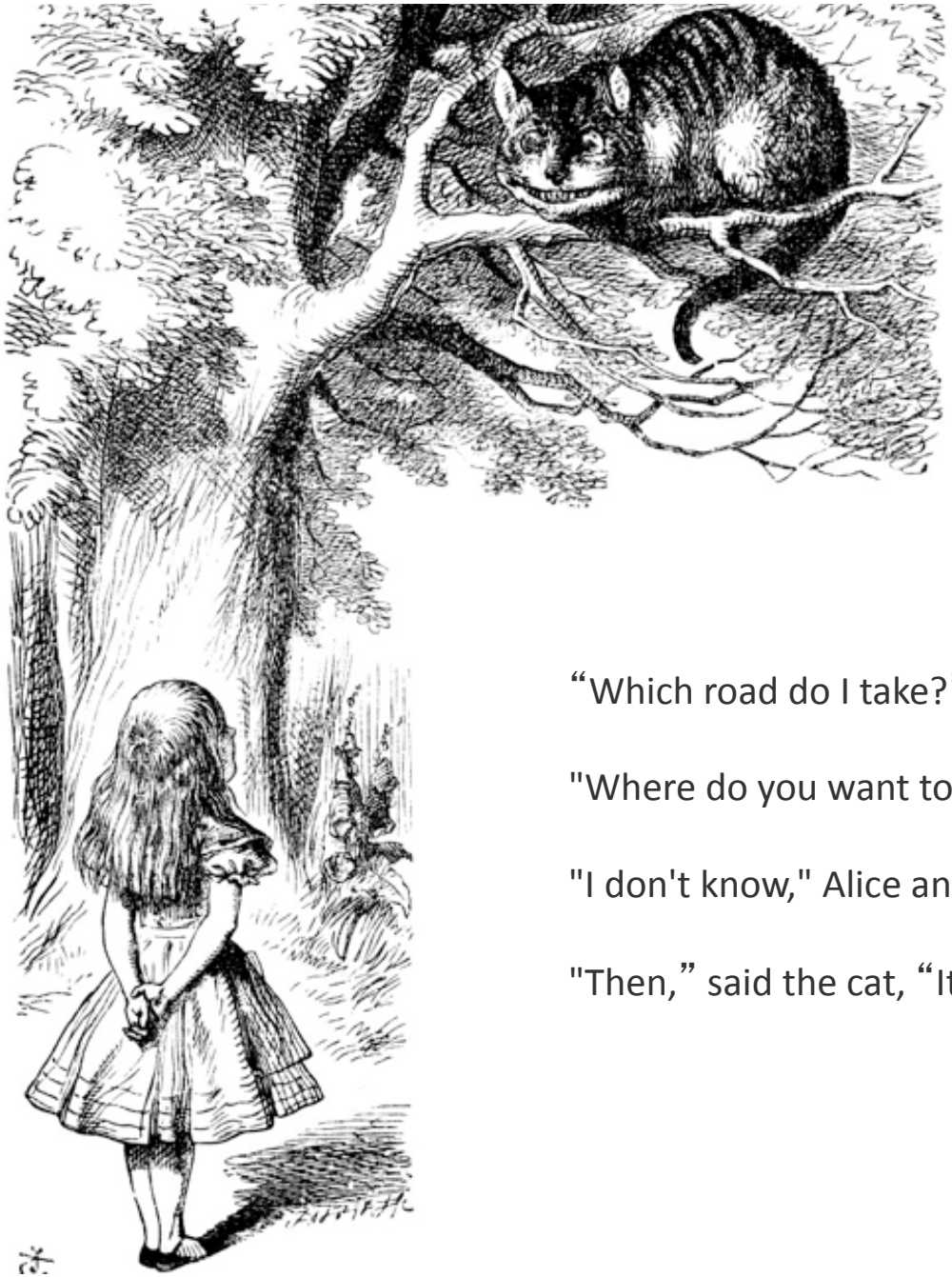
A Reality Check: How Much Do Energy Upgrades Improve Home Energy Performance

Paul Eldrenkamp & Rachel White,
Byggmeister

Why do we do this?

- Accountability and integrity
- To quantify “green”
- To close feedback loops for organizational learning
- Sales and marketing impact



“Which road do I take?” asked Alice.

"Where do you want to go?”replied the cat.

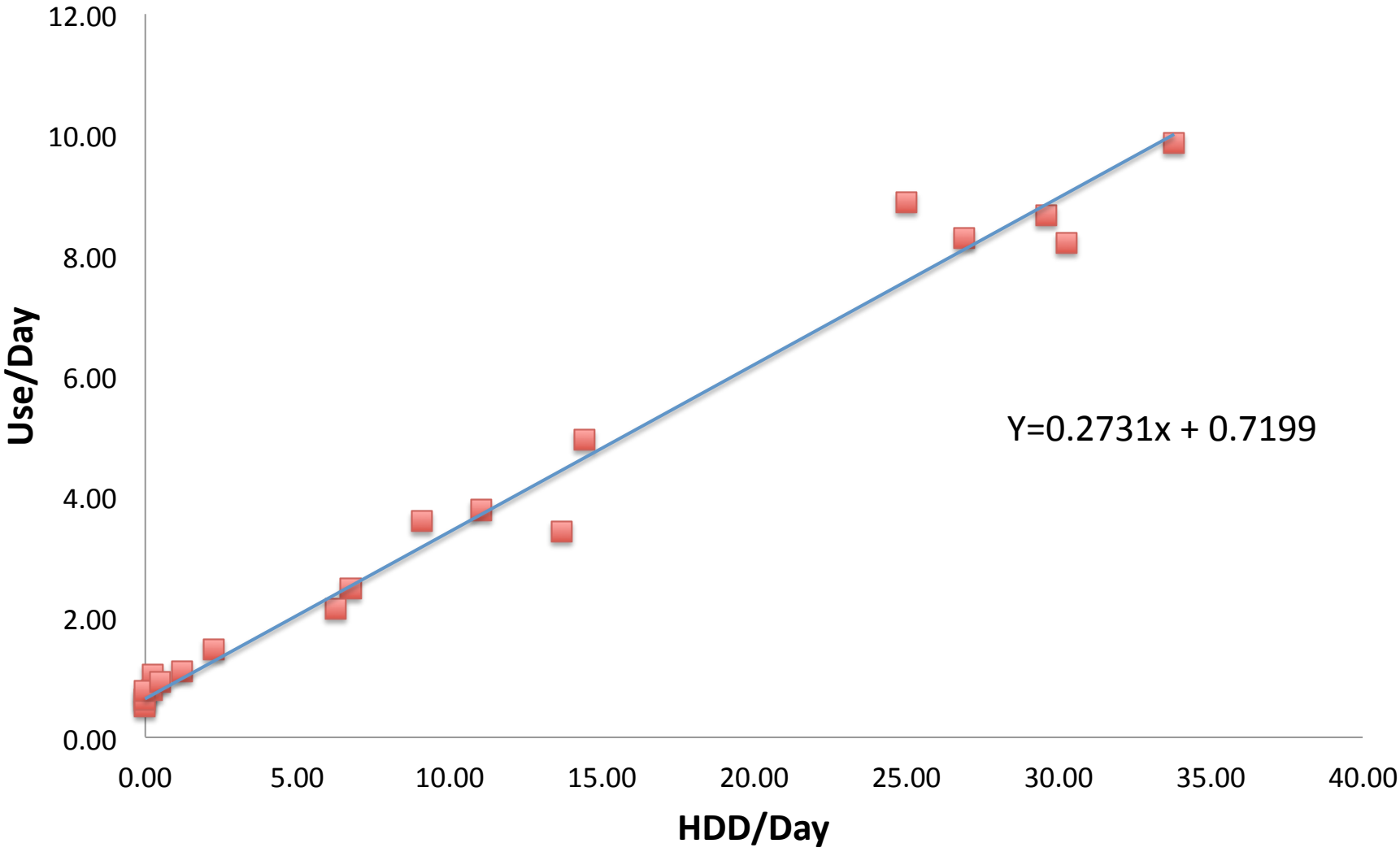
"I don't know," Alice answered.

"Then,” said the cat, “It doesn't matter.”

Measuring Impact: Our Method

- Simple method
  - Compare pre-project v. post-project usage data
- Projection method
  - What would the home use if we hadn't done the work?
  - Create "if no work" projection based on pre-project usage
  - Compare "if no work" projection to actual, measured post-project usage

How We Project Usage

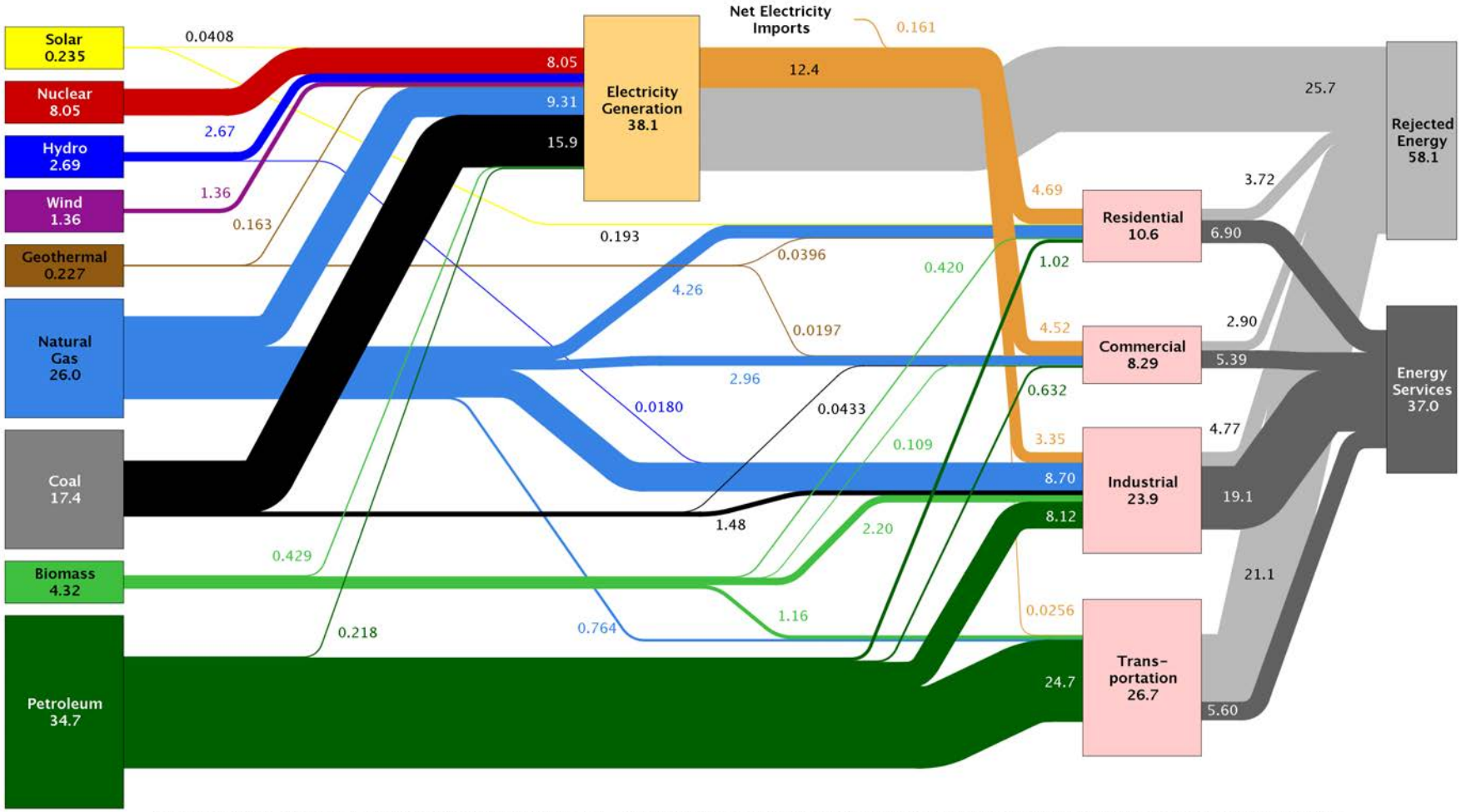


Key Assumptions

- Weather normalization (source: Michael Blasnik)
  HDD 60
  CDD 70; +4 for 1st CDD (we may be changing to CDD 68)
- Primary Energy factors
  Grid electricity: 3.34 (source: NREL)
  Natural Gas: 1.047 (NREL)
  Oil: 1.01 (NREL)
  PV: 0.2 (David White, Right Environments)
- Homes with PV (David White)
  Site = kwh produced + kwh grid
  Primary = (kwh produced x .2) + (kwh grid x 3.34)

Estimated U.S. Energy Use in 2012: ~95.1 Quads

Lawrence Livermore National Laboratory



Source: LLNL 2013. Data is based on DOE/EIA-0035(2013-05), May, 2013. If this information or a reproduction of it is used, credit must be given to the Lawrence Livermore National Laboratory and the Department of Energy, under whose auspices the work was performed. Distributed electricity represents only retail electricity sales and does not include self-generation. EIA reports consumption of renewable resources (i.e., hydro, wind, geothermal and solar) for electricity in BTU-equivalent values by assuming a typical fossil fuel plant "heat rate." The efficiency of electricity production is calculated as the total retail electricity delivered divided by the primary energy input into electricity generation. End use efficiency is estimated as 65% for the residential and commercial sectors 80% for the industrial sector, and 21% for the transportation sector. Totals may not equal sum of components due to independent rounding. LLNL-MI-410527

Data Sources & Collection

- Weather data (NOAA)
- Utility bills
  - electricity & gas: wegowise
  - oil: manual collection and input
- PV production & net metering
- eMonitor (occasionally)

Two-family
deep energy retrofit

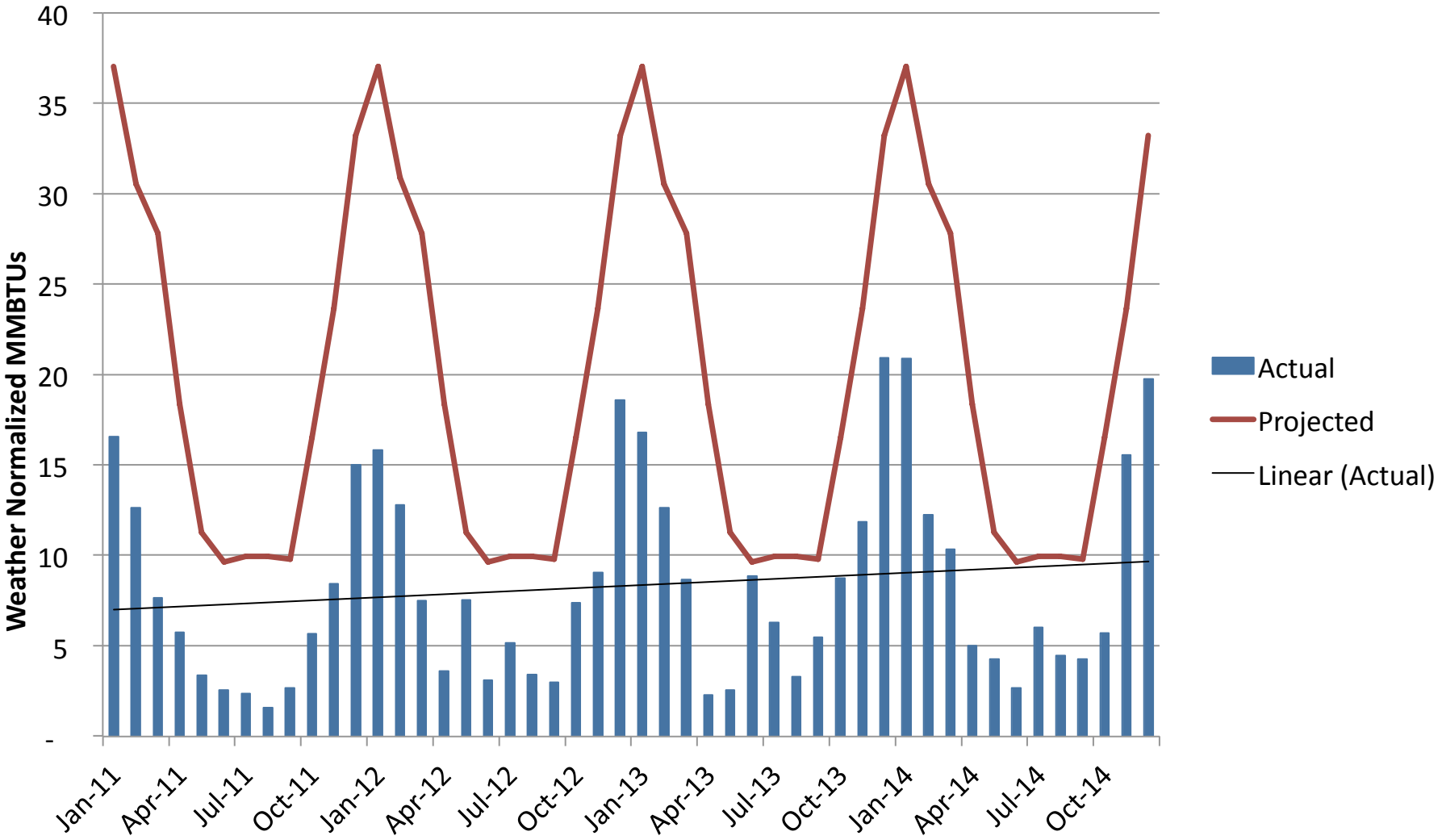

TUFF-R
DOW


Easy Ga
HOUSEWRAP
asy Gard™
USEWRAP
TUFF-R

Solar hot water and electricity

Solar hot water with two electric backup tanks metered separately for each unit. Solar photovoltaic power linked to upstairs unit (power generation value shared with lower unit by monthly accounting).

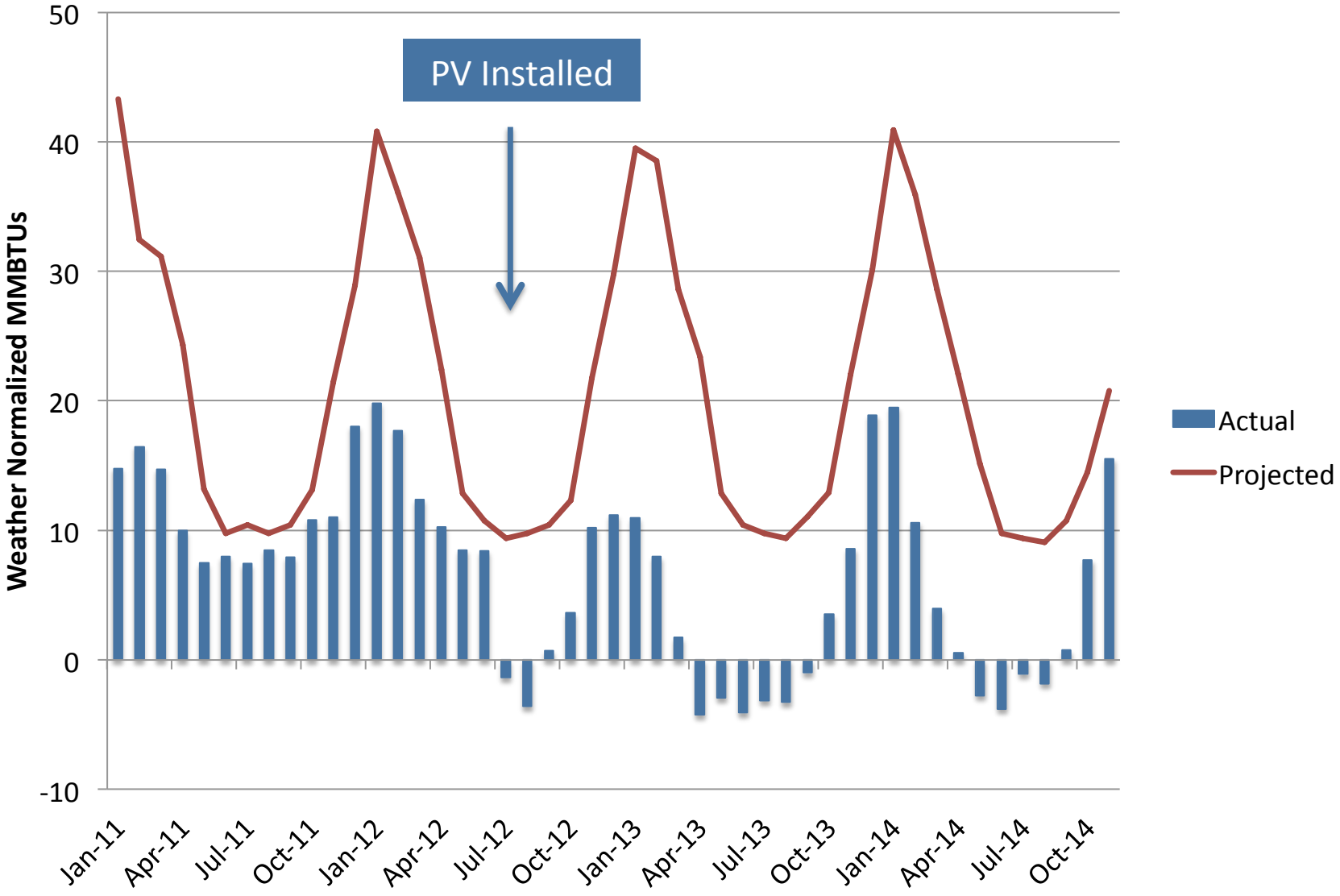
Two Family Deep Energy Retrofit: Monthly Primary Energy Savings



Ranch house deep energy retrofit


TUFF-R
Commercial Insulation
DOW
Tyvek
HomeWrap
DUPONT

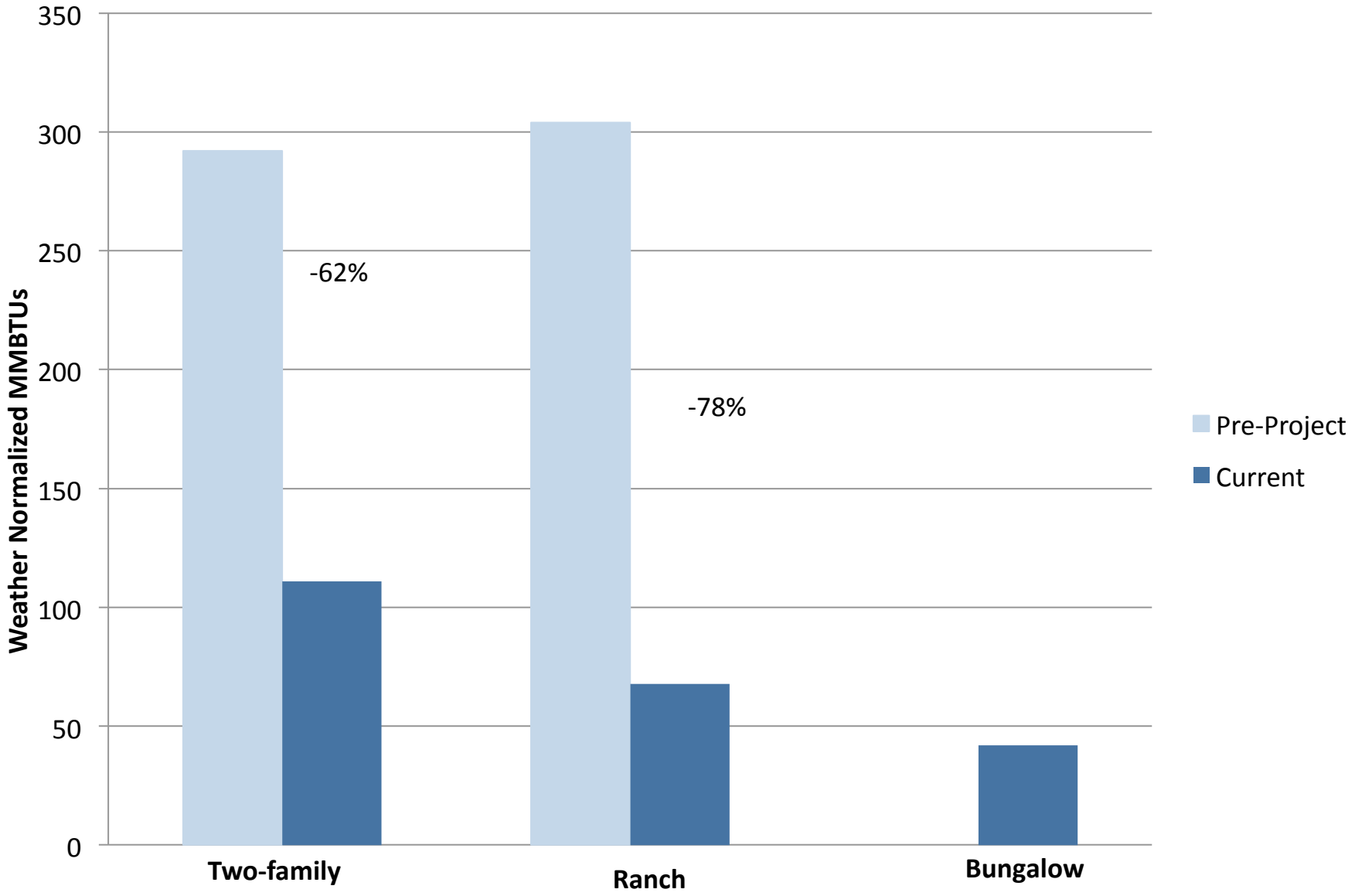
Ranch Deep Energy Retrofit: Monthly Primary Energy Savings



Phased bungalow deep energy retrofit

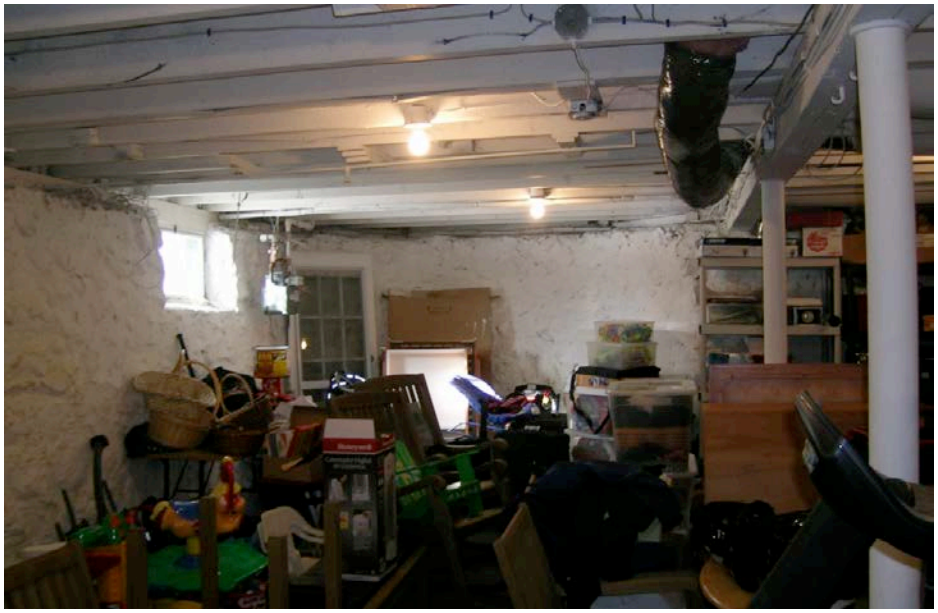

CRAFTSMAN

Deep Energy Retrofits Compared: Annual Primary Energy Savings

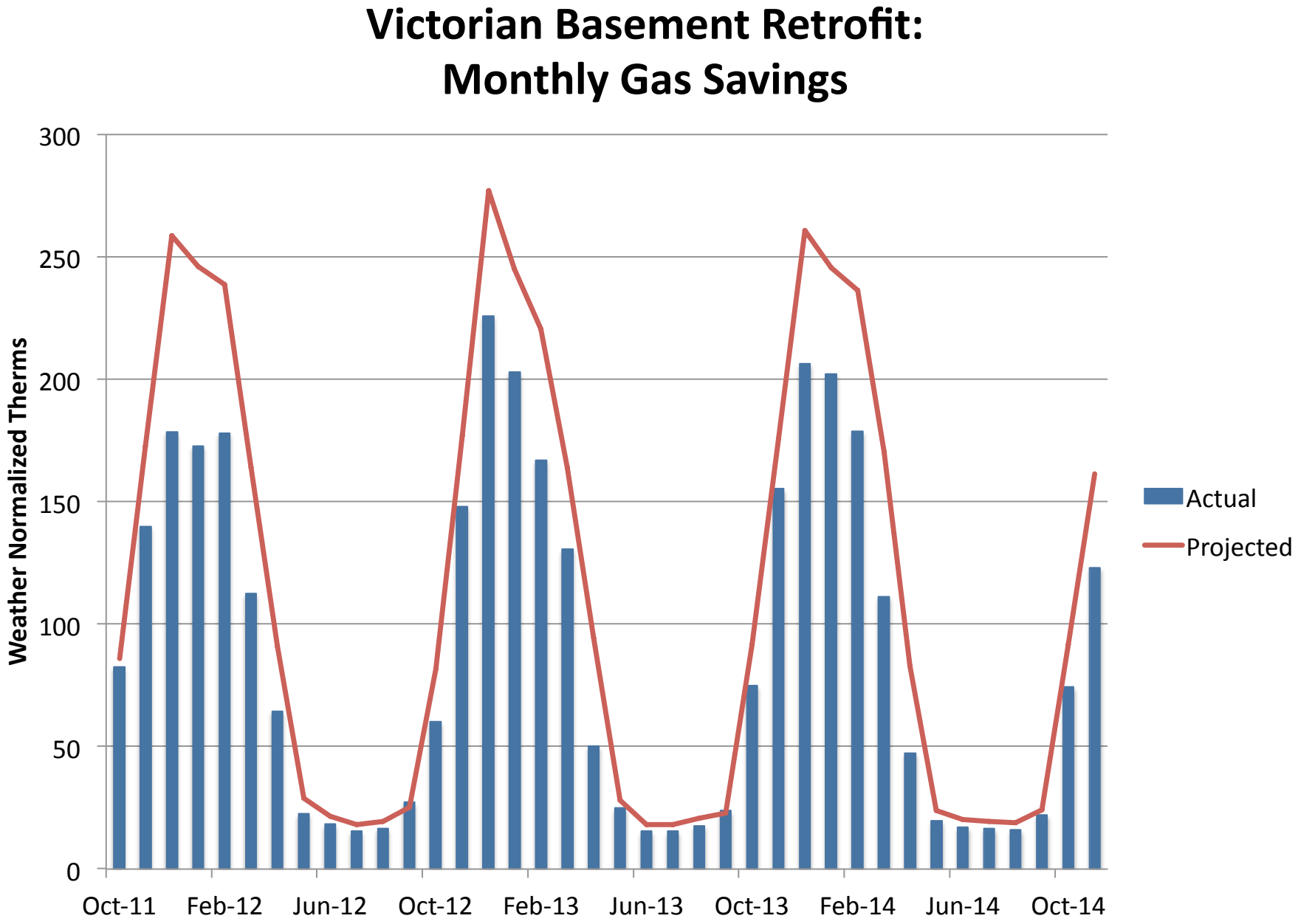


Basement #1:
Victorian-era single-family

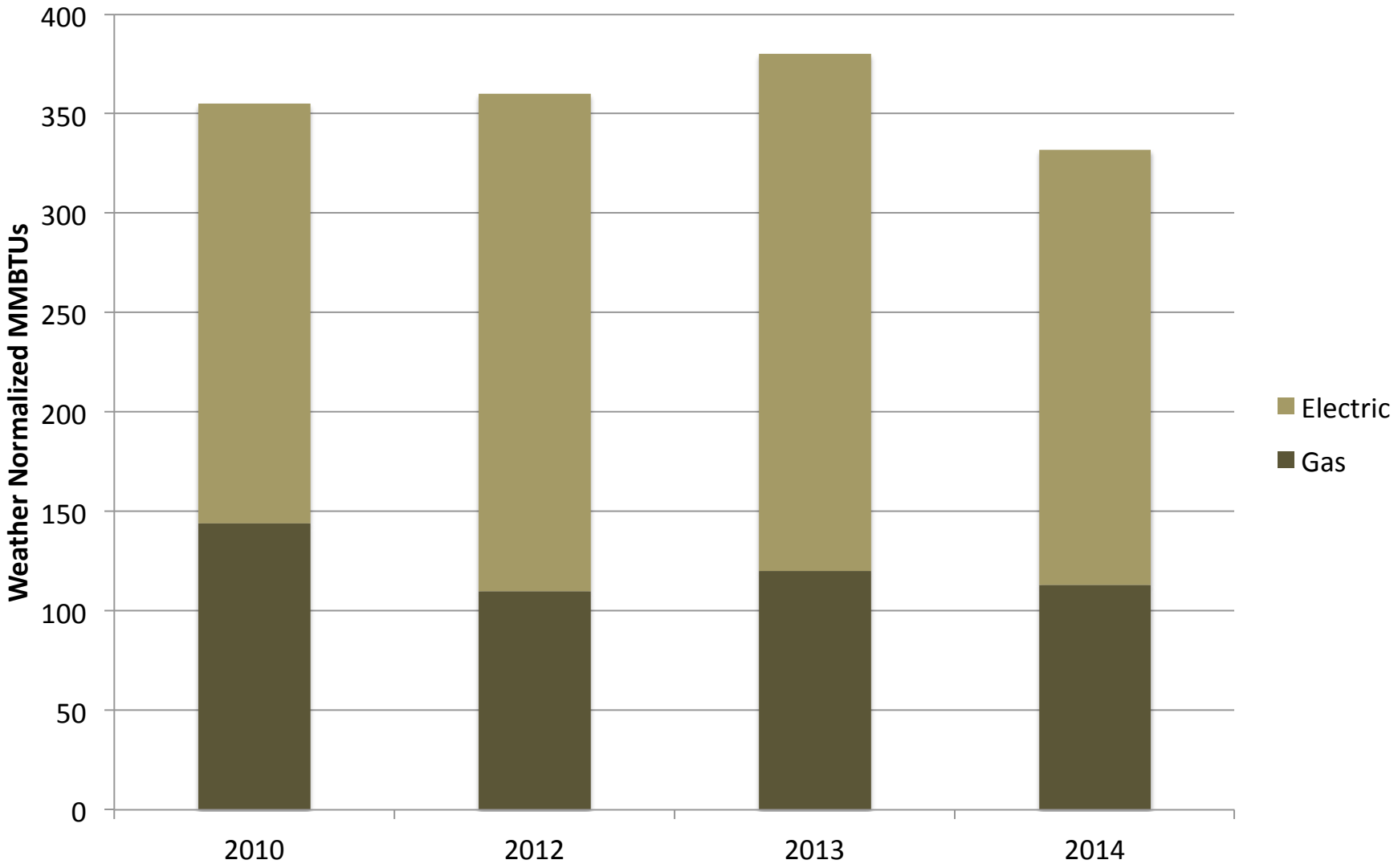
- Wall and floor insulation
- Turned into habitable space
- Install mini-split for basement heating and cooling
- Added HRV




GLAD

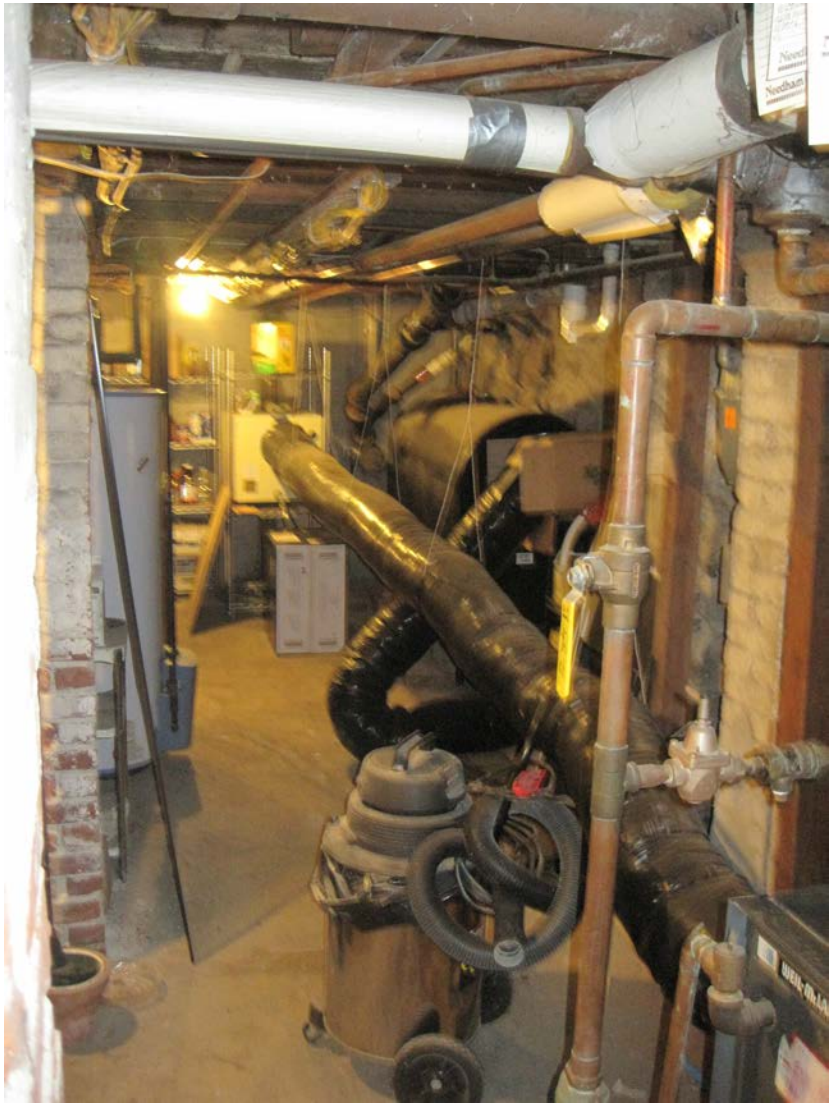

Victorian Basement Retrofit:
Monthly Gas Savings
Weather Normalized Therms
300
250
200
150
100
50
0
Oct-11
Feb-12
Jun-12
Oct-12
Feb-13
Jun-13
Oct-13
Feb-14
Jun-14
Oct-14
Actual
Projected

Victorian Primary Energy Use: Year-to-Year Comparison



Basement #2:
Colonial-era single family

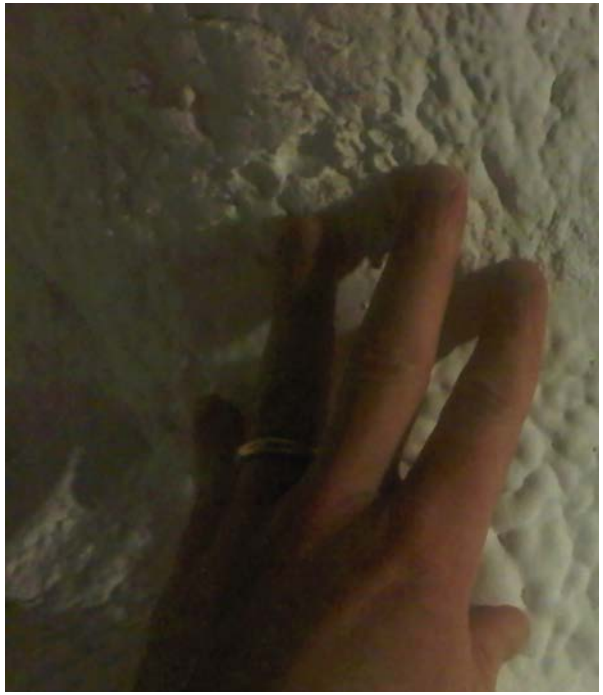
- Basement wall and floor insulation
- Not habitable space
- Converted from oil to gas



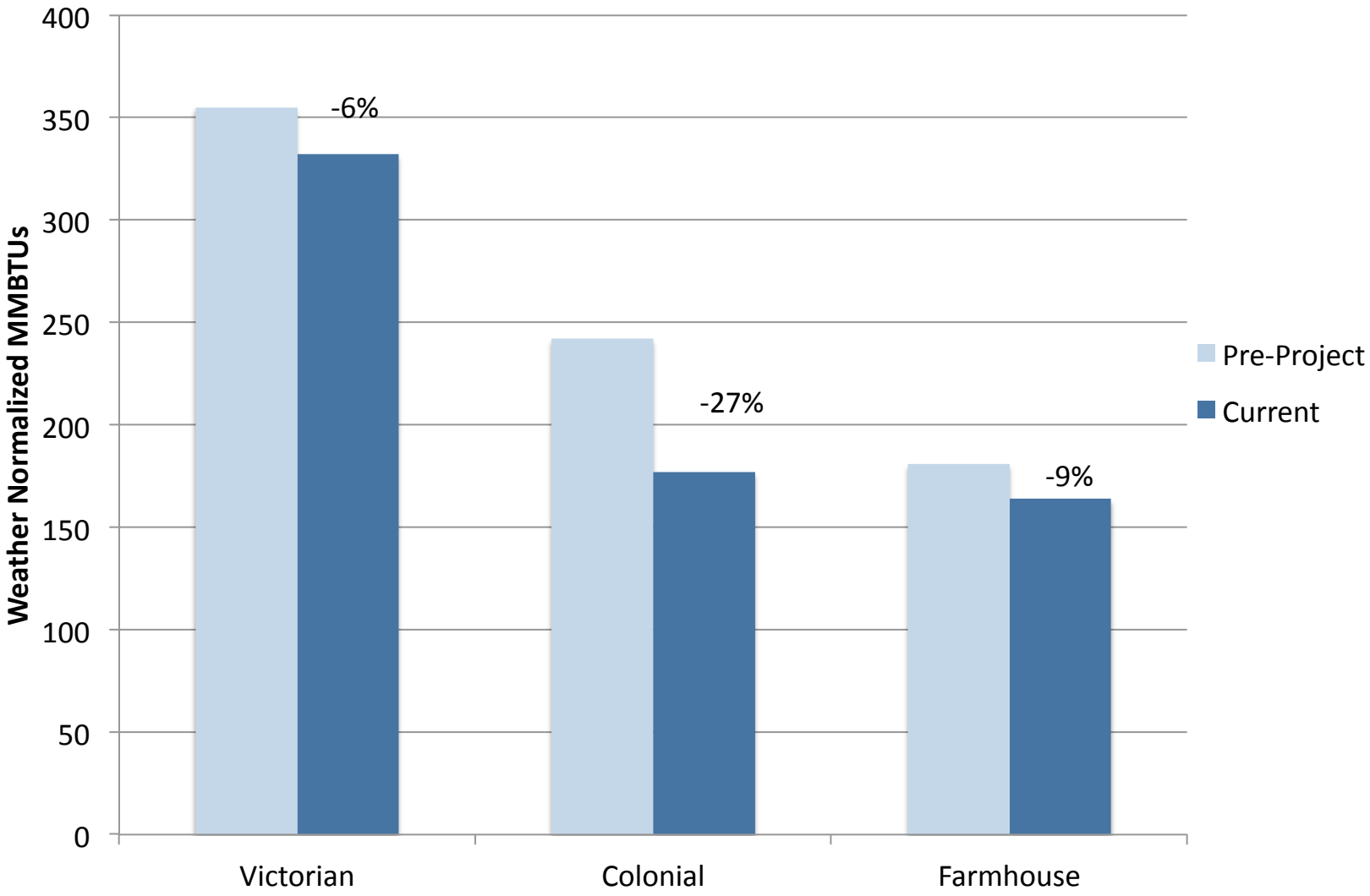
Basement #3:
Early 20th century
farmhouse/hodge-podge

- Insulated walls and floor only
- Insulated adjacent crawlspace
- Could do nothing with adjacent slab-on-grade additions


NOT FOR PRESSURE
ULTRA
ProMar 200
Flat
Scoop Away



Basement Retrofits Compared: Annual Primary Energy Use



Attics

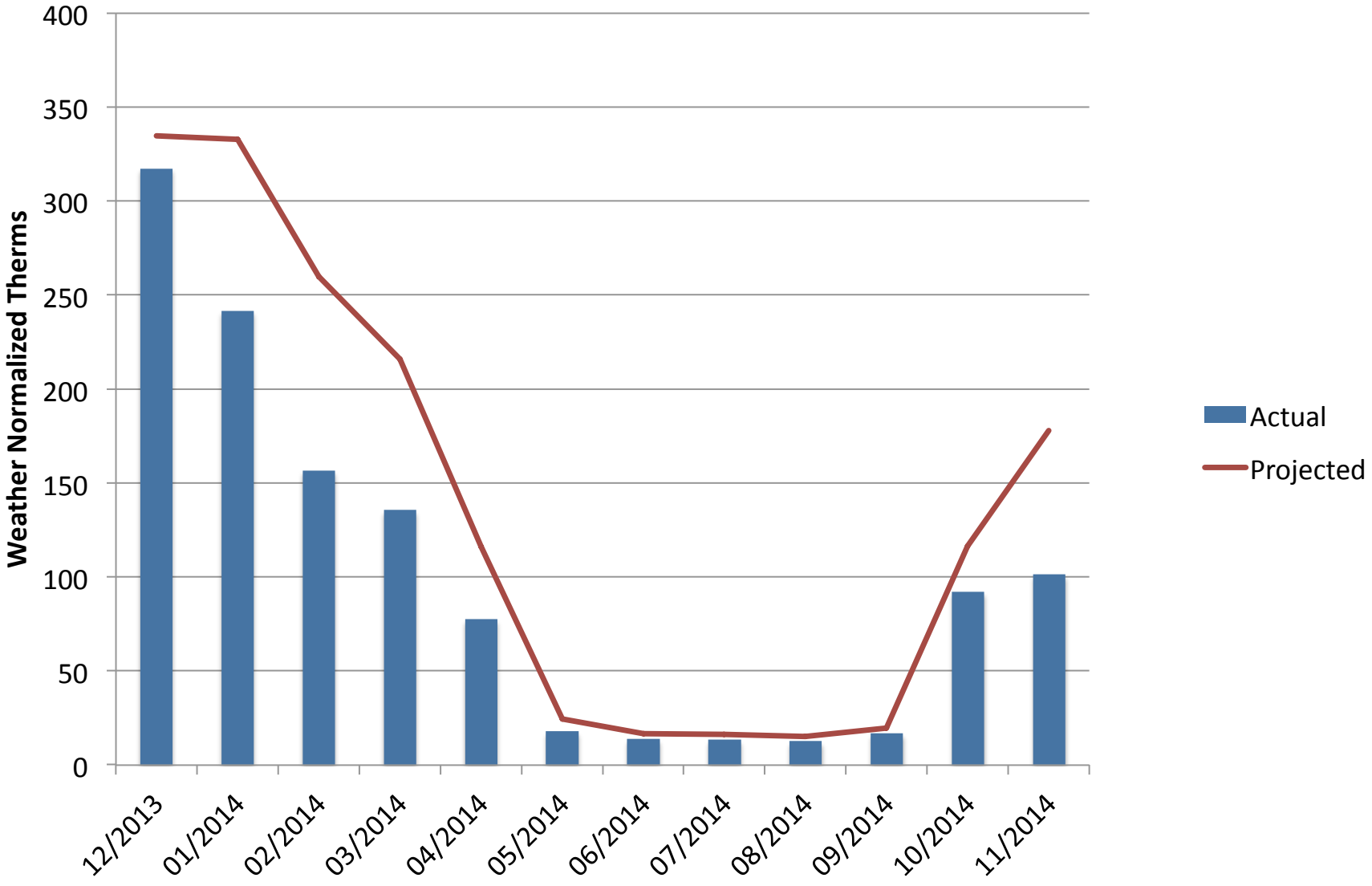
McMansion

- Removed badly “installed” fiberglass batts
- Air-sealed attic floor
- Installed 18” cellulose
- Removed separate ducted forced-air system for master suite and installed a mini-split for that space

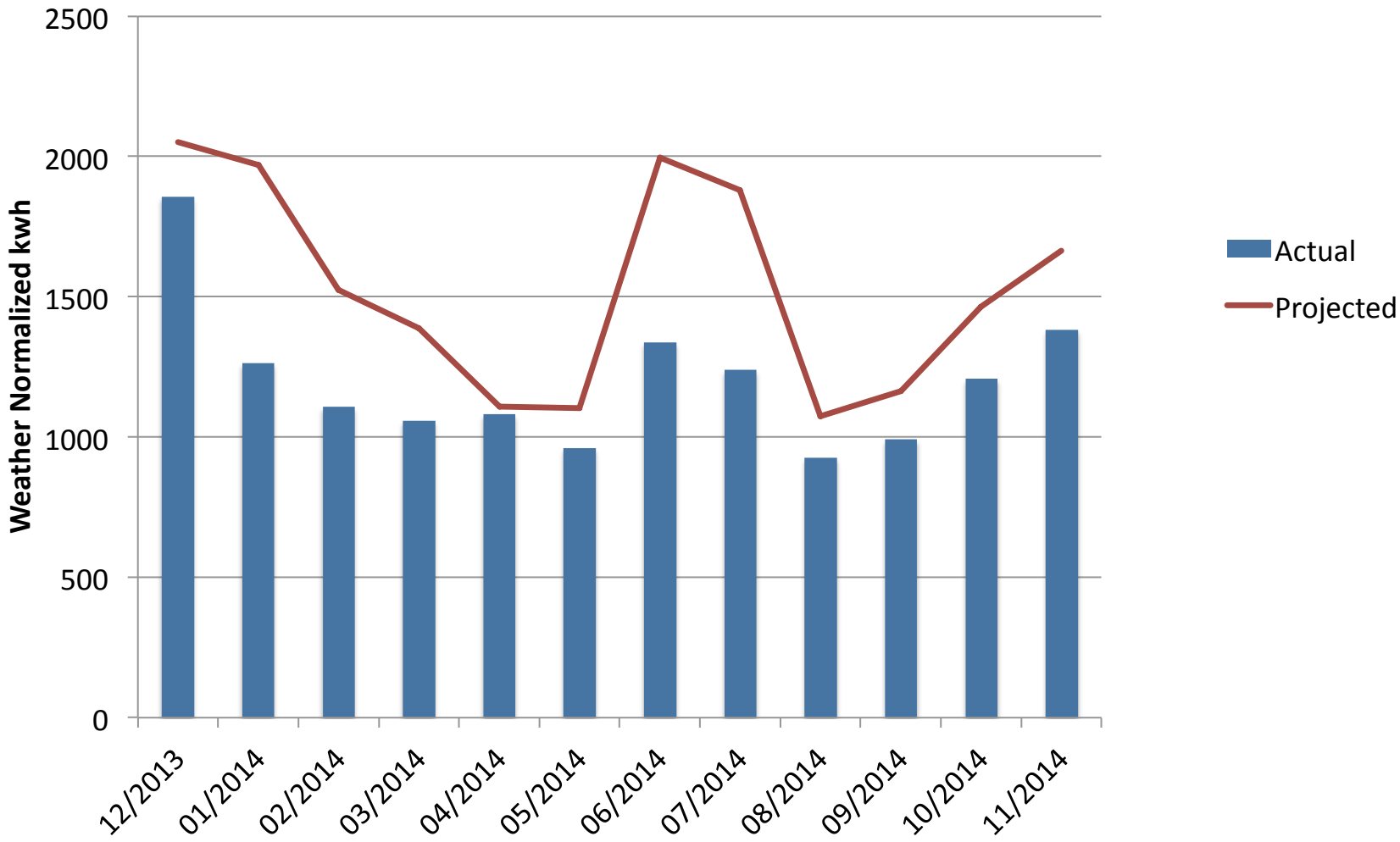
Blower door results

- Pre-project: 3950 cfm@50
- Post-project: 2800 cfm@50

McMansion Home Attic Insulation: Gas Savings



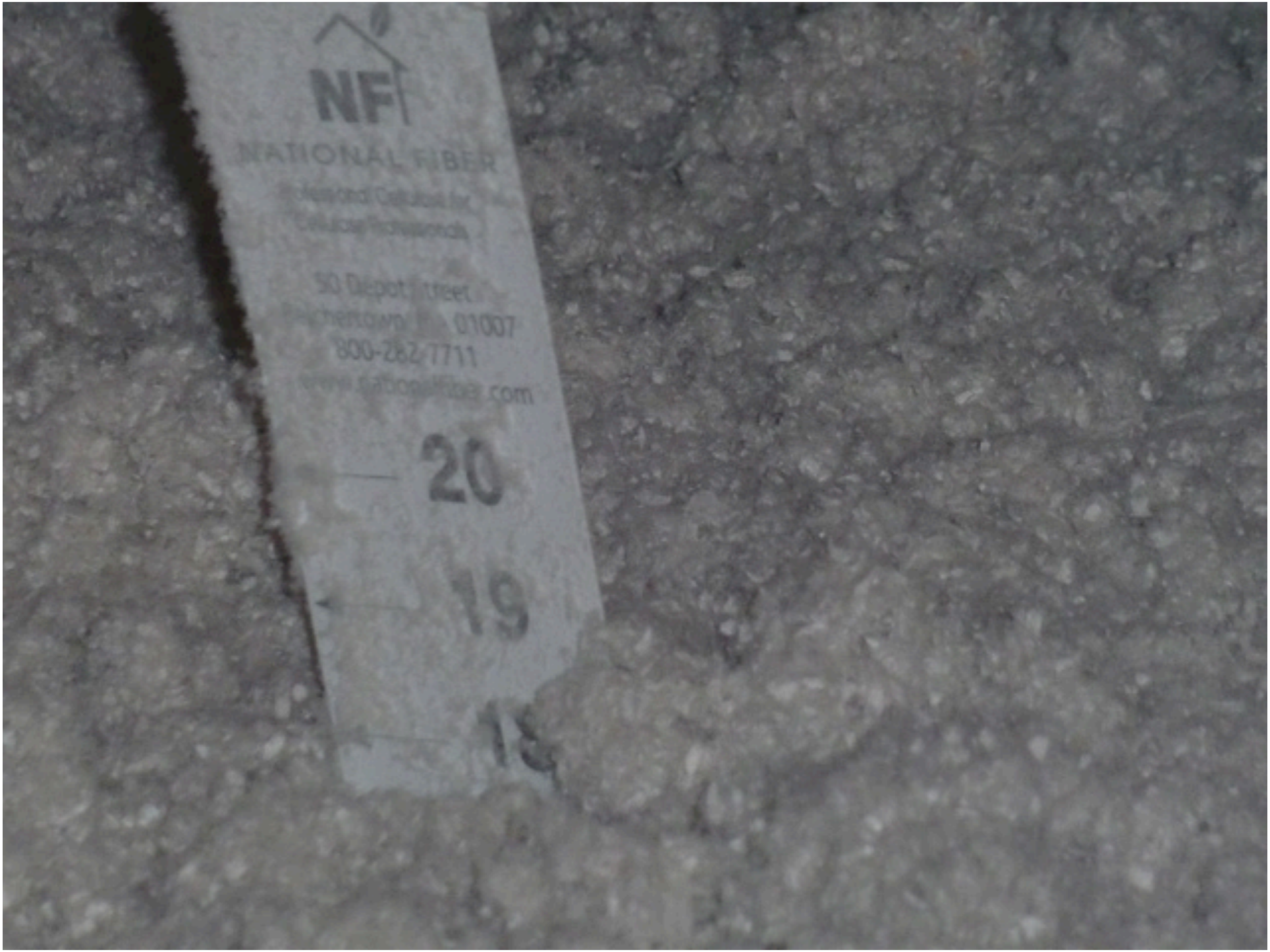
McMansion Attic Insulation: Electricity Savings



Federal-era house

- Slate roof
- Hip roof
- Ducts and air handler in attic
- Air-sealed attic floor
- Replaced incandescent can lights with LED cans
- Installed 18” of cellulose; buried ductwork


ATCO RUBBER PRODUCTS INC
FORT WORTH TEXAS


NFI
NATIONAL FIBER
800-282-7711
20
19

Blower door results

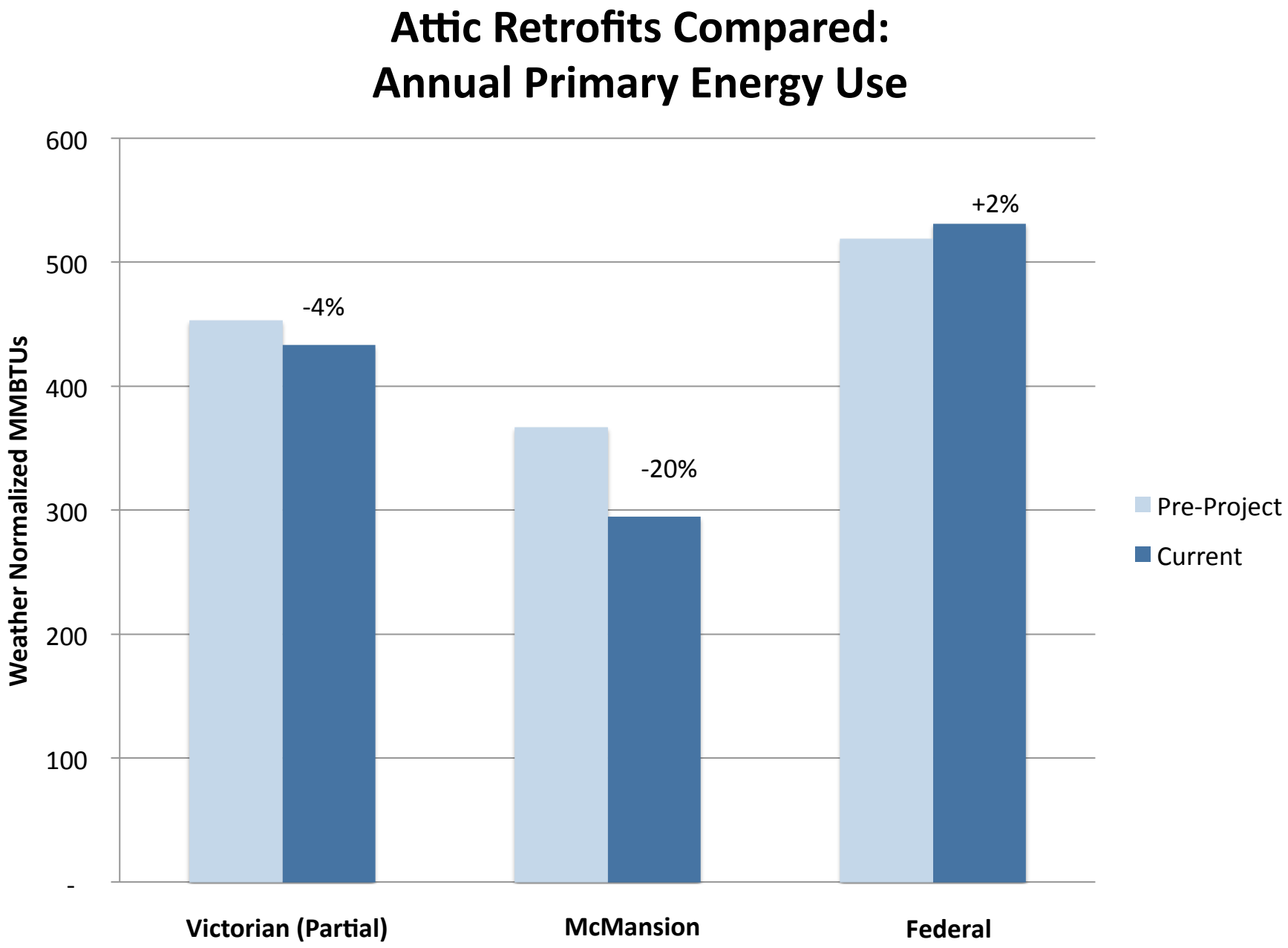
- Pre-project: 7272 cfm@50
- Post-project: 4400 cfm@50

Victorian

- Mostly a kitchen renovation
- We felt duty-bound to do some energy improvements at the same time as the kitchen

Blower door results

- Pre-project: 6800 cfm@50
- Post-project: 4986 cfm@50


Attic Retrofits Compared:
Annual Primary Energy Use
Weather Normalized MMBTUs
600
500
400
300
200
100
-
-4%
-20%
+2%
Victorian (Partial)
McMansion
Federal
Pre-Project
Current

Attic and basement

Contemporary classical revival

- Removed attic fiberglass insulation
- Moved thermal boundary to rafters to bring HVAC indoors
- Installed Thermax HD on basement walls
- Installed rigid foam and Advantech on floor
- Added whole-house HRV

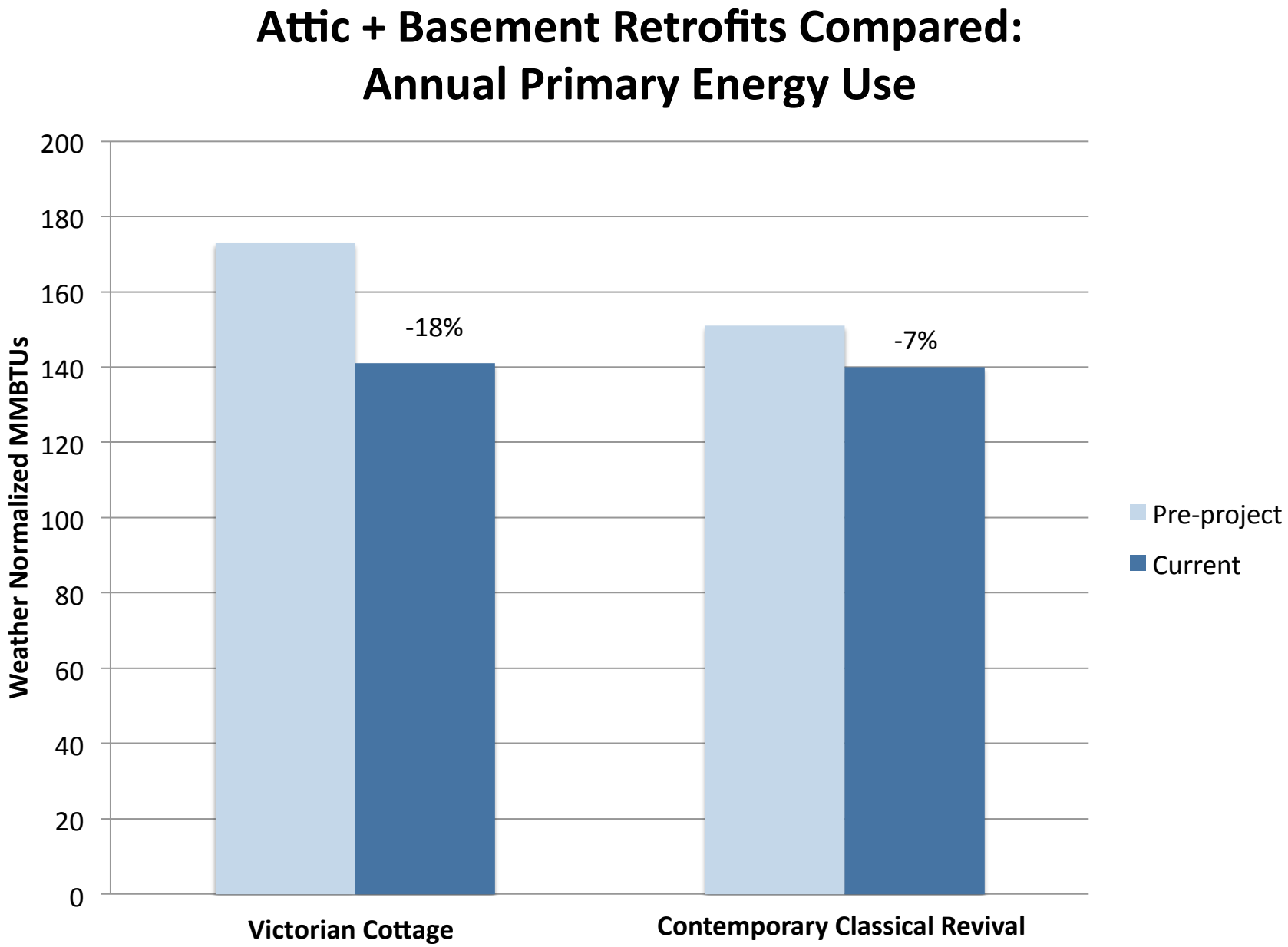

29
HECHT
ELIZABETH
WARREN
545 BE3
787 LC3

Blower door results

- Pre-project: 2669 cfm@50
- Post-project: 1150 cfm@50

Victorian cottage

- Busy street: Sound, truck exhaust, and rat mitigation
- Insulated dirt basement floor and poured slab on top
- Spray-foamed fieldstone foundation walls
- 1/4 wire mesh on floors and walls
- Removed drywall and fiberglass batts from attic rafters and insulated with open-cell foam; re-plastered
- Replace window sashes for sound attenuation
- No change to mechanical systems


Attic + Basement Retrofits Compared:
Annual Primary Energy Use
Weather Normalized MMBTUs
200
180
160
140
120
100
80
60
40
20
0
-18%
-7%
Victorian Cottage
Contemporary Classical Revival
Pre-project
Current

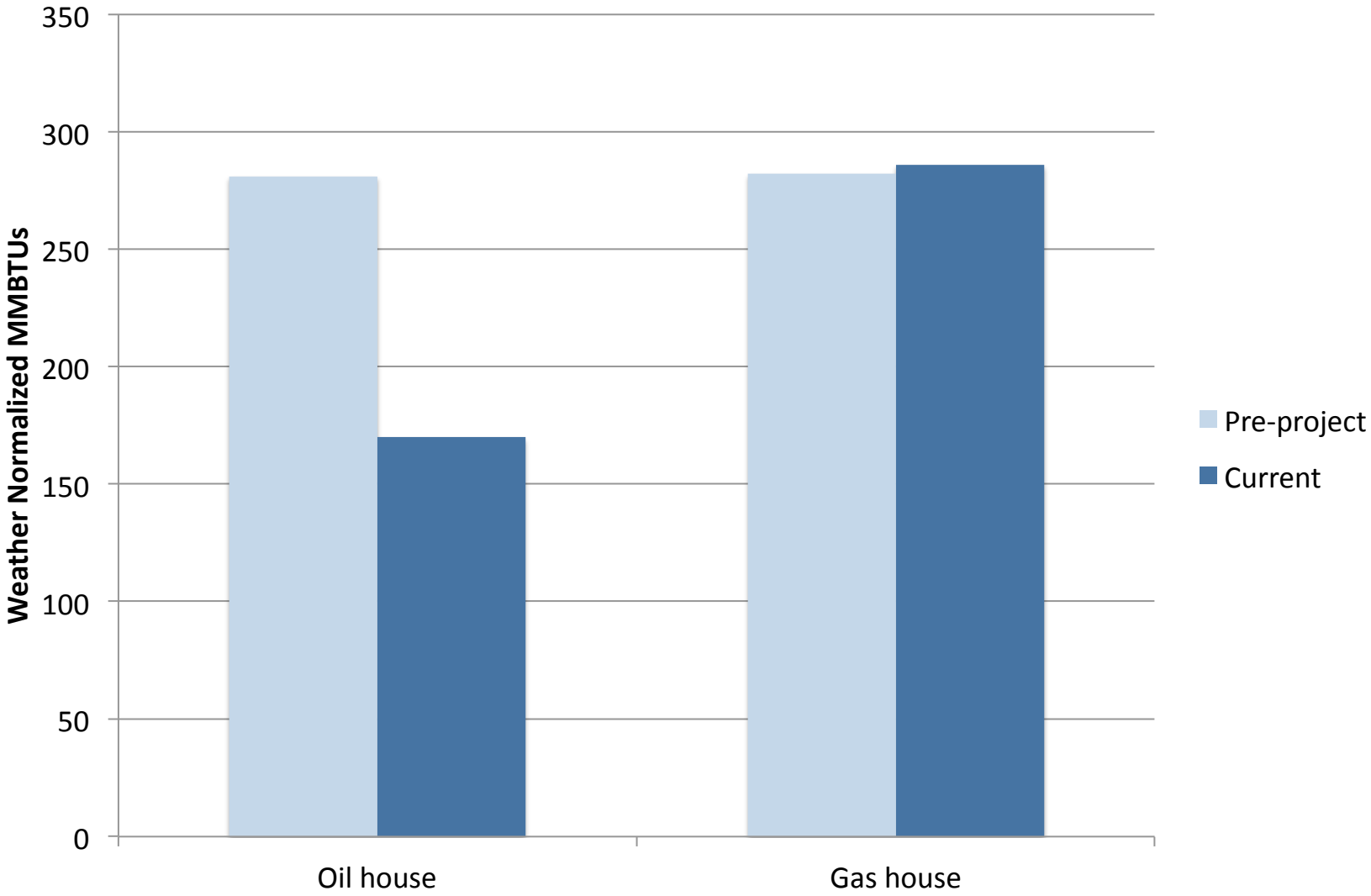
“Zoning” heat pump #1

- Oil boiler
- One-pipe steam
- One zone for whole house
- Main occupancy in 2 first floor rooms

“Zoning” heat pump #2

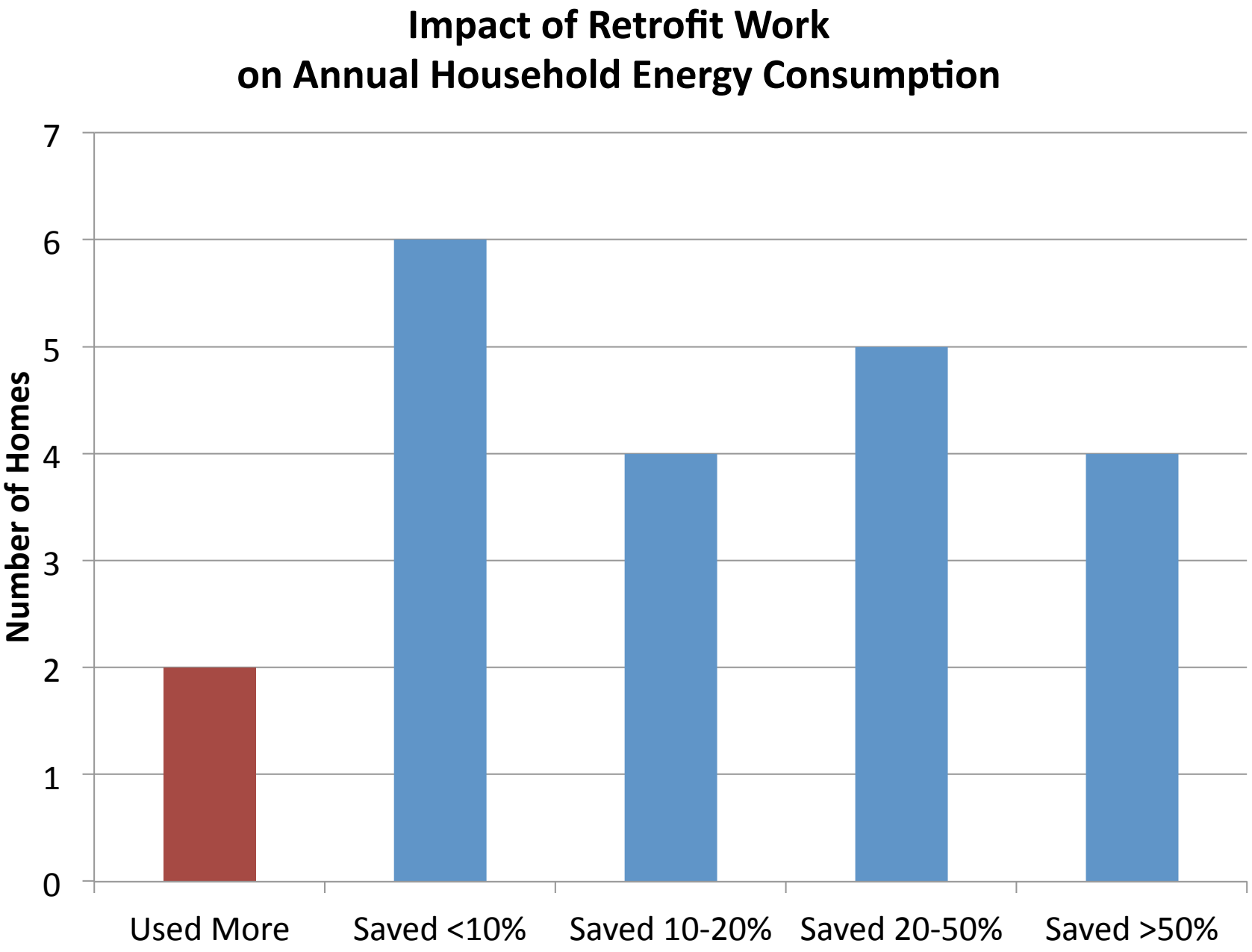
- Kitchen addition: 6-sided cube exposed to outdoor ambient on 5 sides
- Large skylight on flat roof; major summertime solar gain
- Convoluted duct run from existing gas forced-air system

Weatherization + Heat Pump Retrofits Compared: Annual Primary Energy Use



Annual Primary Energy Savings by Project Type

Project Type	Pre-Project (MMBTUs)	Current (MMBTUs)	Impact
Attic	282	164	-42%
Attic	367	295	-20%
Attic	290	233	-20%
Attic	453	433	-4%
Attic	275	268	-2%
Attic	519	531	+2%
Basement	251	122	-51%
Basement	181	194	-9%
Basement	361	331	-6%
Basement/Attic	173	136	-22%
Basement/Attic	155	142	-8%
DER	304	68	-78%
DER	292	111	-62%
DER	264	133	-50%
DER	223	139	-38%
DER/Addition	167	191	+14%
Heat Pump	295	190	-36%
Heat Pump	285	281	-1%
Roof	206	90	-56%
Roof/Addition	129	116	-10%
Walls	196	170	-13%


Impact of Retrofit Work
on Annual Household Energy Consumption
Number of Homes
0
1
2
3
4
5
6
7
Used More
Saved <10%
Saved 10-20%
Saved 20-50%
Saved >50%

Lessons Learned

- Whole enchilada deep energy retrofits work
- Partial retrofits achieve modest savings
- If you're not doing the whole enchilada, try to target the weakest parts of the house first
- If you miss an opportunity this time, it could be half a century until the next time
- The more energy you use to begin with, the more you can save
- PV works!
- Zoning with minisplits works?
- You'll have to cherry-pick your projects if you're interested in significant portfolio-wide savings