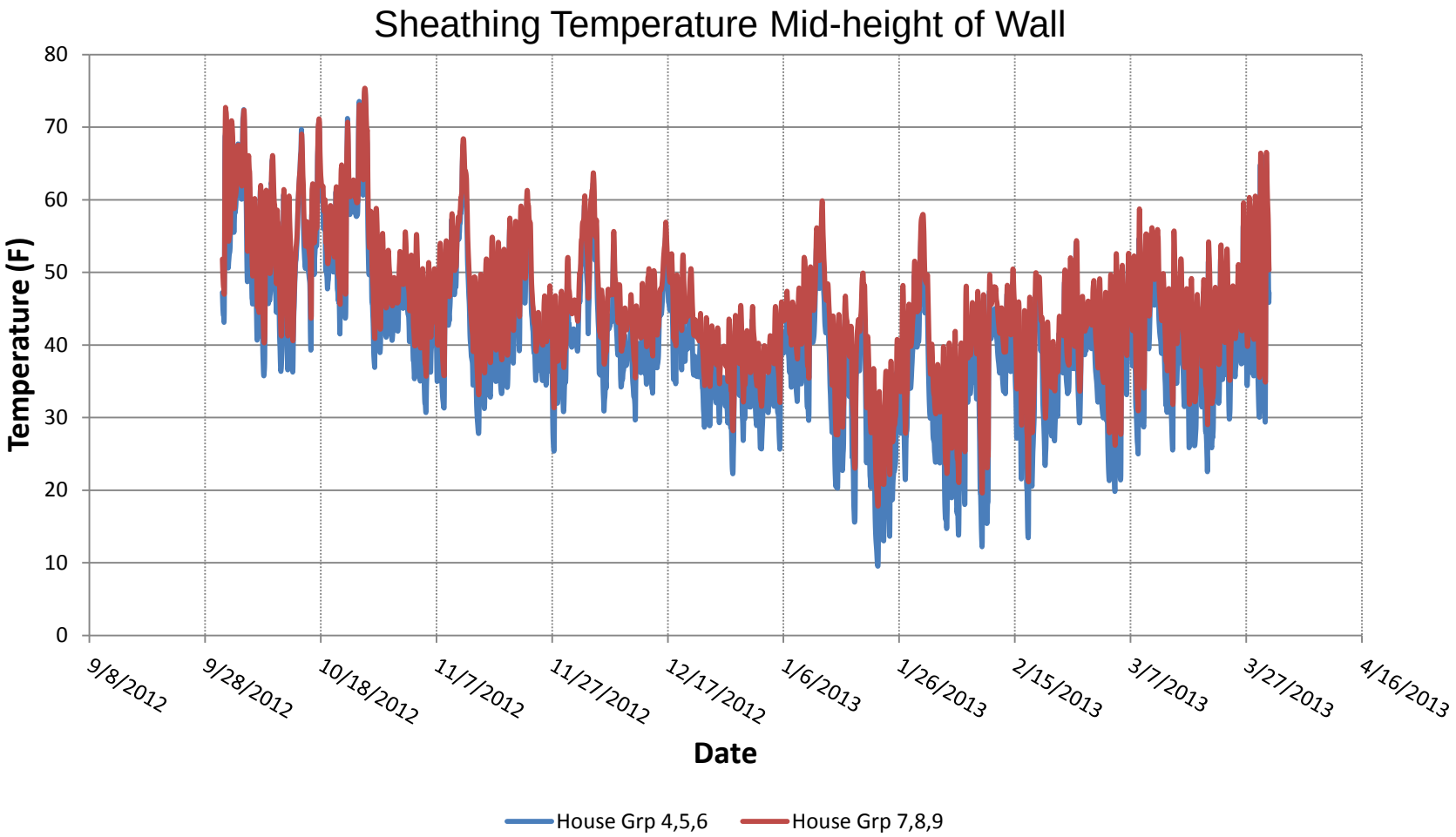
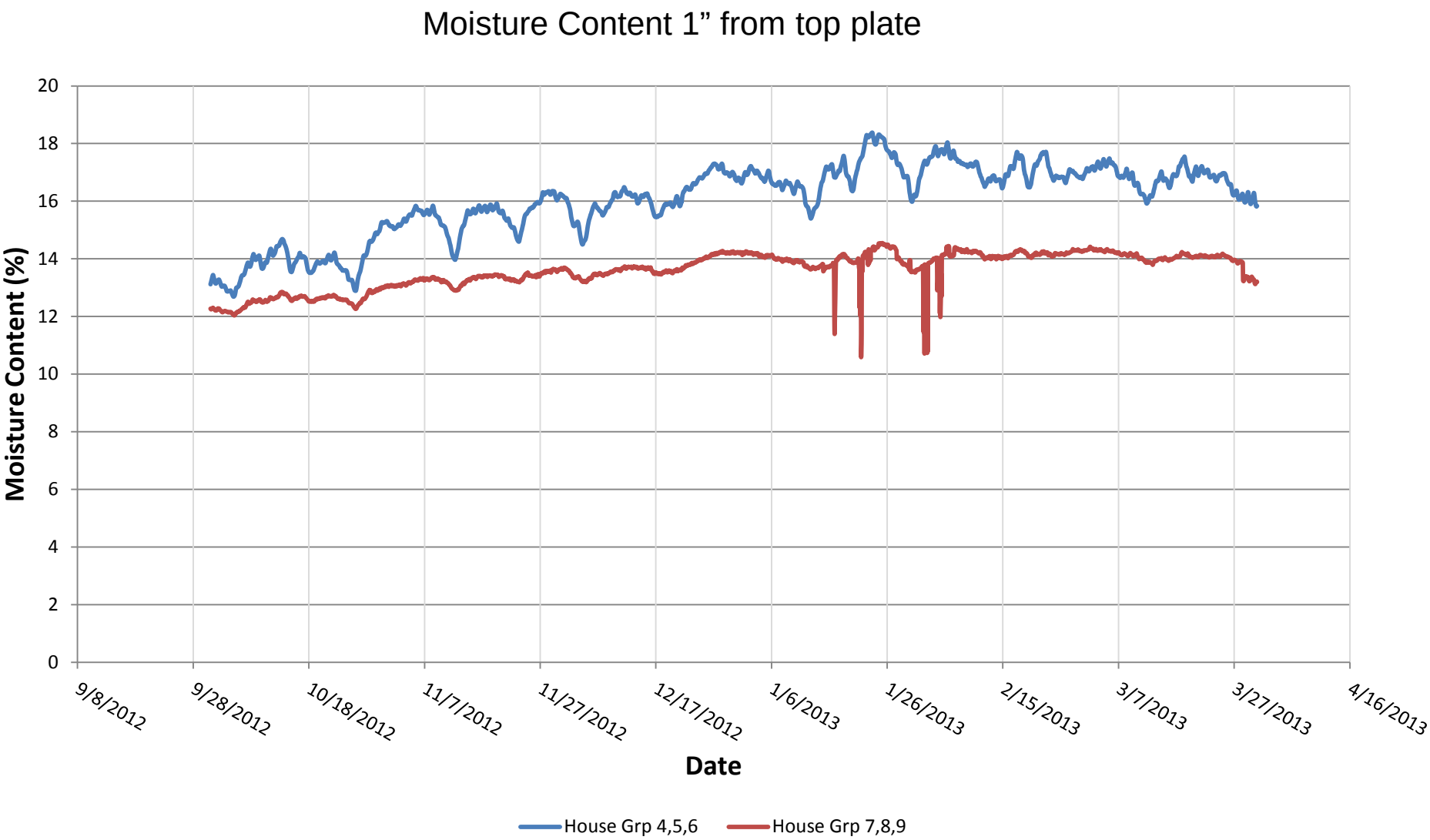
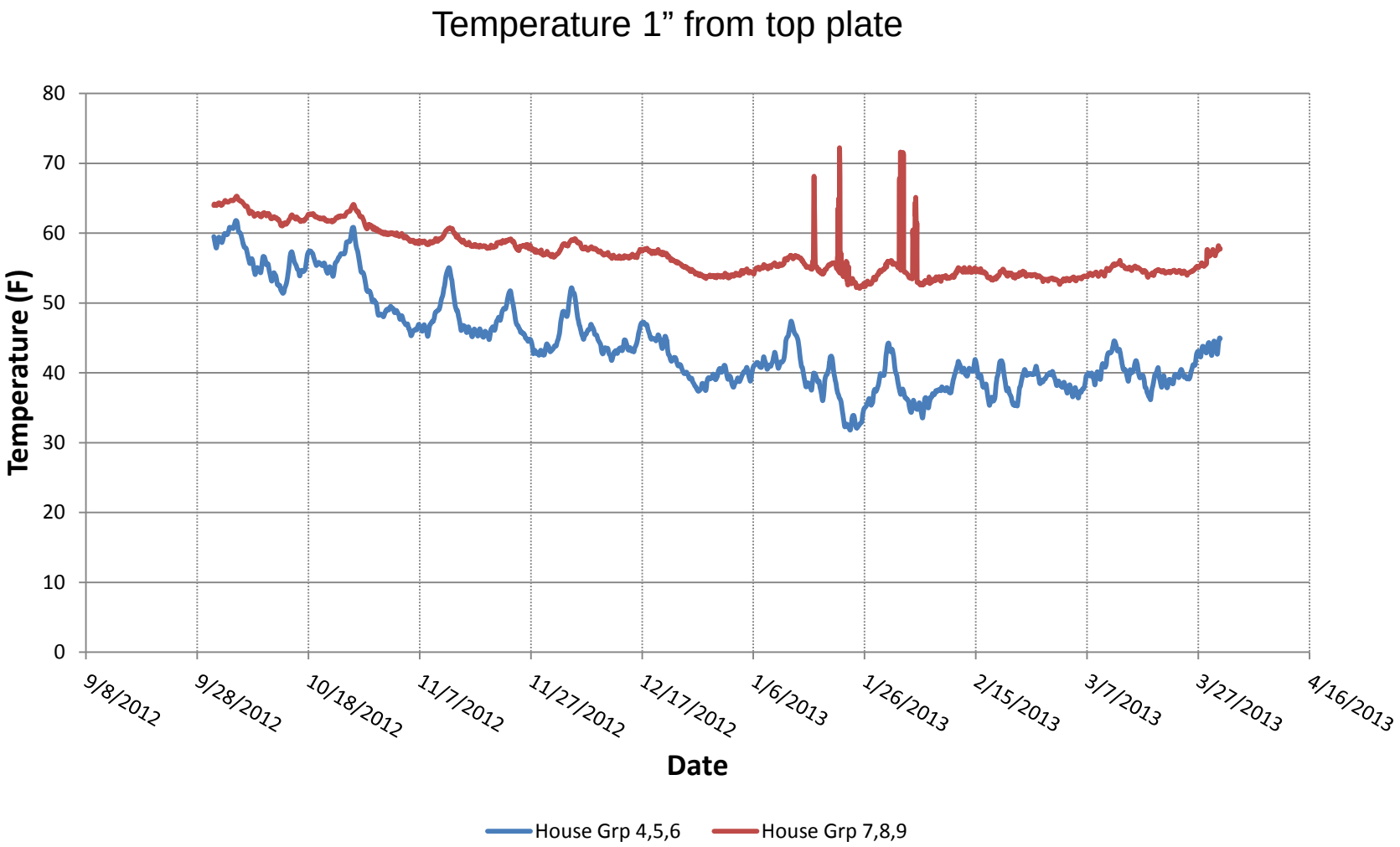


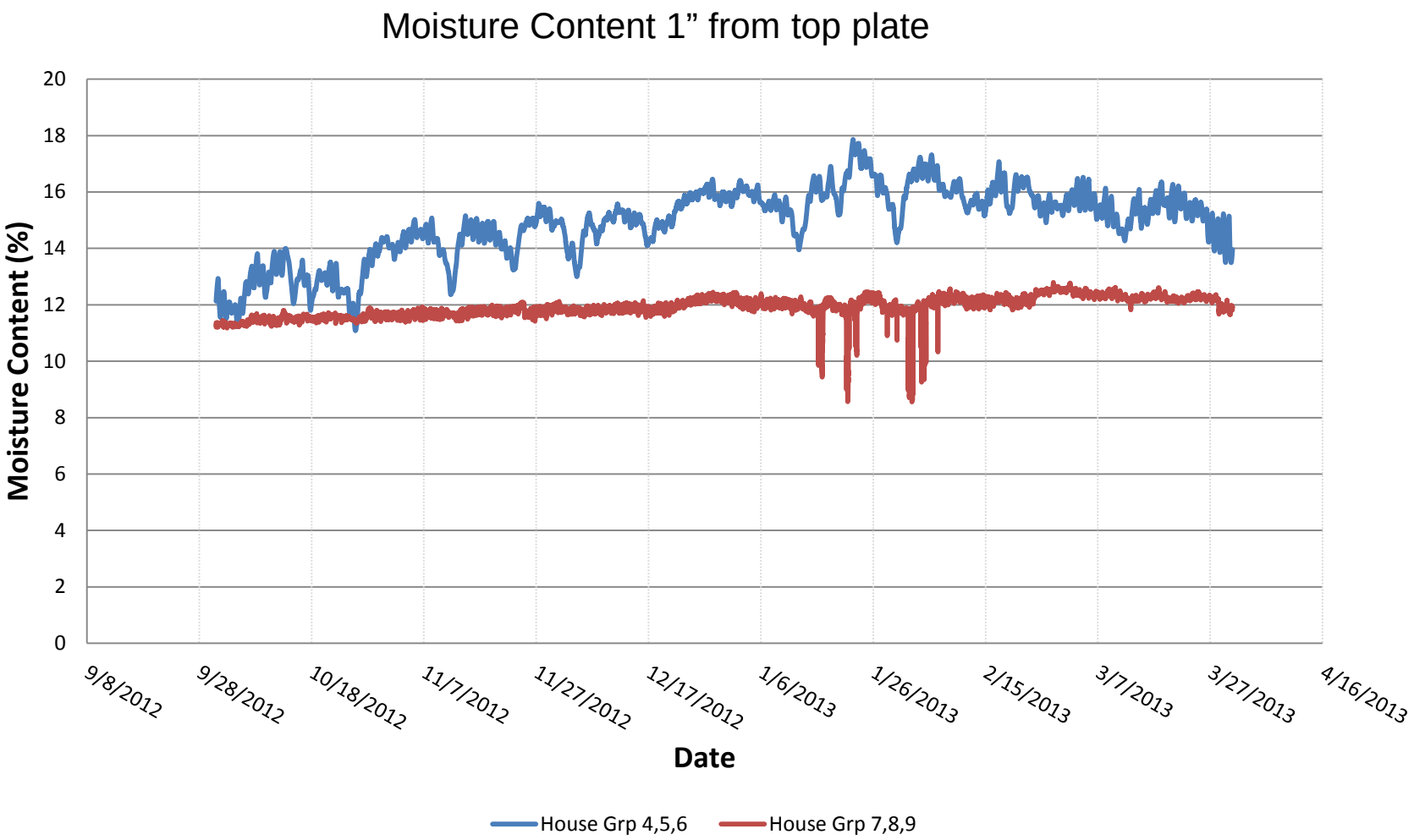
Basement Wall Finished Area



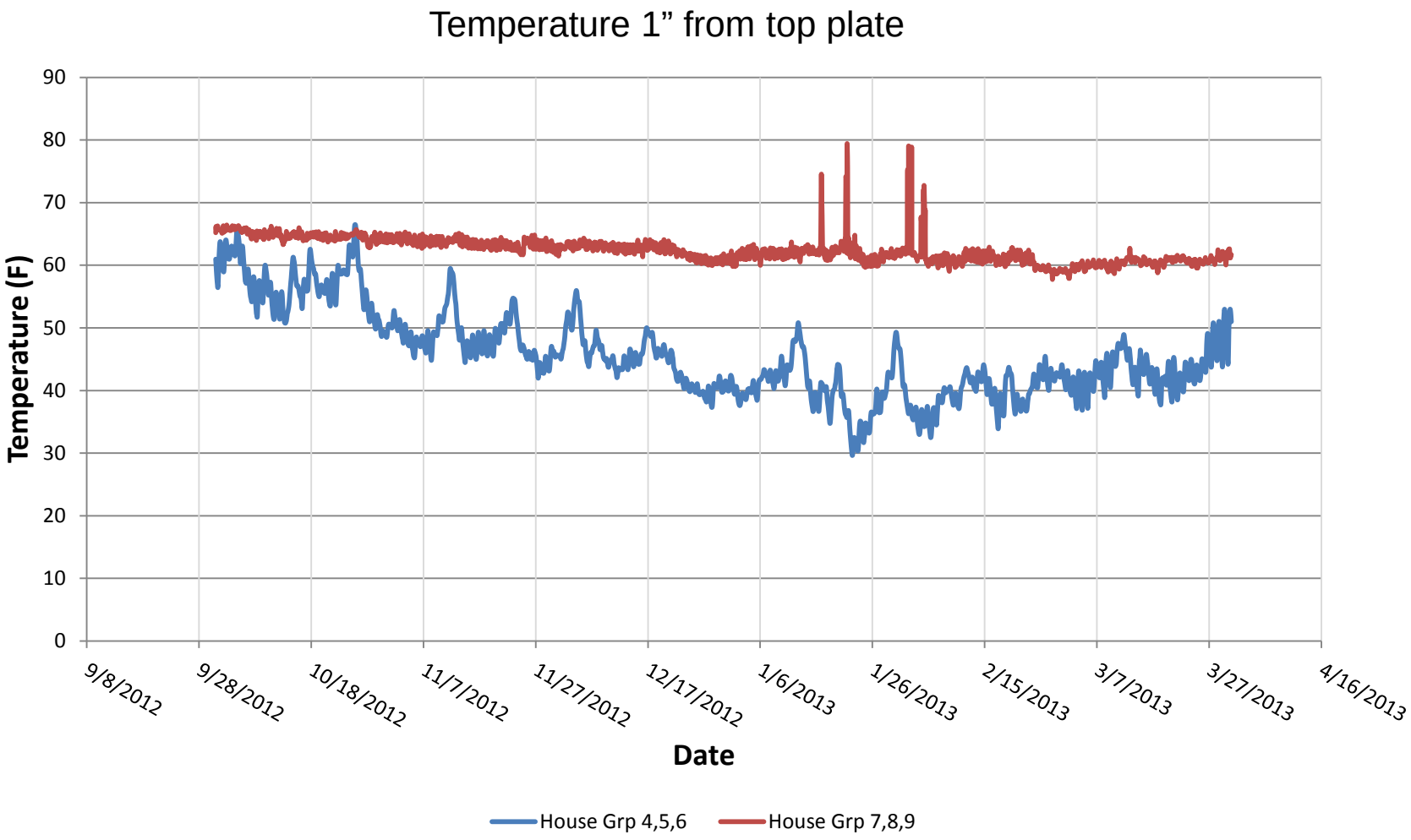
Basement Wall Finished Area



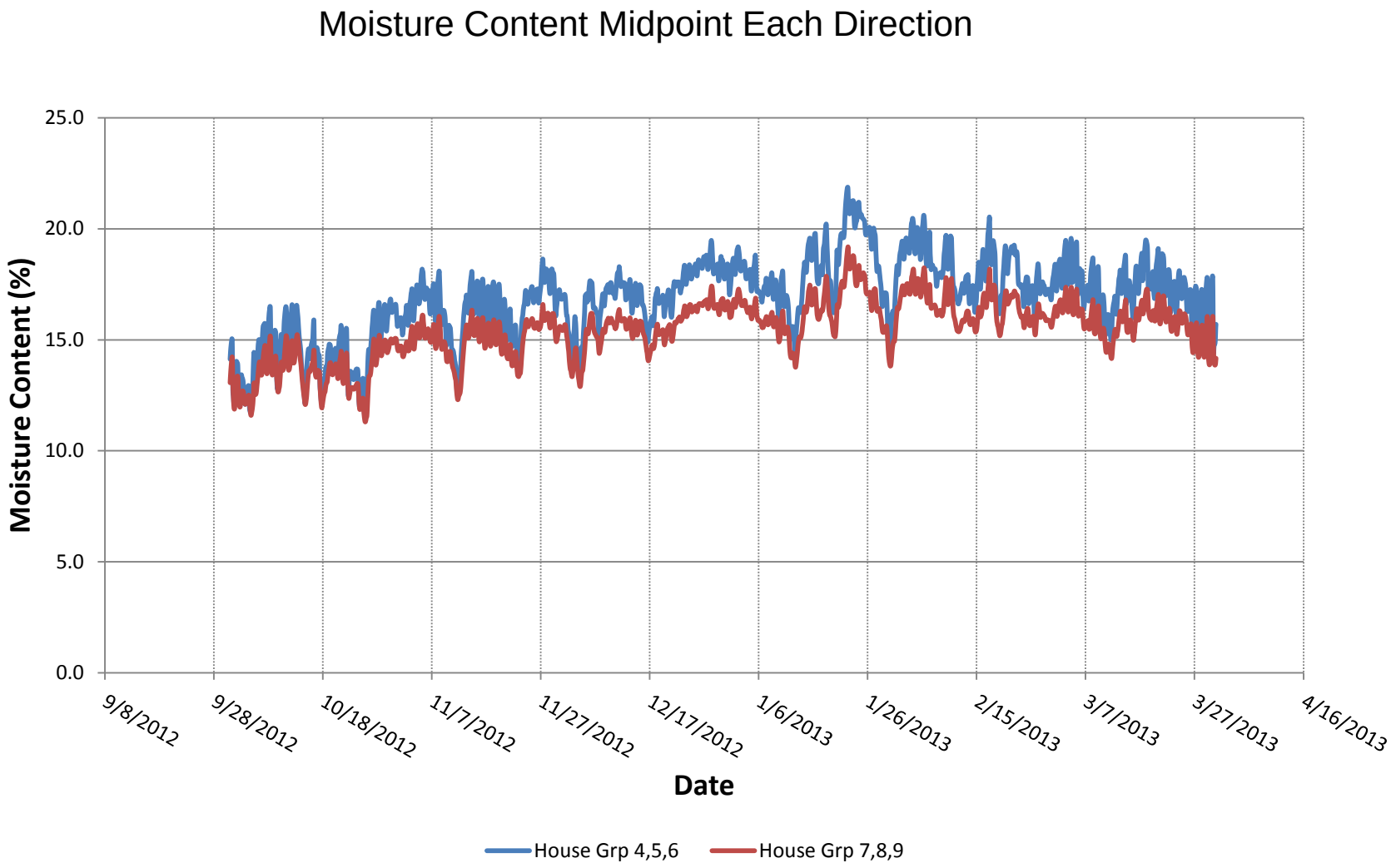
Basement Wall Unfinished Area



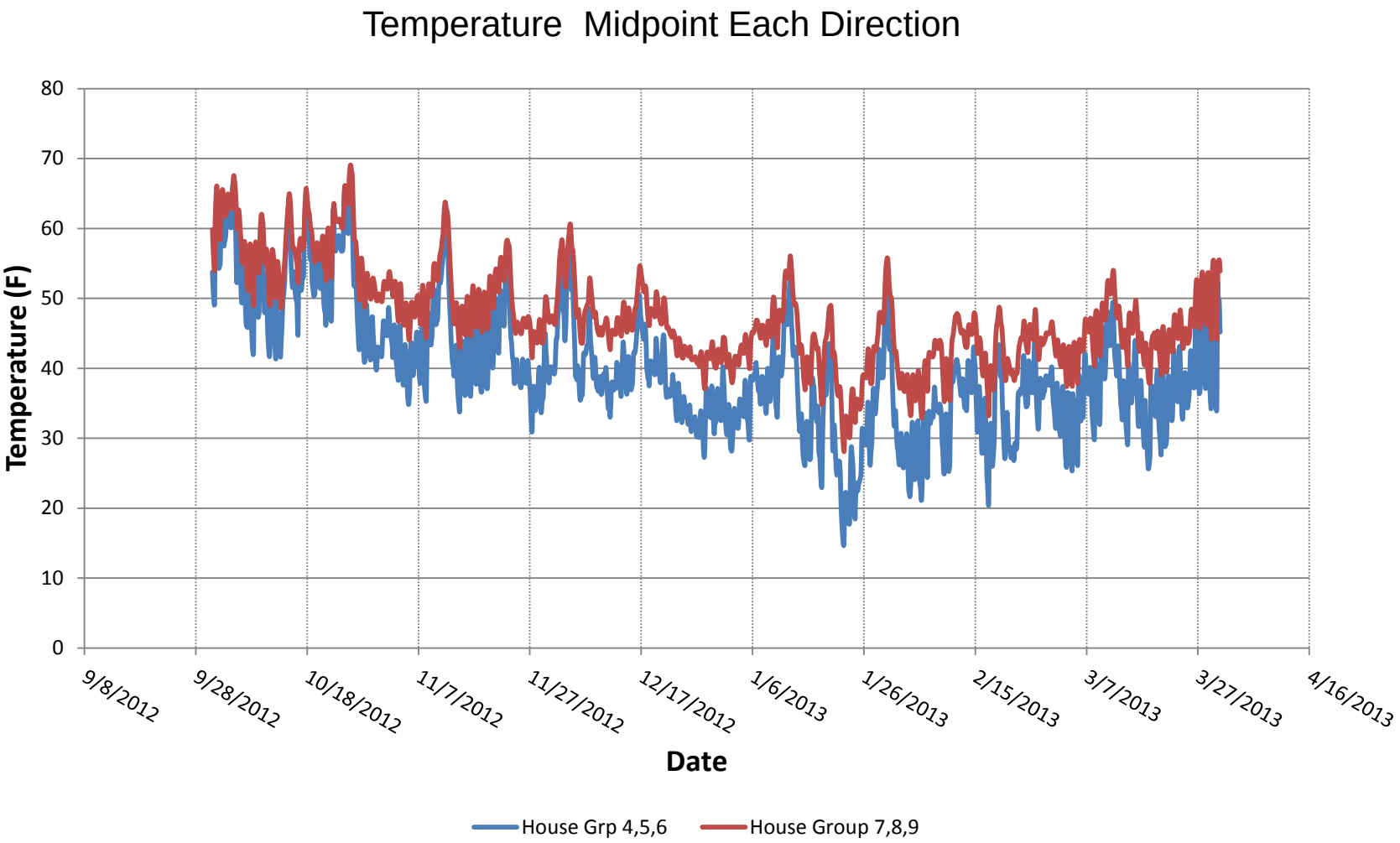
Basement Wall Unfinished Area



Rim Joist


Moisture Content Midpoint Each Direction
25.0
20.0
15.0
10.0
5.0
0.0
Moisture Content (%)
9/8/2012
9/28/2012
10/18/2012
11/7/2012
11/27/2012
12/17/2012
1/6/2013
1/26/2013
2/15/2013
3/7/2013
3/27/2013
4/16/2013
Date
House Grp 4,5,6
House Grp 7,8,9

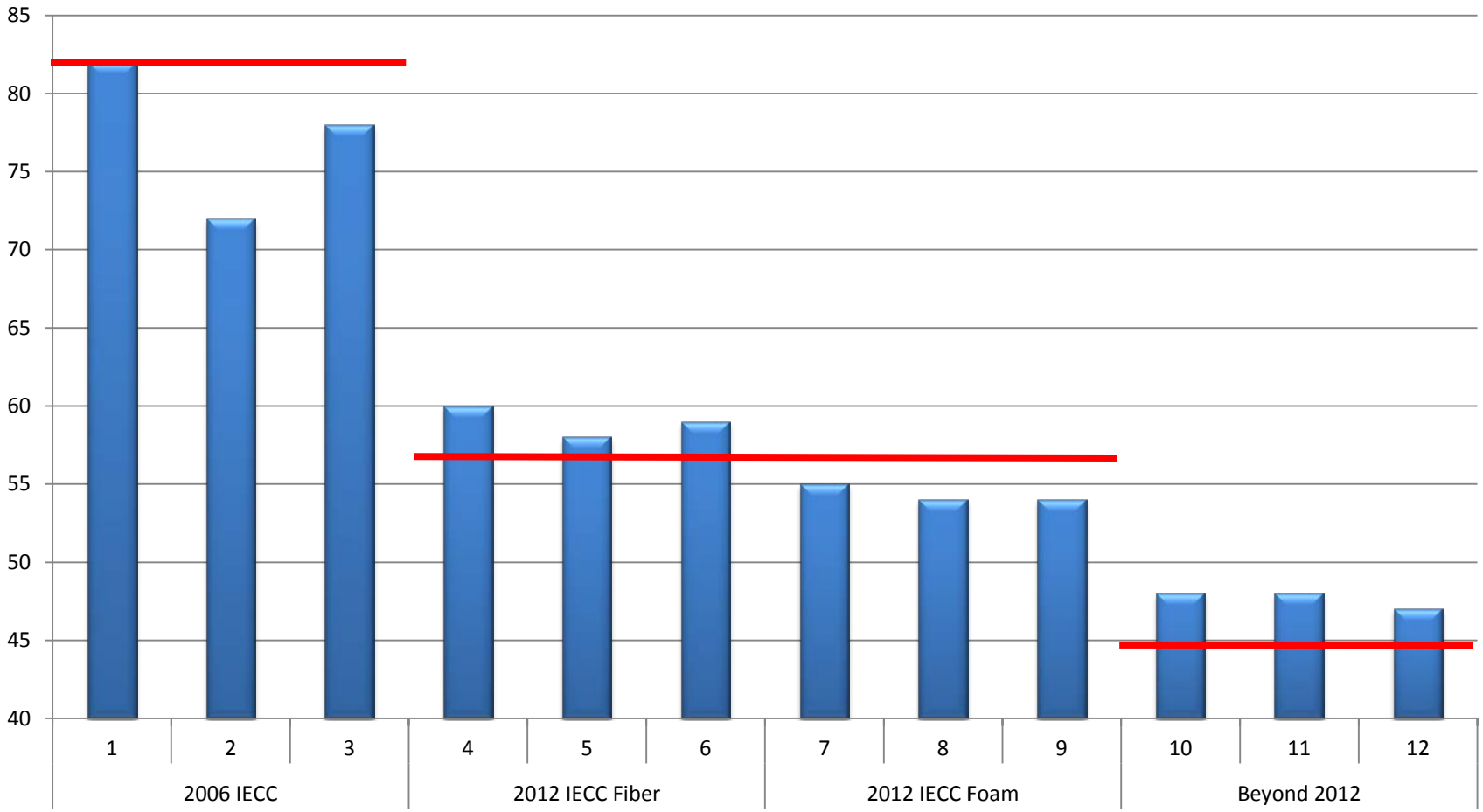
Rim Joist


Temperature Midpoint Each Direction
Temperature (F)
80
70
60
50
40
30
20
10
0
9/8/2012
9/28/2012
10/18/2012
11/7/2012
11/27/2012
12/17/2012
1/6/2013
1/26/2013
2/15/2013
3/7/2013
3/27/2013
4/16/2013
Date
House Grp 4,5,6
House Group 7,8,9

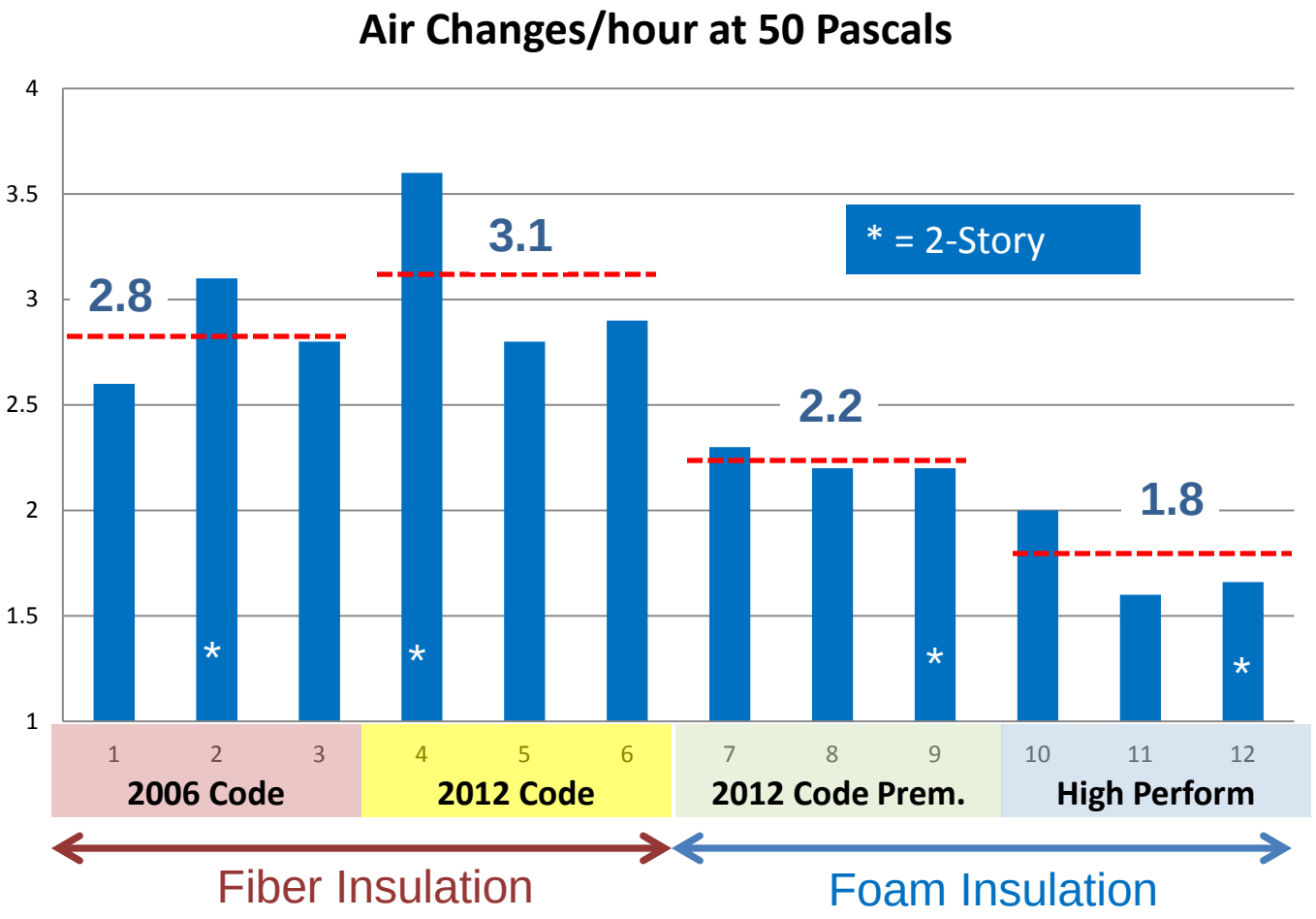
Modeled vs. Actual Energy Use

Energy

Target vs. Confirmed HERS Index

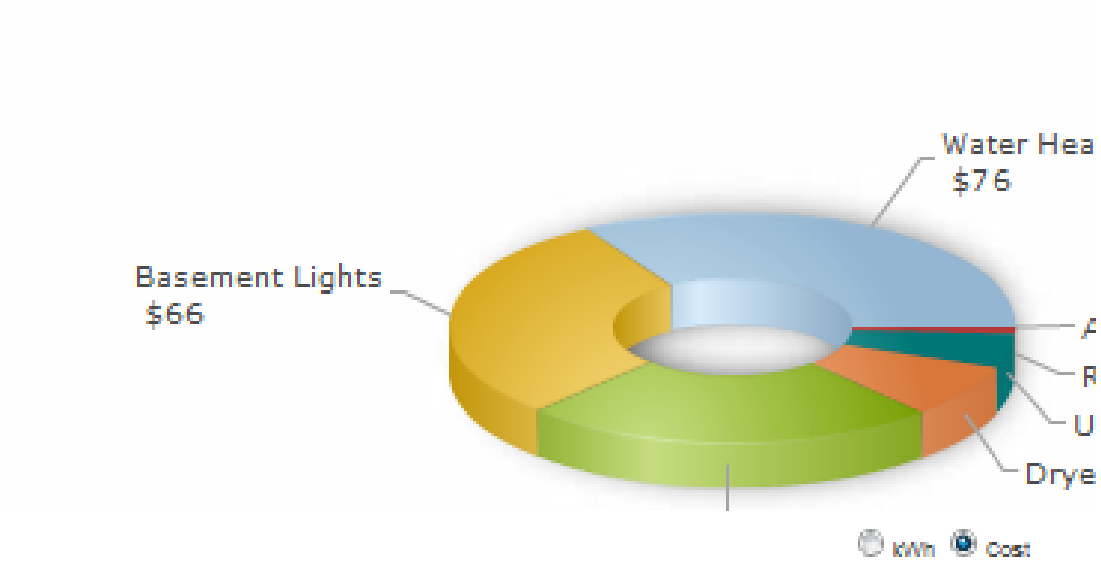


Comparison of Air Leakage



Where I've used electricity in the past 30 days: Top 12 Circuits

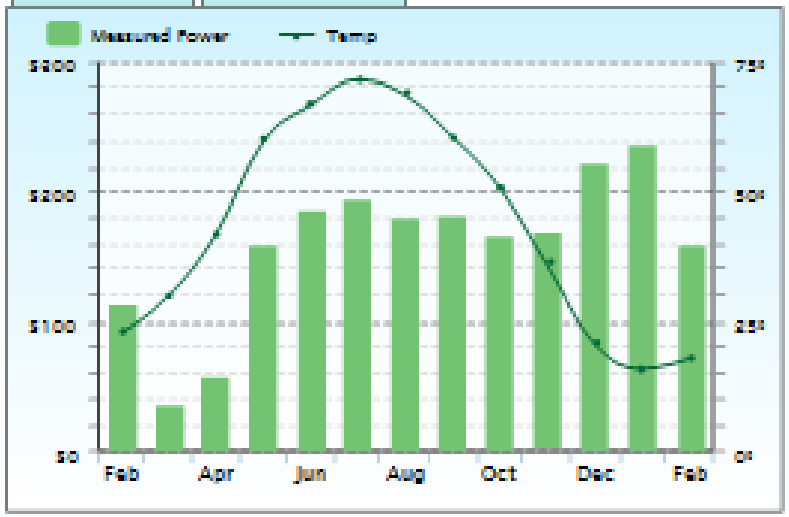
Click a slice or label for detail / View All Circuits



Electricity Cost by Month

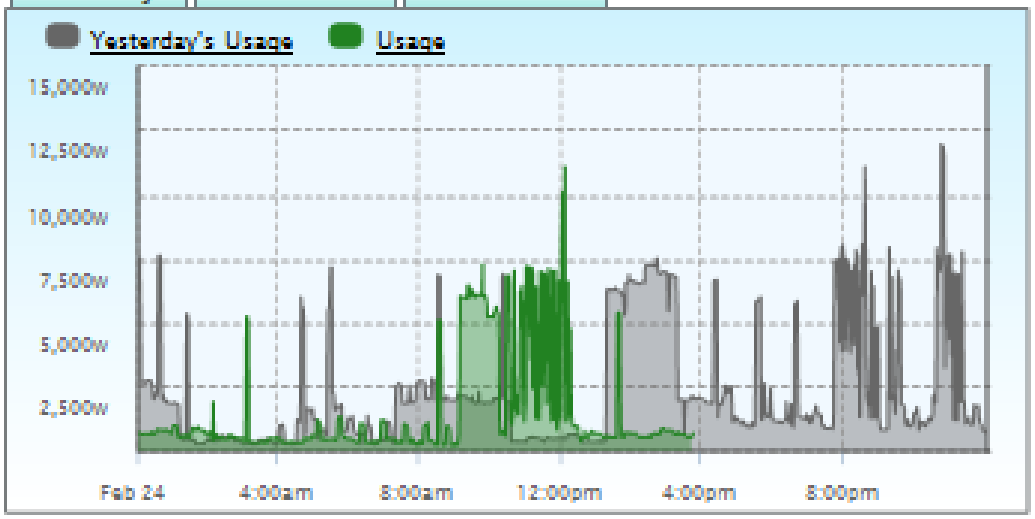
Top 4 Users by Cost - Last 30 days

Past Year | Past Month | kWh | Cost



View History Details

Past Day | Past Week | Past Month

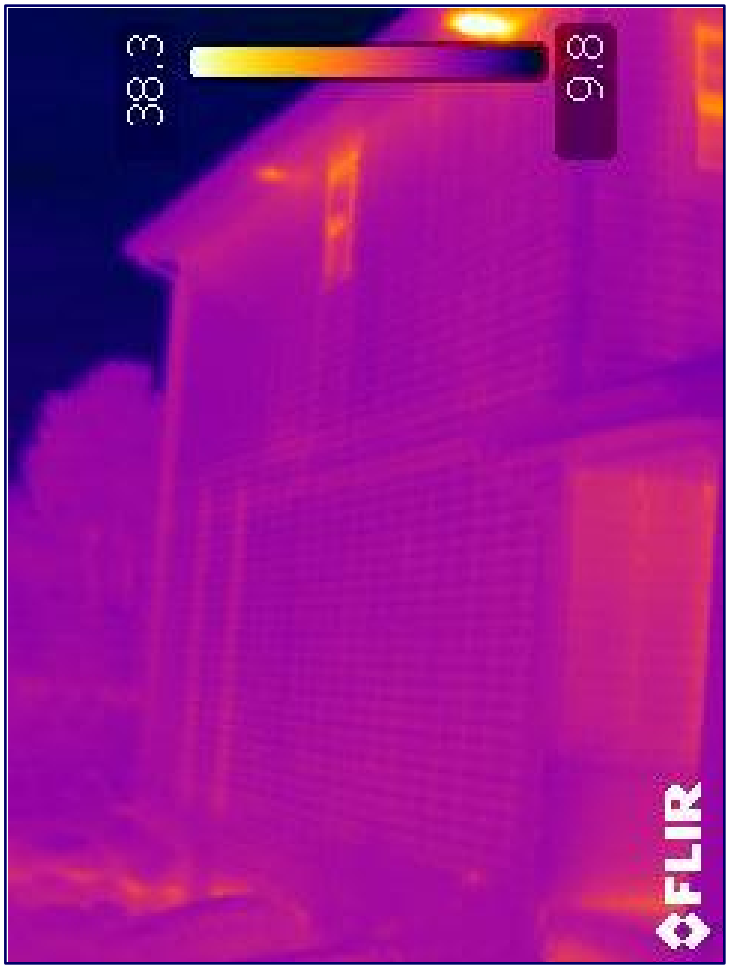


Click and drag in the plot area to zoom in.

View Circuit Details

2012 IECC Without & With Continuous Insulation

OSB Plus Housewrap

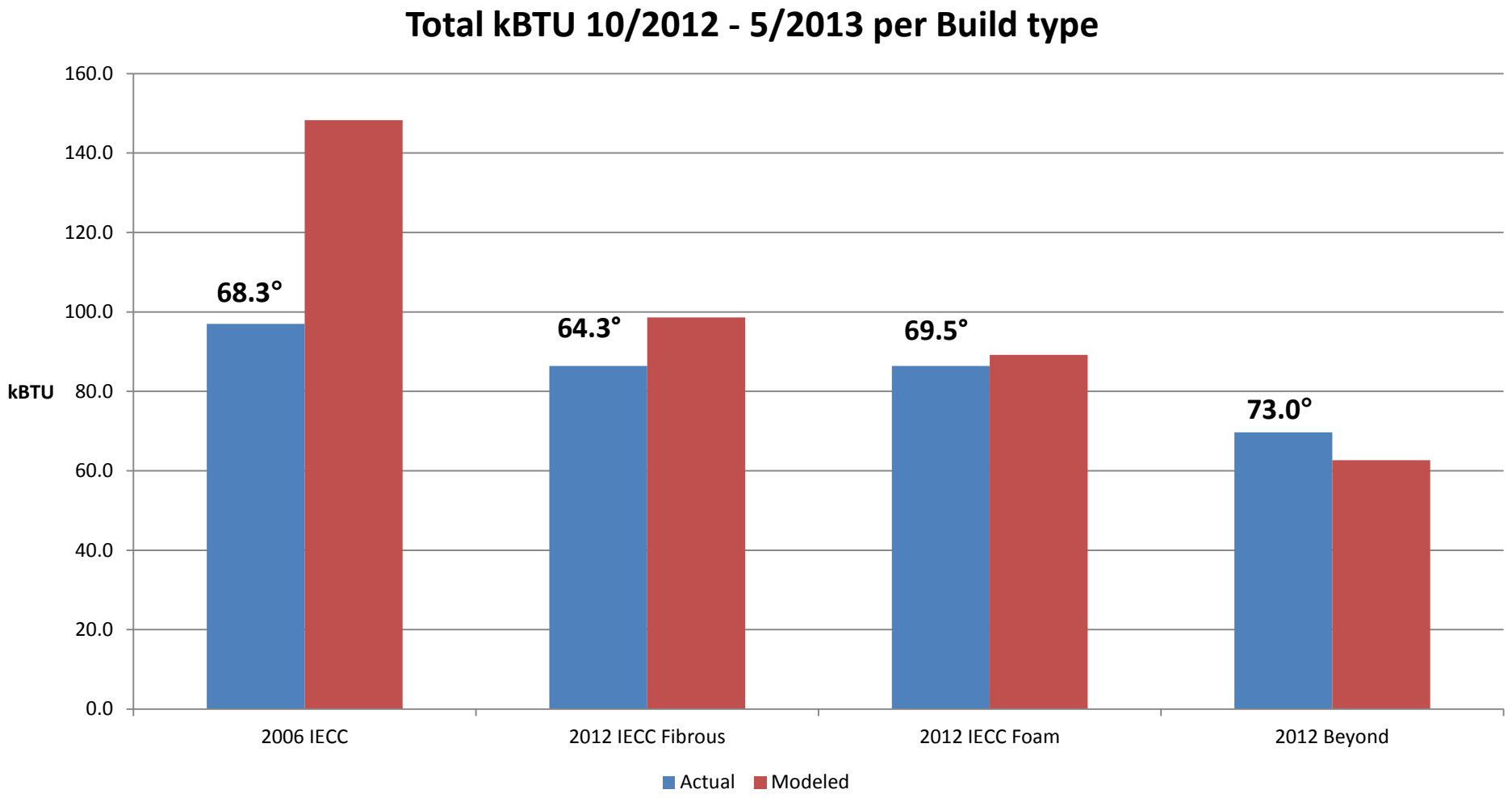


R-5 Continuous Insulation

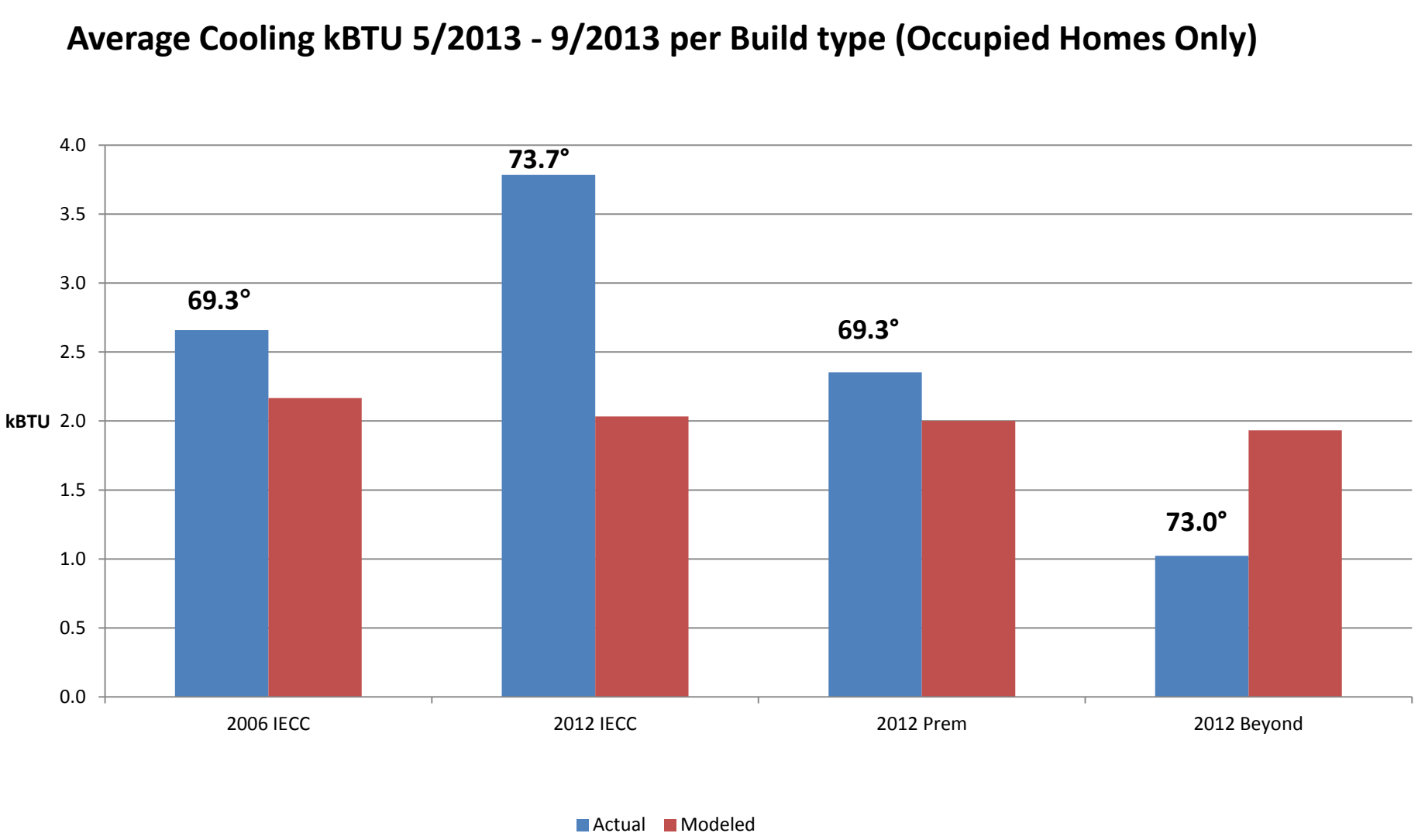
Cash Flow of Modeled Energy Savings

	2012 IECC Fibrous	2012 IECC Foam	Beyond 2012
Average cost of Improvements over Baseline	$1,612.	$5,828.	$15,644.
Monthly Payment 30yr @ 4%	$7.70	$27.82	$74.69
Modeled Energy Savings	($19.67)	($25.40)	($37.81)
Cash Flow	$11.97	($2.42)	($36.88)

Actual vs. Modeled Heating – Winter 2012-2013



Actual vs. Modeled Cooling – Summer 2013



Occupant Surveys

Value of High Performance

Occupant Survey: General Observations

Notes:

- Two surveys have been conducted to date
- Occupants do not know the energy performance strategy of their home

- Nearly all say it is important to reduce the energy use in their homes
- They closely follow their energy bills
- They don't have a good understanding on the impact they have on the amount of energy they use
- Some associate higher than expected energy bills to poor construction quality

Occupant Survey

How efficiently is the home performing energy-wise?

2006 IECC	2012 IECC - Fiber	2012 IECC - Foam	Beyond 2012
			

Occupant Survey

How satisfied are you with the level of warmth in your home when it is cold outside?

2006 IECC	2012 IECC - Fiber	2012 IECC - Foam	Beyond 2012
			

Occupant Survey

How satisfied are you with the level of cooling in your home when it is hot outside?

2006 IECC	2012 IECC - Fiber	2012 IECC - Foam	Beyond 2012
			

Occupant Survey

Does the temperature feel the same to you throughout all the rooms of your home?

2006 IECC	2012 IECC - Fiber	2012 IECC - Foam	Beyond 2012
			

Occupant Survey

Does your home feel drafty?

2006 IECC	2012 IECC - Fiber	2012 IECC - Foam	Beyond 2012
			

Next Steps

- Report Winter 2013-14 in May
- Compare % of H&C to total energy used
- Compare reported T-stat set point to actual temperature
- Focus group
  - $ Comfort
  - $ Durability
  - Share Actual Data

Summary & Conclusions

- Cost to build to 2012 IECC was lower than many estimates
- Foam strategies resulted in significant improvements in air leakage
- Actual energy used to heat was lower than model for three out of four strategies
- 2012 IECC strategies are cost effective
- Exterior insulation above and below grade produced warmer and dryer assemblies
- Consumers are in need of better information on the energy efficiency features of their homes and the role they play in energy usage

www.insulateyourhome.com

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NOTICE: Changes to the International Residential Code require the installation of a water-resistive barrier (WRB) within most exterior wall assemblies in residential construction. The following Dow insulated sheathing products qualify as a WRB when installed according to the installation instructions developed for "installation of foam sheathing as a weather-resistive barrier": STYROFOAM™ DURAMATE™ Plus, STYROFOAM™ Residential Sheathing, STYROFOAM™ Tongue and Groove, STYROFOAM SIS™, STYROFOAM™ Square Edge, STYROFOAM™ Residing Board, DOW™ High Performance Underlayment, THERMAX™ Sheathing, TUFF-R™ and Super TUFF-R™ and therefore do not require the use of a building paper or a housewrap as a WRB. When a WRB is not needed, these Dow foam sheathings may be installed according to standard installation instructions for foam sheathing from Dow. Be sure products and installation instructions meet code requirements for your particular location. Note: WEATHERMATE™ and WEATHERMATE™ Plus Housewraps have already qualified as water-resistive alternatives to the prescribed felt (see Evaluation Reports NER-593 and NER-640 for approved alternative).

STYROFOAM™ Brand Extruded Polystyrene Foam Insulation
CAUTION: This product is combustible. Protect from high heat sources. A protective barrier or thermal barrier may be required as specified in the appropriate building code. For more information, consult MSDS, call Dow at 1-866-583-BLUE (2583) or contact your local building inspector. In an emergency, call 1-989-636-4400.

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CAUTION: This product is combustible and shall only be used as specified by the local building code with respect to flame spread classification and to the use of a suitable thermal barrier. For more information, consult MSDS, call Dow at 1-866-583-BLUE (2583) or contact your local building inspector. In an emergency, call 1-989-636-4400.

WARNING: Rigid foam insulation does not constitute a working walkable surface or qualify as a fall protection product.

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CAUTION: When cured, these products are combustible and will burn if exposed to open flame or sparks from high-energy sources. Do not expose to temperatures above 240ºF. For more information, consult MSDS, call Dow at 1-866-583-BLUE (2583) or contact your local building inspector. In an emergency, call 1-989-636-4400.

STYROFOAM™ Brand Spray Polyurethane Foam contains isocyanate, hydrofluorocarbon blowing agent and polyol. Read the instructions and Material Safety Data Sheets carefully before use. Wear protective clothing (including long sleeves), gloves, goggles and proper respiratory protection. Supplied air or an approved air-purifying respirator equipped with an organic vapor sorbent and a P100 particulate filter is required to maintain exposure levels below ACGIH, OSHA, WEEL or other applicable limits. Provide adequate ventilation. Contents under pressure. STYROFOAM™ Brand SPF should be installed by a trained SPF applicator.

FROTH-PAK™ spray polyurethane foam contains isocyanate, hydrofluorocarbon blowing agent and polyol. Read the instructions and Material Safety Data Sheets carefully before use. Wear protective clothing (including long sleeves), gloves, goggles or safety glasses, and proper respiratory protection. Supplied air or an approved air-purifying respirator equipped with an organic vapor sorbent and a P100 particulate filter may be required to maintain exposure levels below ACGIH, OSHA, WEEL or other applicable limits. Provide adequate ventilation. Contents under pressure.

GREAT STUFF™ and GREAT STUFF PRO™ Insulating Foam Sealants contain isocyanate and a flammable blowing agent. Read the labels and Material Safety Data Sheets carefully before use. Eliminate all sources of ignition before use. Wear long sleeves, gloves, and goggles or safety glasses. Provide adequate ventilation or wear proper respiratory protection. Contents under pressure.

Building and/or construction practices unrelated to building materials could greatly affect moisture and the potential for mold formation. No material supplier including Dow can give assurance that mold will not develop in any specific system.

Speaker Contact:

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