



BALANCING ENERGY, VENTILATION, AND IAQ

Case Study of a LEED v4 Rehab

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Health, Environment and Energy



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Learning Objectives



- ✓ Understand where Energy and IAQ objectives conflict in a rehab project
- ✓ Learn the top 3 mistakes made by an “expert” during a green home renovation, so that you never, ever repeat them
- ✓ Define and track energy and IAQ metrics on your next project



Case Study Background

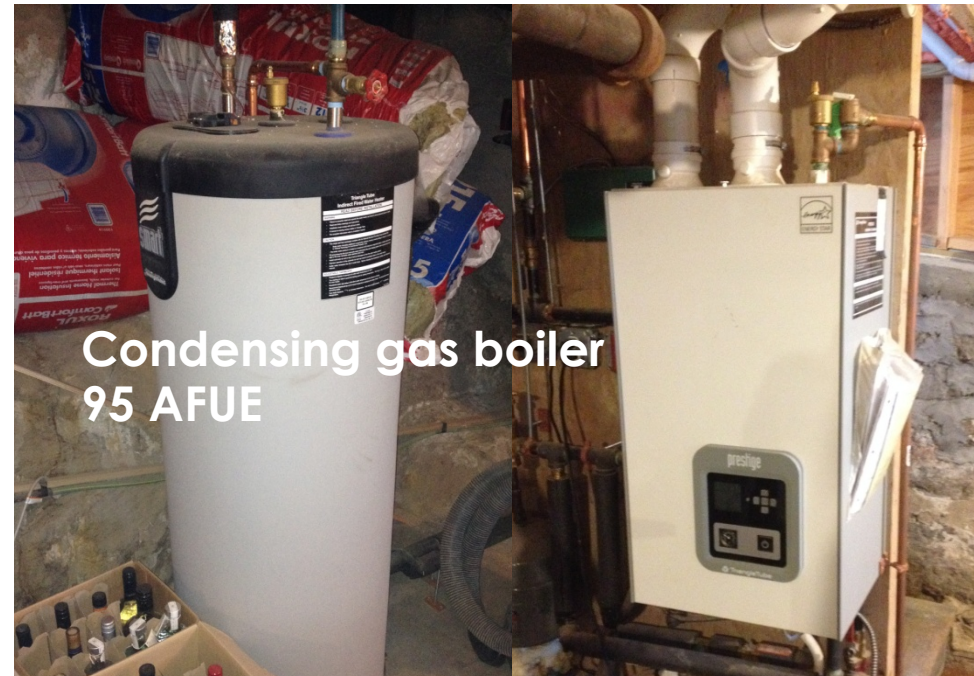
2012-2013: Mechanical System



- Existing oil boiler, atmospheric gas DHW, 15+ yr old appliances
- Keep radiators; replace boiler with condensing gas tankless + indirect tank; add radiant floors in kitchen & bath

HERS 173
25.6 ACH₅₀

HERS 143
25.6 ACH



2012-2013: Insulate attic, basement



- Spray foam attic @ sheathing
- Spray foam basement @ ceiling

HERS 111
9.7 ACH



Crawl space, basement ceilings foamed



Intumescent paint on closed cell in attic

2012-2013: Interior renovation



- Gut kitchen & bath, add ½ bath
- New PEX plumbing, WS fixtures
- LED lights, ES appliances
- NAUF cabinets, reclaimed trim, low emitting paints & sealants
- Interior air sealing (HES)

HERS 128
18.5 ACH



2014: Exterior envelope



- Remove cedar siding (1924) & stucco
- Rebuild stone foundation
- Repair tongue-and-groove sheathing
- Add 1" foil faced Polyiso (R-6.5)
- Cold-pour open cell foam in walls (R-13)
- New flashed vinyl windows
- New fiber cement siding
- Repoured sidewalks adjacent to 2 sides

HERS 62
5.6 ACH



HERS 111 to 62
9.7ACH50 to 5.6



2016-2018: Ventilation and IAQ



- Installed wood fireplace insert & lined chimney

HERS 58
3.1 ACH

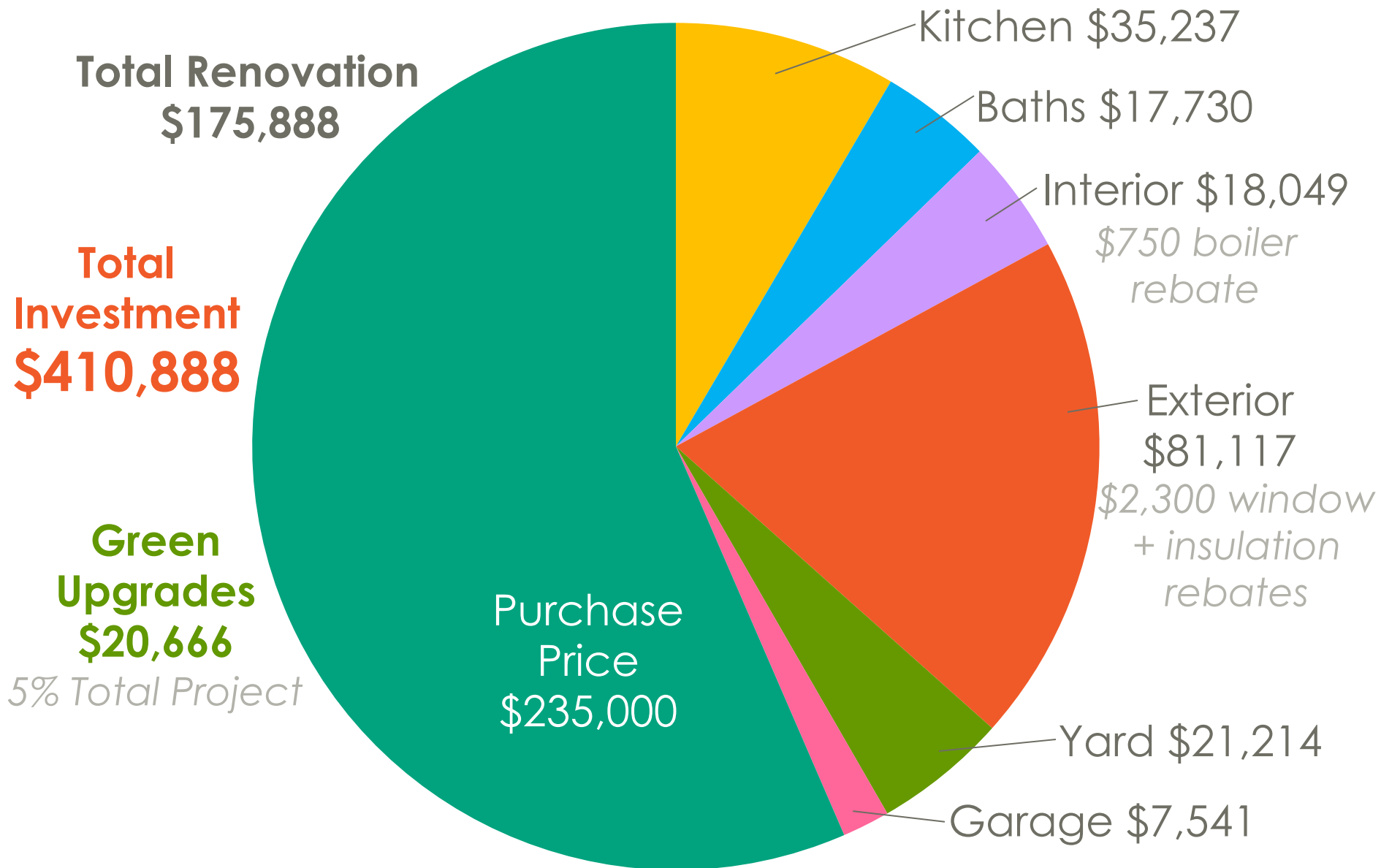
ISSUE! -11 Pa with bath + kitchen exhaust

ISSUE! Often felt stuffy upstairs

- Added fresh air makeup + limited kitchen range hood to pass combustion safety worst-case depressurization
- Added ERV to replace exhaust-only strategy

HERS 59
3.1 ACH

“The Fiscal Cliff” Cost Data



IAQ Challenges



Toughest IAQ Challenges for Rehabs

#1 Combustion Venting

- Fireplaces must have doors
- If fireplace/stove doesn't have closed combustion or power venting, must be $<-5\text{Pa}$ with worst-case depressurization (required makeup for range hood)



Indoor Environmental Quality Category



MISTAKE: RANGE HOOD TYPE

- Chose range hood based on looks and cost, pre-LBNL research, for infrequent use
- Had to limit the flow rate (124 low, 290 high) and put in motorized fresh air damper to avoid excess depressurization
- Too high, too shallow. **Next time, COVER ALL BURNERS!**
- TOO LOUD. Not unusually so, but bad for conversation. **Next time, REMOTE MOUNT FAN!**

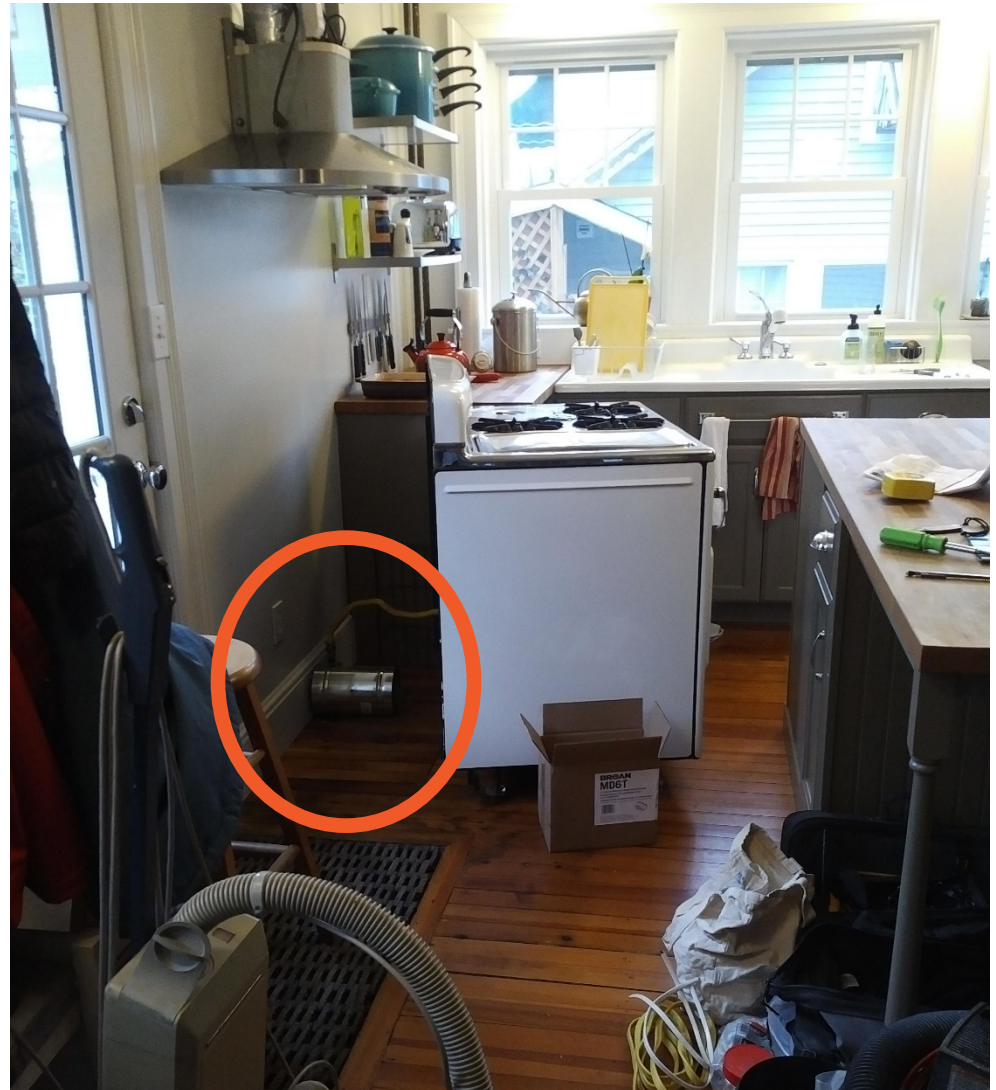


RANGE SOLUTION:

Added motorized 6" damper tied to hood to alleviate -11Pa depressurization with 124 cfm hood and 42 cfm bath.

After: -3.3 Pa

Energy: same?





POSSIBLE MISTAKE: GAS RANGE?

- Chambers 61 C, circa 1950
- Great insulation, modulation
- *“Cooks with the gas turned off”*
- Life cycle analysis... 70 yrs+ use
- My favorite thing ever, BUT...
- Cooking with gas is not the best for IAQ!



POSSIBLE MISTAKE: FIREPLACE?

- Love this EPA-listed wood burning insert for aesthetics, slow burn, heat output
- Lining the chimney + installing the unit dropped ACH50 from 5.6 to 3.1!
- Before the fresh air damper, definitely smelled ashes when range hood was on
- They really are not great for IAQ 😞

Toughest IAQ Challenges for Rehabs

#2 Whole House Ventilation

- Exhaust-only allowed in ASHRAE 62.2
- Points given for ERV or balanced



Indoor Environmental Quality Category



MISTAKE: EXHAUST-ONLY



- Low-cost, minimally invasive in a home with interior preserved
- Suitable for moderately tight homes in moderate climates
- Bath fan upstairs pulling **45cfm** continuous with boost controller
- Home got progressively tighter, to 3.1 ACH50
- **We found bedrooms stuffy.** Monitored humidity, but did not seem unusually high



FRESH AIR SOLUTION:

Added a 100cfm ERV in the attic. Ducted supply to each of 4 beds. Returns from main bath and register in stairwell.

MERV 13 FILTER

After: Noticeably more comfortable! BUT Watch out for outdoor contaminants.

Next Time: put shut-off on main level for easy access.

Energy: 438 kwh/yr, \$83/yr

Comfort: 2° warmer/colder upstairs... re-balance heat!



#3 Radon Mitigation

- Radon resistant construction required in Zone 1 (high risk); OR
- Rehabs can test to show compliance



Indoor Environmental Quality Category



MISTAKE: THINKING 4 pCi/L SAFE

- Sealed basement away from living space with ccspf, gaskets
- 4 day tests initially showed Radon levels of 1-3 pCi/L
- After home was tightened, increased to right around 4 pCi/L
- “There is NO safe level of radon” (World Health Organization)



RADON SOLUTION:

Added continuously operating 50 cfm 13 watt fan exhausting from crawlspace.

After: 1.2-1.4 pCi/L

Next time, aim for
Radon <2 pCi/L

Energy: 114 kwh/yr, \$21



A photograph of a two-story yellow house with a snow-covered roof. The house has two dormer windows on the roof and several windows on the main floor. The scene is set in winter, with snow on the ground and rooftops. A stone wall and a wooden fence are visible in the foreground. The text "Energy Challenges = IAQ Challenges" is overlaid on the bottom half of the image.

**Energy Challenges =
IAQ Challenges**

CHALLENGE: LEDGE FOUNDATION



SOLUTION: ISOLATE & LEAVE IT BE, DEHUMIDIFY



CHALLENGE: LIMITED INSULATION SPACE

- Wanted to preserve footprint, interior plaster & trim
- Avoid re-framing to limit costs
- Maintain the option to finish out the attic





SOLUTION: VARIOUS FOAMS

- Closed cell (attic, basement), open cell (cold-pour exterior walls), and 1" rigid exterior foams for best R-per-inch plus vapor resistance
- Aimed for lower ozone depletion products, but choices still impact environment + health
- Added intumescent paint in attic for fire protection

IAQ: short-term impacts during and shortly after install. Long term...???



CHALLENGE: CLADDING

- Removed beautiful 90-year old cedar siding (and stucco beneath) to address drainage and add continuous insulation

DECISION: RE-HOME, ADD NEW

- 75% cedar was in perfect condition and taken away free via Craigslist
- Replaced with fiber cement, high embodied energy but good durability, low maintenance

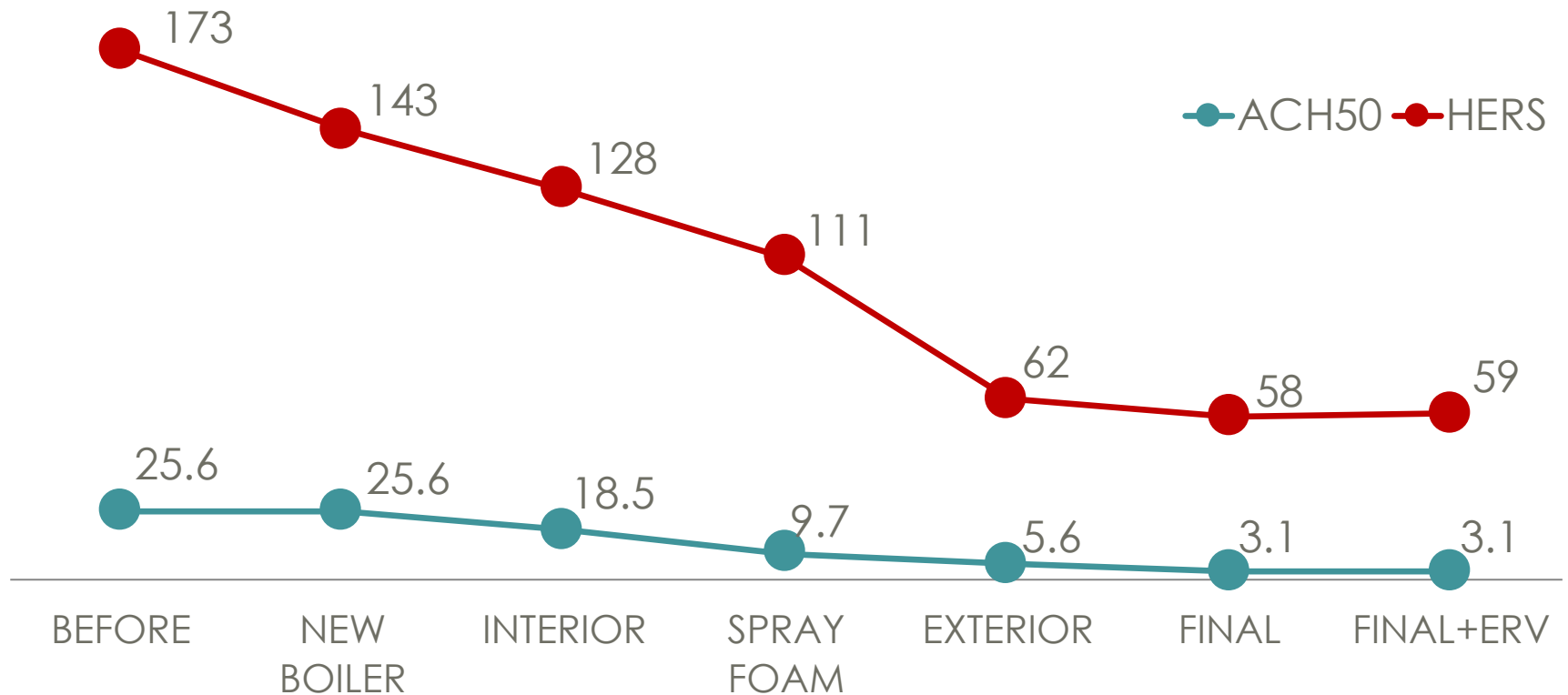


Drops in HERS Index and ACH50

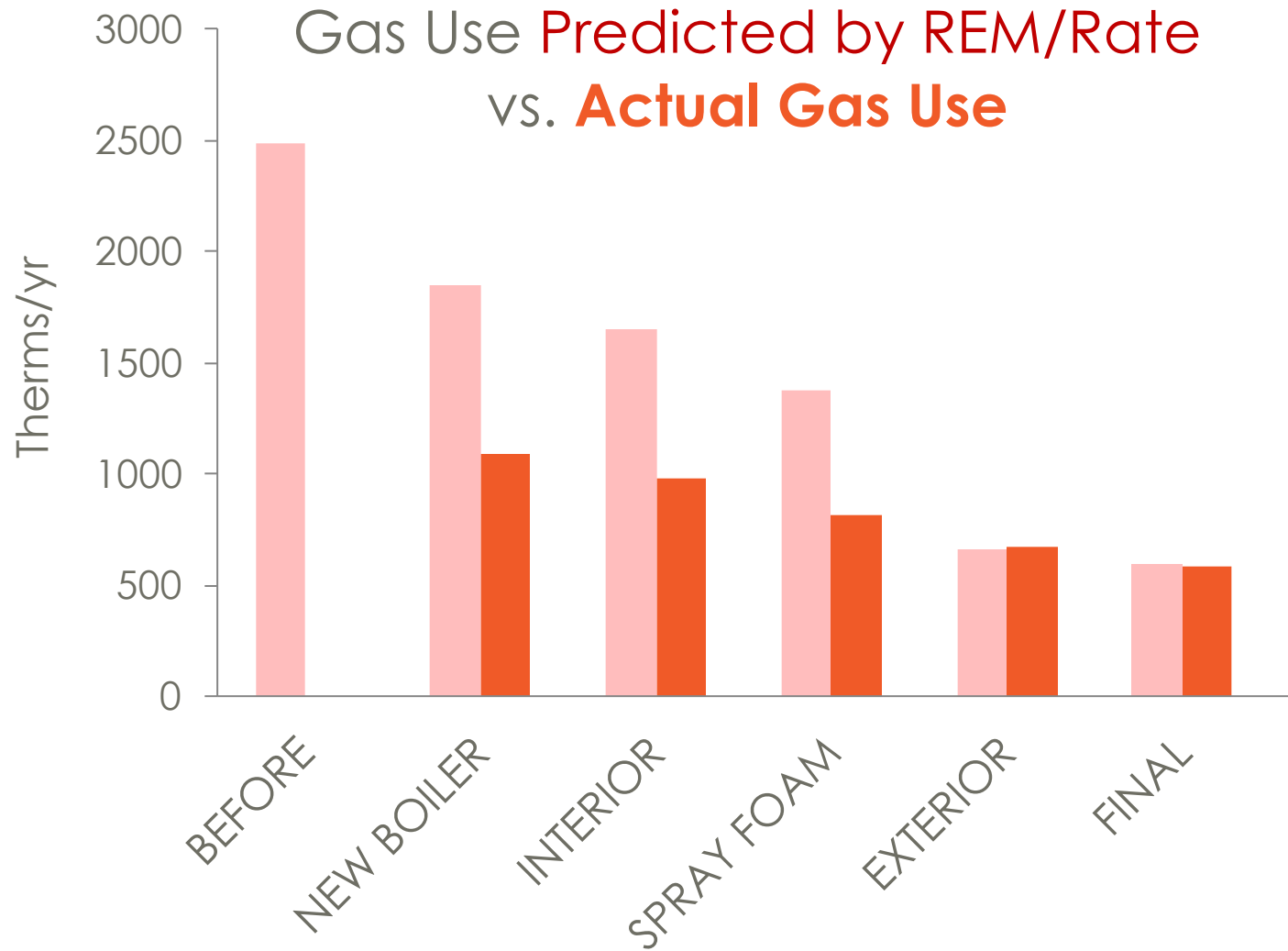


HERS drops from 173 to 59

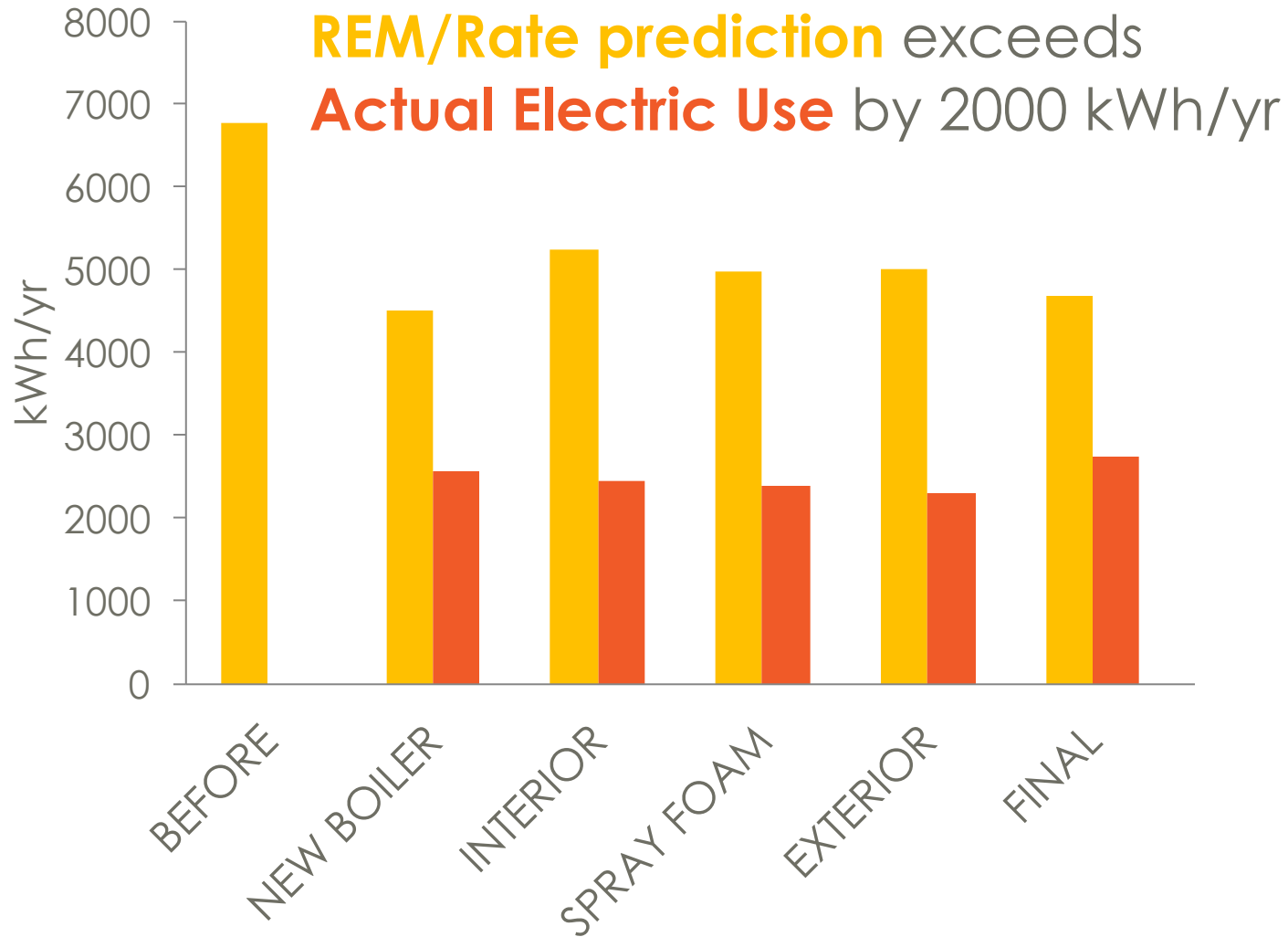
ACH50 drops from 25.6 to 3.1



Gas Use: now close to 600 Therms/yr



Electric Use: Predicted exceeds Actual



Utility Costs - Benchmark

Current Water: \$165/year

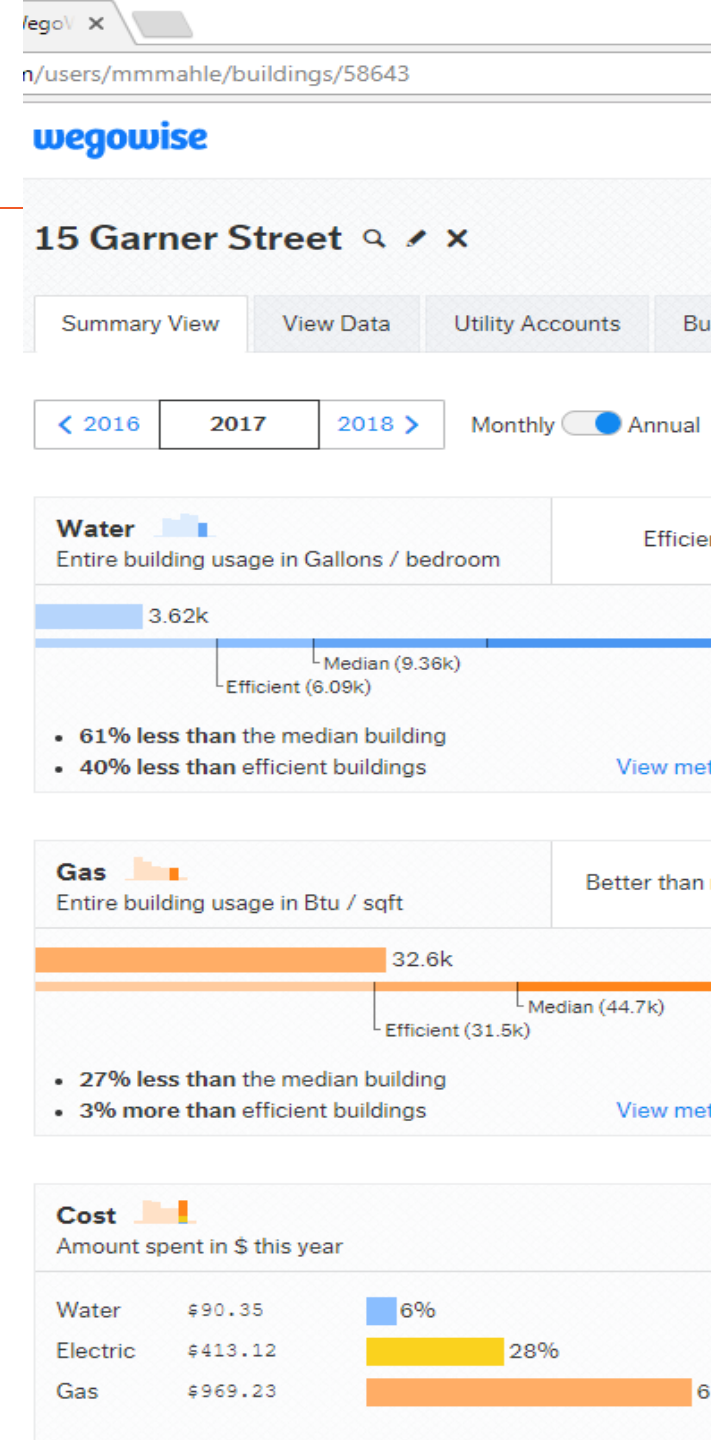
- \$59 landscaping install summer
- \$37 winter/shoulder month
- \$43 average month over 5 yrs

Current Electric: \$590/year

- \$58 summer month
- \$34 shoulder month
- \$44 average month over 5 yrs

Current Gas: \$965/year

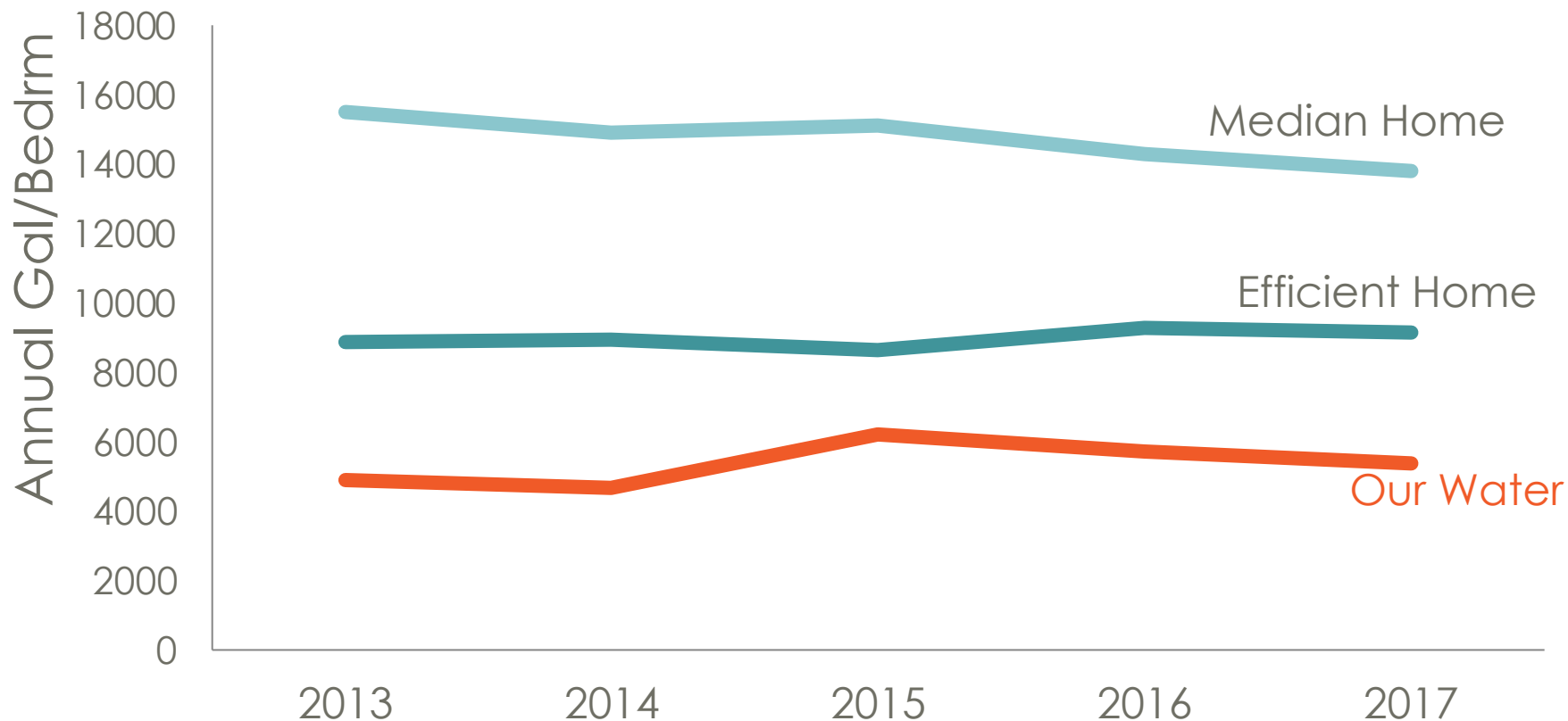
- Was \$280 winter high, now \$160
- \$24 summer months
- \$98 average month over 5 years



Water Use: 40% better than “Efficient”



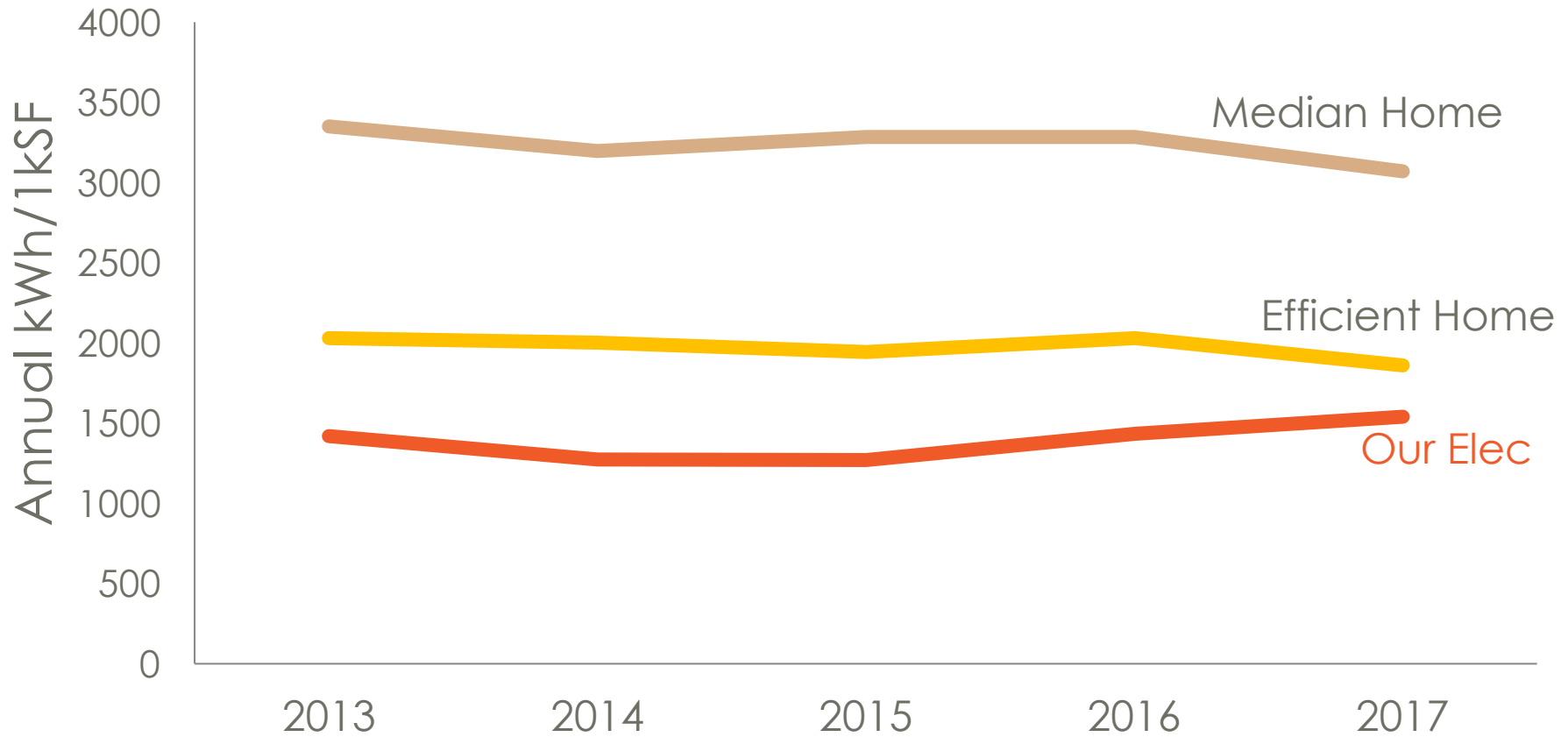
wegowise Annual Water Use



Electric Use: 20% better than “Efficient”



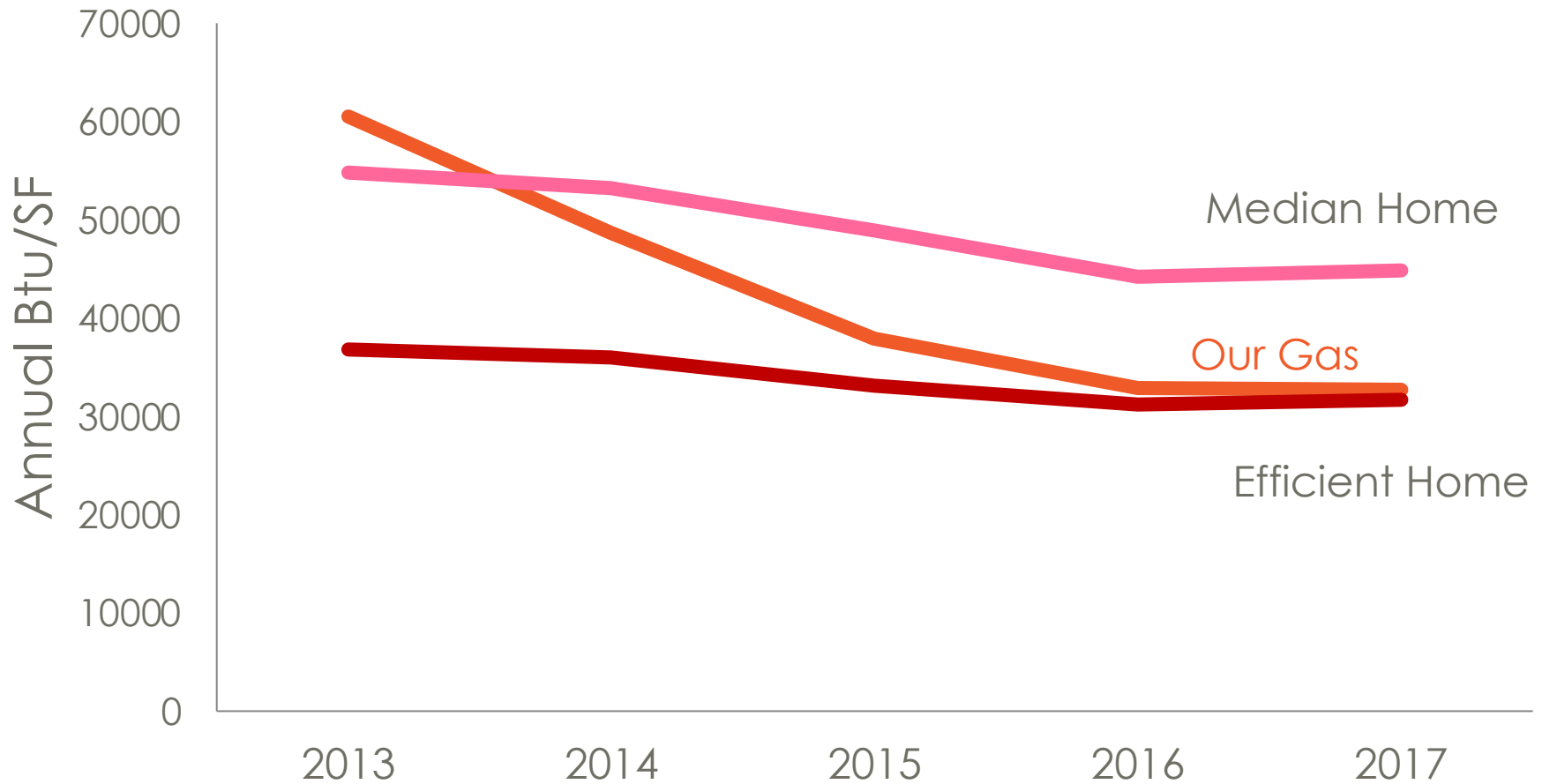
wegowise Annual Electric Use



Gas Use: 2% worse than “Efficient”



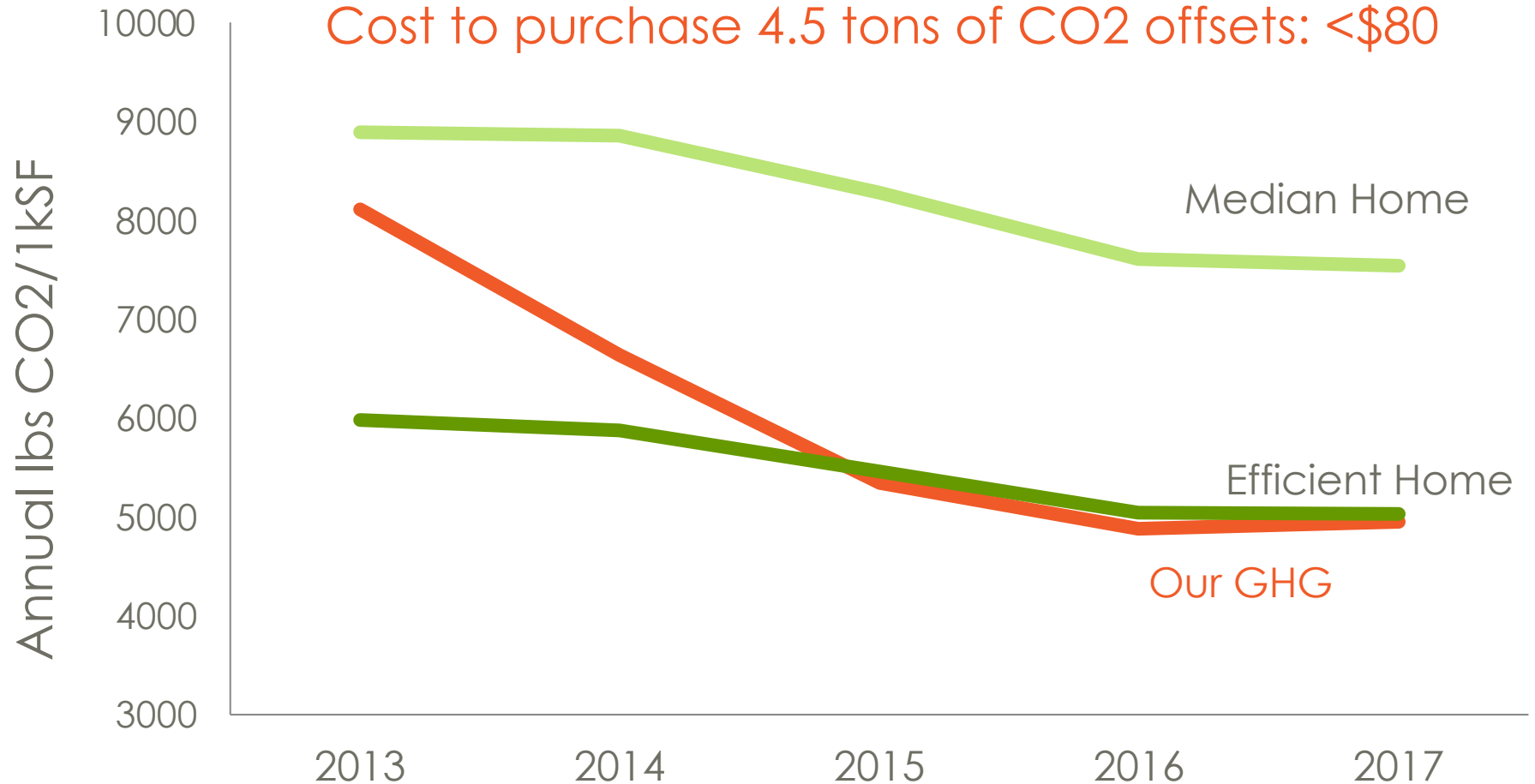
wegowise Annual Gas Use



Greenhouse Gas: 2% better than Efficient

wegowise Annual Greenhouse Gas

Cost to purchase 4.5 tons of CO2 offsets: <\$80



Health Impacts



- Double the cfm of fresh air
#THECOGFXSTUDY
- Avoid new chemicals of concern
 - Nonylphenol Ethoxylates (NPE)
 - Phthalates
 - Antimicrobials
 - Flame Retardants
 - Perfluorinated Chemicals (PFC)
- MERV 13 Filters
- Dehumidification
- Circadian lighting (for better sleep)
- Radon no more than 1-2 pCi/L
- Kitchen Exhaust Quieter, wider, makeup air

To live is to learn!



The actual comfort and costs experienced do not always match our predictions.

Adjustments are an essential part of achieving a high performance home!

Expect 'retroCx' in your process, especially for heating, cooling, and ventilation!





Thank you!
Any questions?

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