Steven Winter Associates, Inc.

BALANCING ENERGY AND IAQ
Case Study of a LEED Home Rehab

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Course Description

Balancing Energy and IAQ: Case Study of a LEED Home Rehab

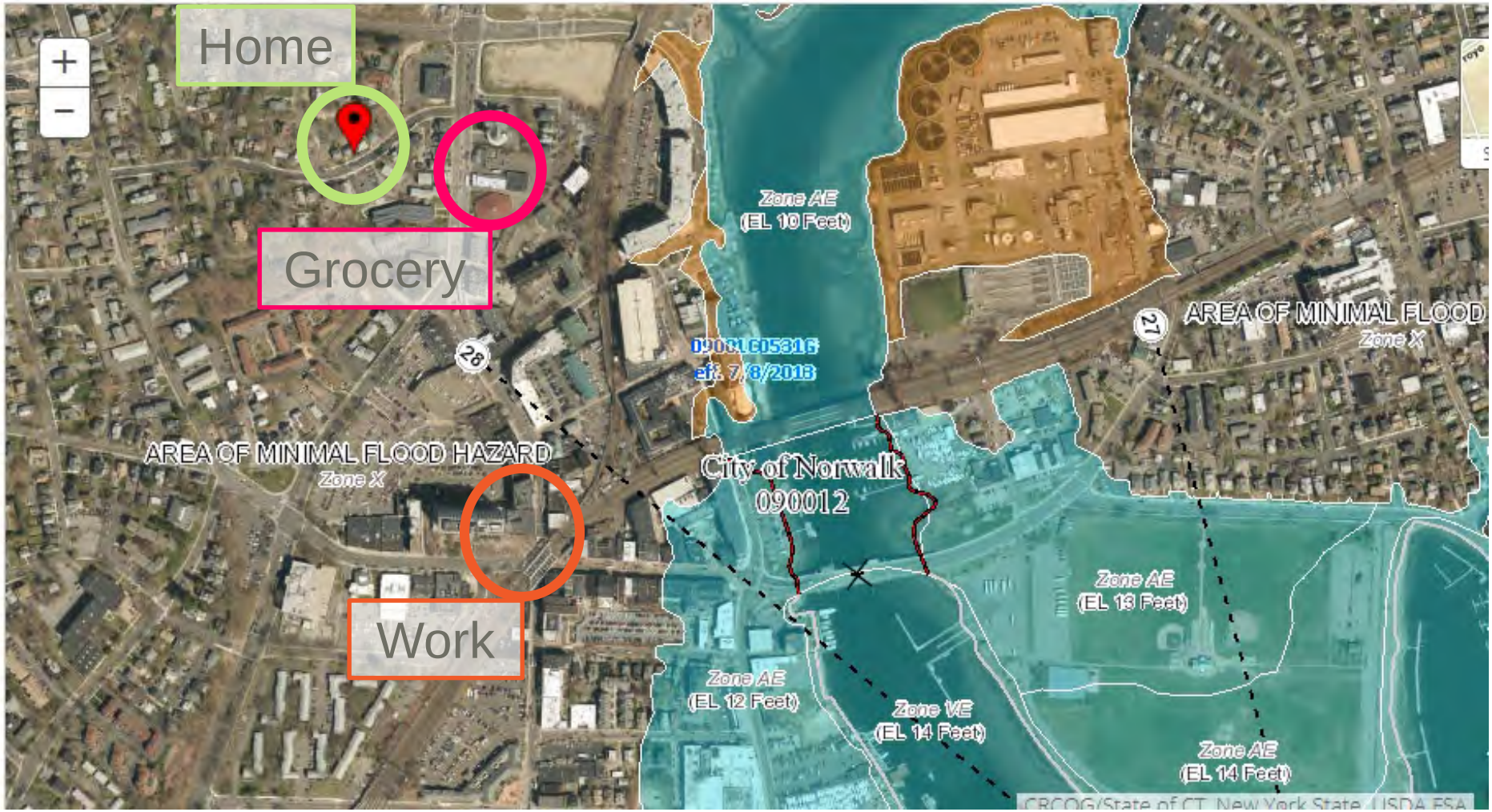
This case study highlights the lessons learned when those who certify actually GET CERTIFIED. Describes a 5+ year occupied renovation of this 1915 home located in an urban infill setting, including decision-making, results, and the pros and cons of LEED v4 for Homes applied to rehabs.

Learning Objectives

1. Identify the easiest and most challenging LEED v4 for Homes credits for rehab projects
2. Understand where Energy and IAQ objectives conflict in a rehab project
3. Learn the top 3 mistakes made by an “expert” during a green home renovation, so that you never, ever repeat them
4. Define and track energy and IAQ metrics on your next project

Case Study Background

Purchase decision: Walk to work and train, but avoid possible flood zones



Tan: 500-year flood zone; Blue: 100-year flood zone (1% chance every year)

Goals for love & money...

1. A home either of us could afford, just in case ☺
2. Total investment < market value

Home purchased Oct 26, 2012

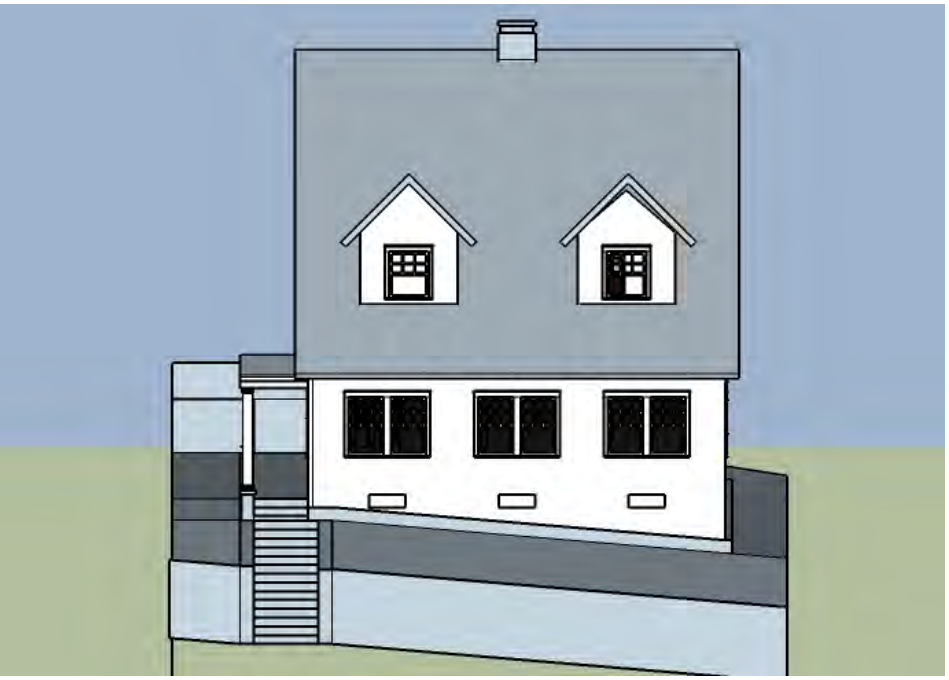
- $235,000
- Built 1915
- Wood frame
- 4-bed, 1-bath
- 1794 conditioned SF
- Hydronic heat

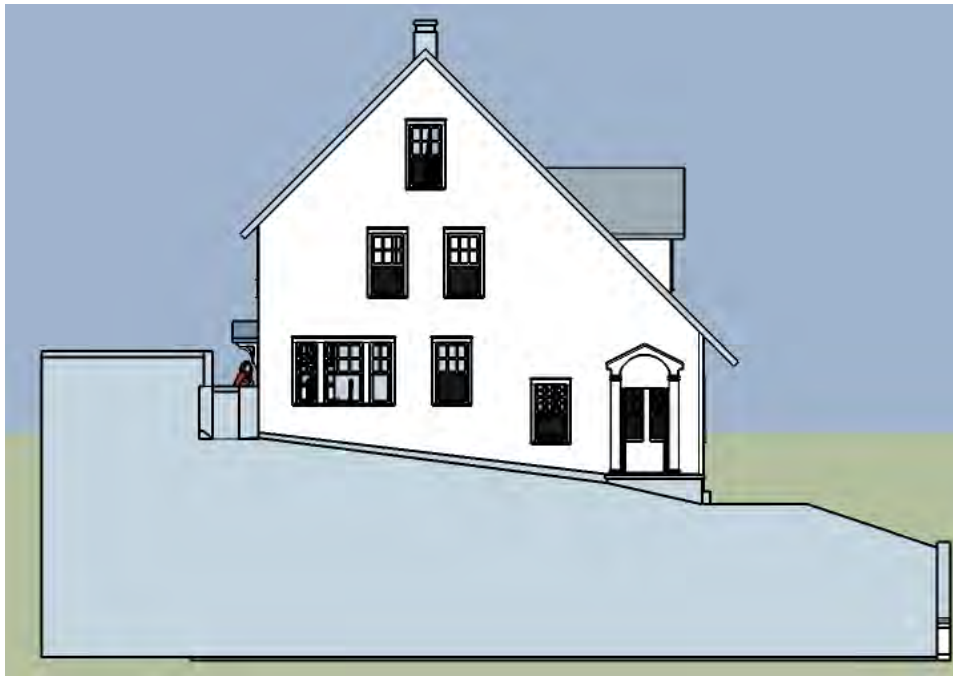
Hurricane Sandy Oct 29, 2012

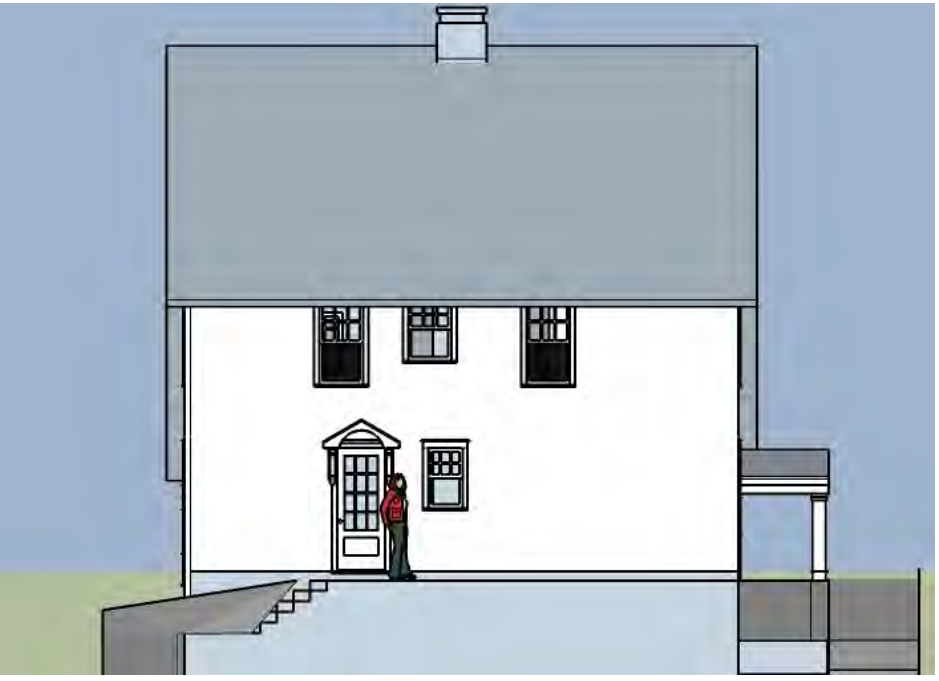
1915 home, wood frame, 4 bed, 1794 SF

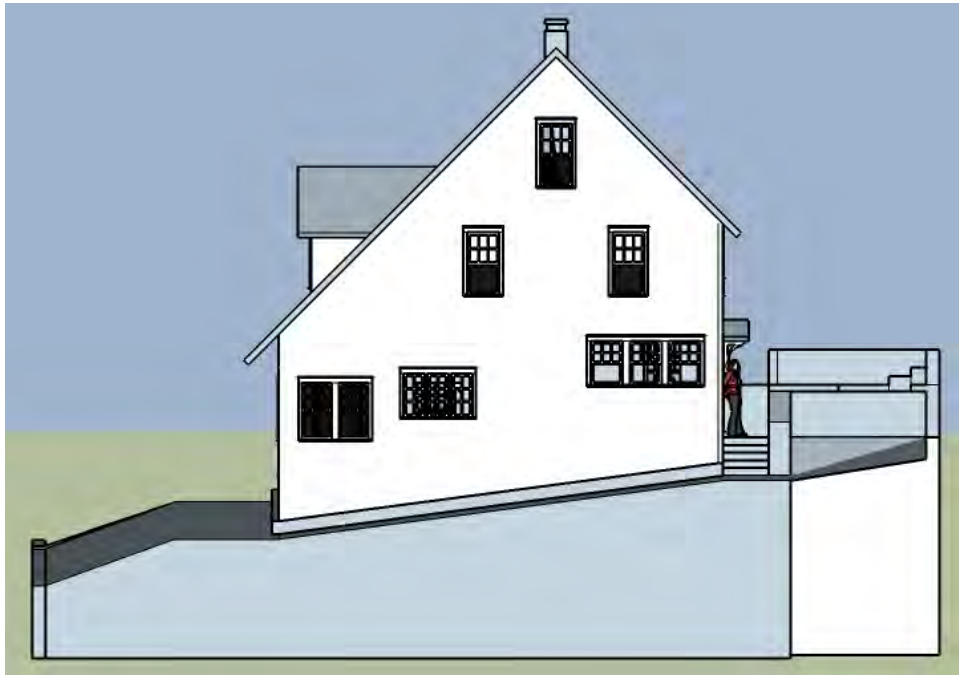
First Floor

Second Floor









Timeline

• 2012 Aug to Oct	House purchase
• 2012 Nov – 2013 Dec	Boiler, floors, kitchen, baths, insulate attic + basement
• 2014 July to Nov	Exterior: siding, insulation, windows, foundation, trim
• 2015 April to Sept	Landscaping - sides
• 2016 June to Aug	Garage
• 2017 June to Aug	Landscaping - front & back
• 2017 Nov to Dec	Energy Recovery Ventilator
• 2015 Feb to present	Interior paint, trim

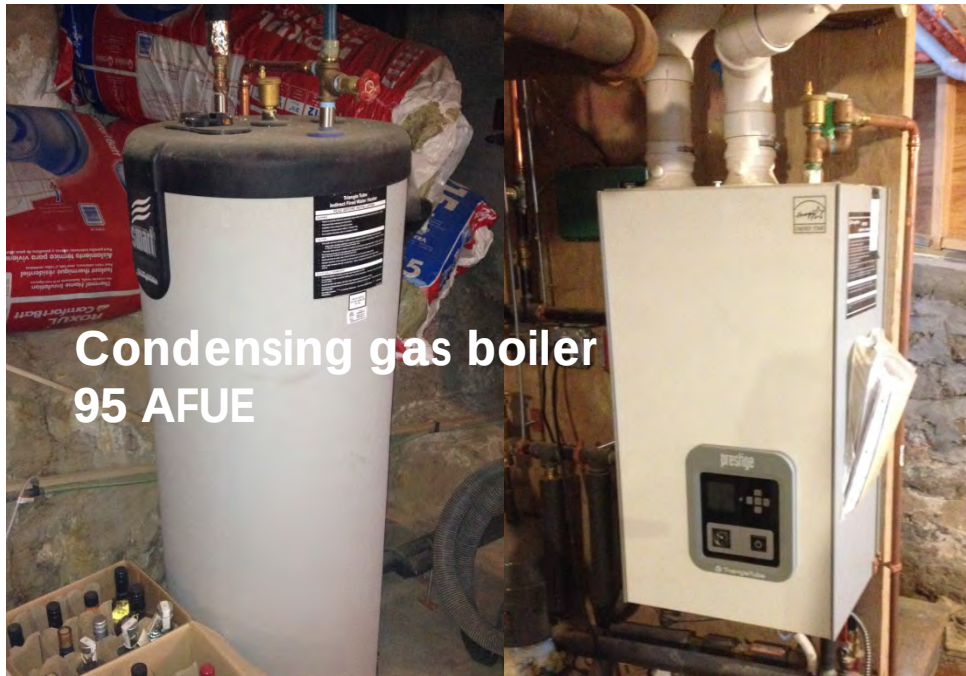
2012-2013: Mechanical System

- Existing oil boiler, atmospheric gas DHW, 15+ yr old appliances

HERS 173
25.6 ACH_{50}

- Keep radiators; replace boiler with condensing gas tankless + indirect tank; add radiant floors in kitchen & bath

HERS 143
25.6 ACH



2012-2013: Insulate attic, basement

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

HERS 111
9.7 ACH

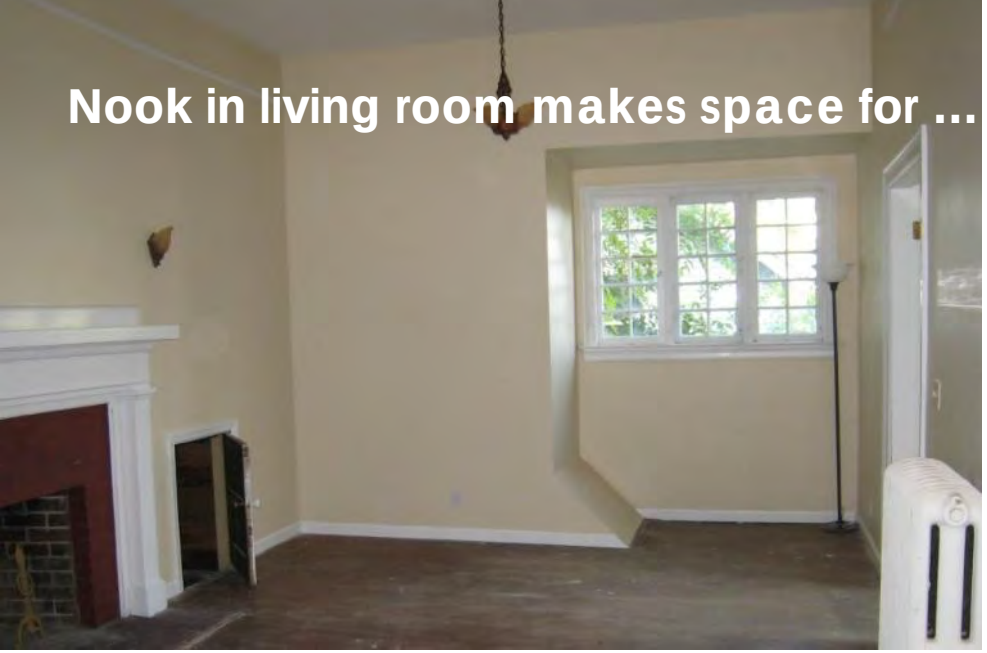
Crawl space, basement ceilings foamed

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)

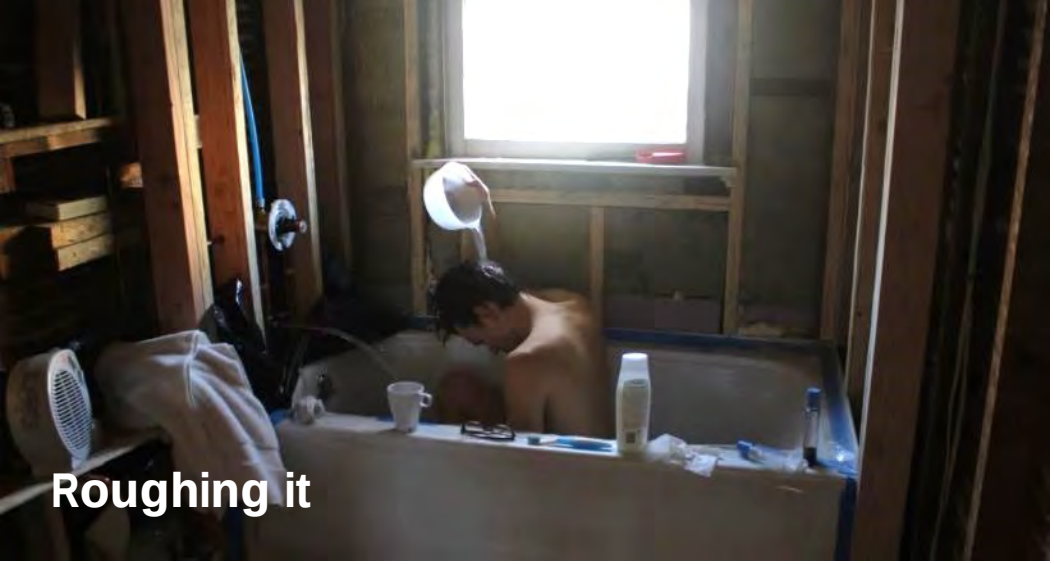
HERS 128
18.5 ACH


Nook in living room makes space for …

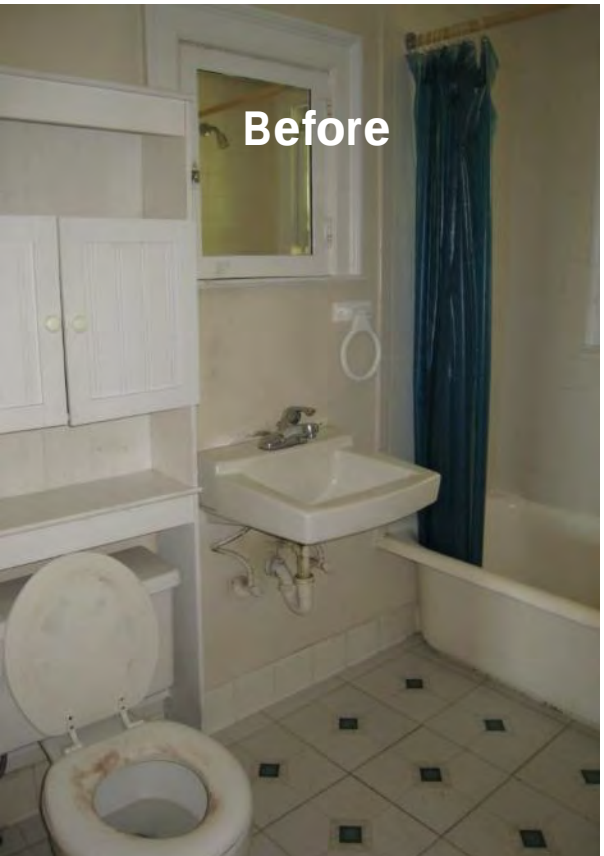

…a half bath


Doug fir floors, before…


…and after


Roughing it


Tile experiment


Before


During


After

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

9.7 ACH50 to 5.6

Summers 2015, 2017: Landscaping

216 new plants, 210 gal rainwater
68% LEED Total Water Reduction

2016-2018: Ventilation and IAQ

- Installed wood fireplace insert & lined chimney

HERS 58
3.1 ACH

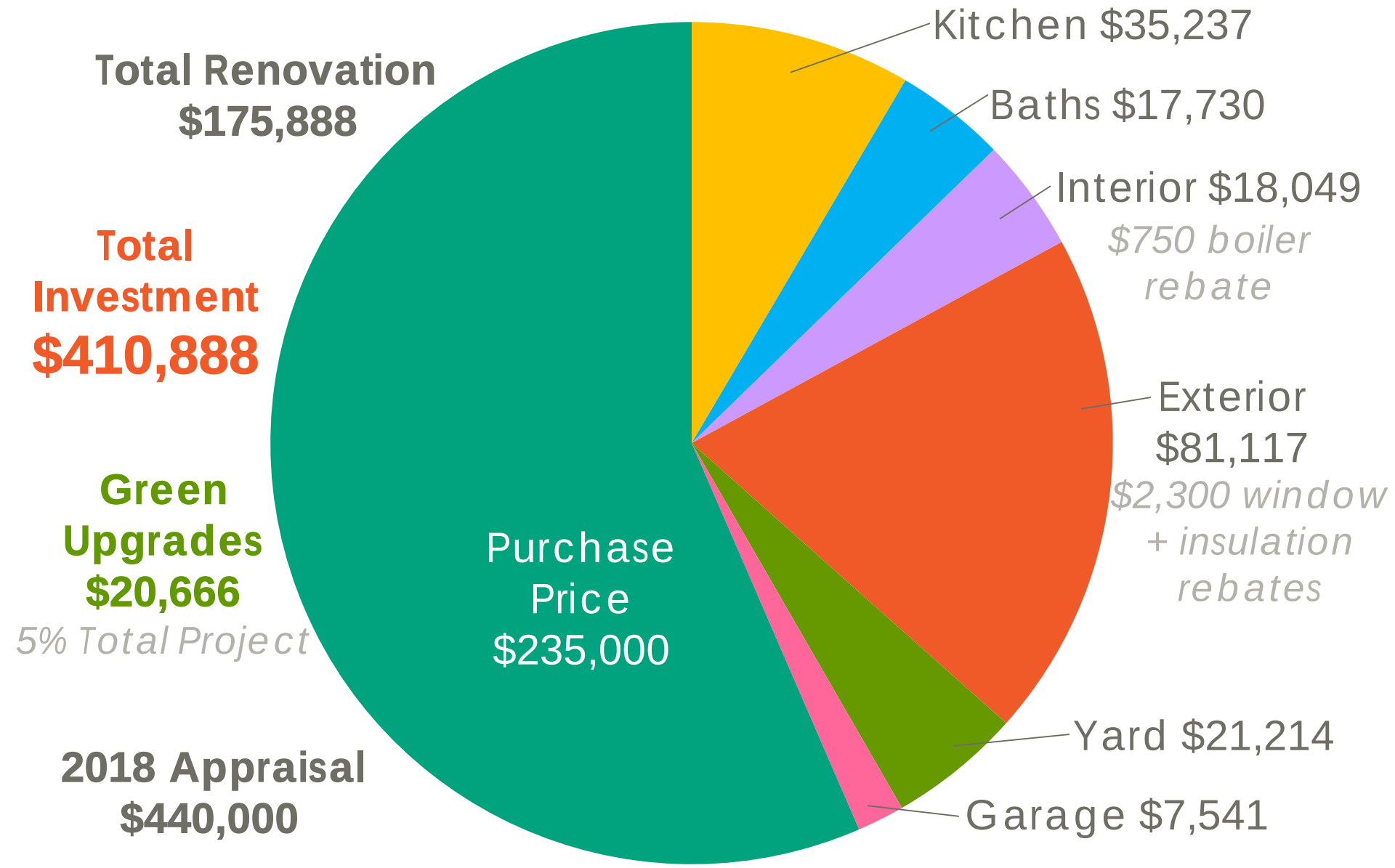
ISSUE! -11Pa with bath + kitchen exhaust

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



LEED-H Occupied Rehab

v4 Platinum Scorecard: 85 of 110

Integrative Process	2 of 2
Location & Transportation	14.5 of 15
Sustainable Sites	3 of 7
Water Efficiency	12 of 12
Energy & Atmosphere	26.5 of 38
Materials & Resources	10 of 10
Indoor Environmental Quality	6 of 16
Innovation	6 of 6
Regional Priority	4 of 4

Easiest Rehab Credits in LEED-H v4

#1 Site Selection +9pts

+4 Previously Developed

+2 Infill

+1 Open Space

+1 Street Network

+1 Bonus Regional Priority

Location + Transportation Category

Easiest Rehab Credits in LEED-H v4

#2 Environmentally Preferable Products +7.5

+1.5 Local – now 100 miles

+4 Requires just 25% per component reclaimed: flooring, sheathing, roofing, gypsum board (or plaster), floor covering

+1 Reclaimed for 90% of 3 of trim, doors, decking, etc.

+1+ Innovation – Exemplary Performance

Materials & Resources Category

Easiest Rehab Credits in LEED-H v4

#3 Low-Emitting Products: Composite Wood +1pt

- With over 95% of interior trim and doors preserved, there was very little new wood to worry about.
- Kitchen cabinets were NAUF

Indoor Environmental Quality Category

Easiest Rehab Credits in LEED-H v4

#4 Construction Waste Management +3pts

LEED v4 now requires you to count recycled waste at only a 25% reduction (75% still counts as waste), AND limits are lower. Only rehabs are likely to score high

Material Efficient Framing +2pts

Rehabs can count only new components, OR take credit for no new material

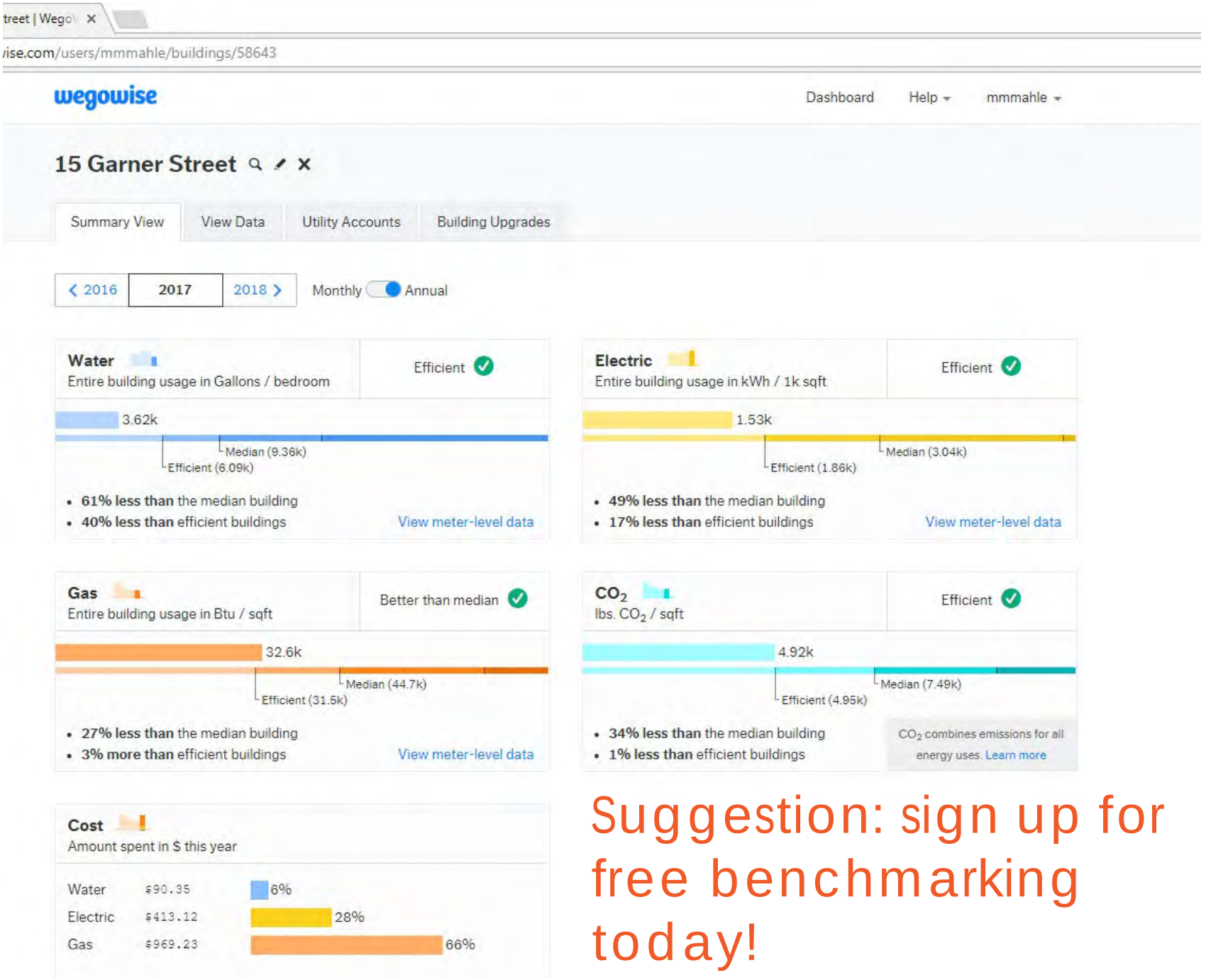
Materials & Resources Category

Easiest Rehab Credits in LEED-H v4

#5 Advanced Utility Tracking +1pt

Easy when end-users are known! Requires signing up for a WegoWise or WegoHome (free!) account and linking utility data. If your utility doesn't automatically link, upload automatically, or get 10 neighbors and ask Wego to set up the link.

Energy & Atmosphere Category



Suggestion: sign up for free benchmarking today!

IAQ Challenges

Toughest IAQ Challenges for Rehabs

#1 Combustion Venting (Prereq + 1pt)

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

Indoor Environmental Quality Category

MISTAKE: RANGE HOOD TYPE

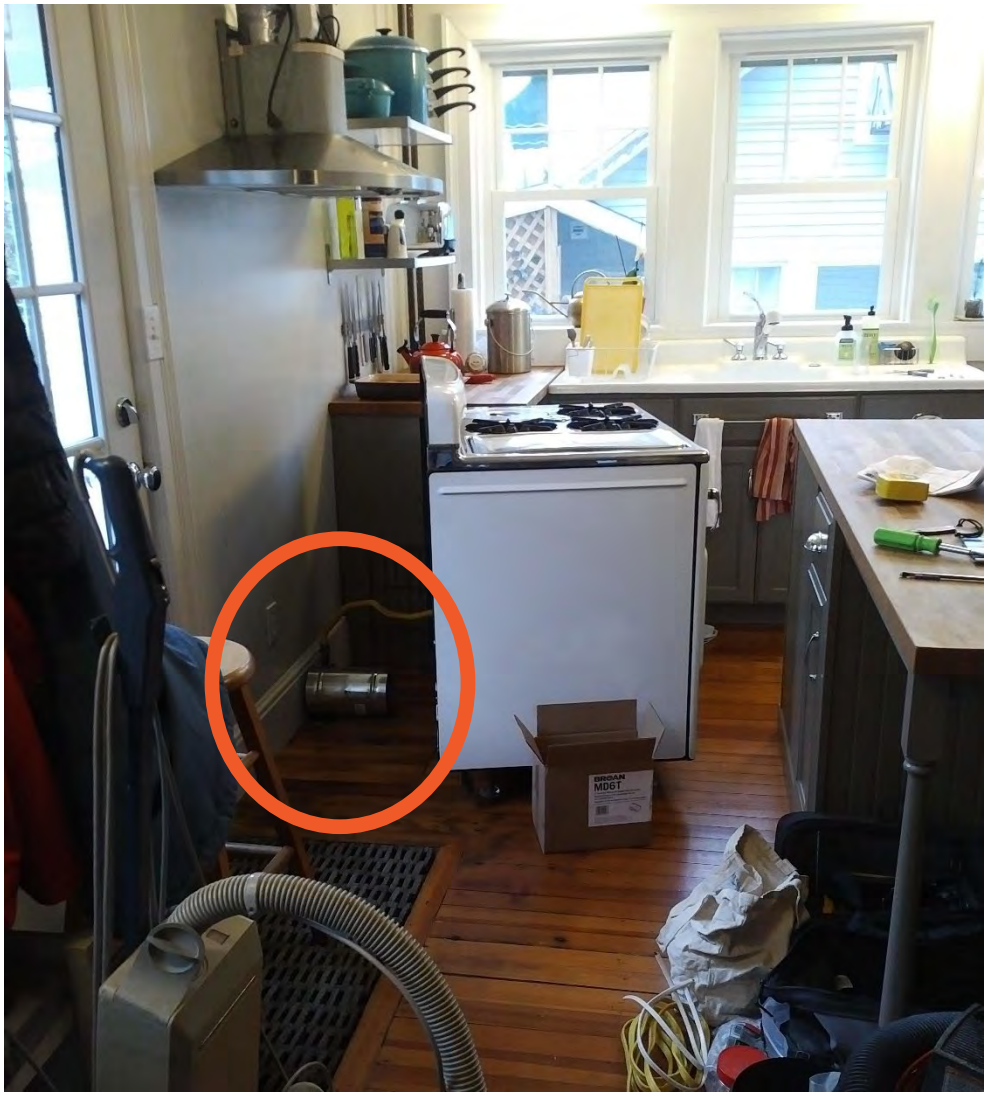
- Chose range hood based on looks and cost, pre-LBNL research, for infrequent use
- Had to limit the flow rate (124 low, 290 high) and put in motorized fresh air damper to avoid excess depressurization
- Too high, too shallow. Next time, COVER ALL BURNERS!
- TOO LOUD. Not unusually so, but bad for conversation. 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 61C, 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 (Prereq +2pts)

- 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.

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!

Toughest IAQ Challenges for Rehabs

#3 Radon Mitigation (Prereq)

- 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

Energy Challenges

Energy Challenges for Rehabs in v4

#1 Annual Energy Use (Prereq + 1-30pts)

Requires meeting **HERS Index Target** & earning **ENERGY STAR. Rehabs get exceptions** to parts of the Thermal Enclosure System Checklist (*4.1 attic insulation)* and Water-Managed Site and Foundation *(1.3 capillary break, unless water damaged)*

However, Rehabs may have limitations (e.g. that limit earning EA points cost-effectively.

Energy & Atmosphere Category

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

CHALLENGE: WINDOWS

- $11,000 for 35 Paradigm ENERGY STAR double pane, double hung vinyl windows U-0.28, SHGC 0.25.
- Wood $12,000 more. Triple pane $5,000 more. PH $38,000 more.

DECISION: VINYL DOUBLE PANE

- Good energy performers, tight for double-hung, good divided light look, in our budget… BUT VINYL
- 100% of old windows were re-homed, listed FREE on Craigslist

Next time, casements for tightness and looks? What about coverings?

CHALLENGE: EXISTING HEATING

- 5-year old oil boiler; 99-year old radiators (steam converted to H20)

DECISION: CONDENSING GAS BOILER FOR HEAT + HOT WATER, NO A/C

- Traded boiler for moving services
- Kept radiators except LR; added radiant tubing kitch + bath
- NEST thermostat works well to manage high-mass system
- 6,000 and 8,000 BTU window A/C

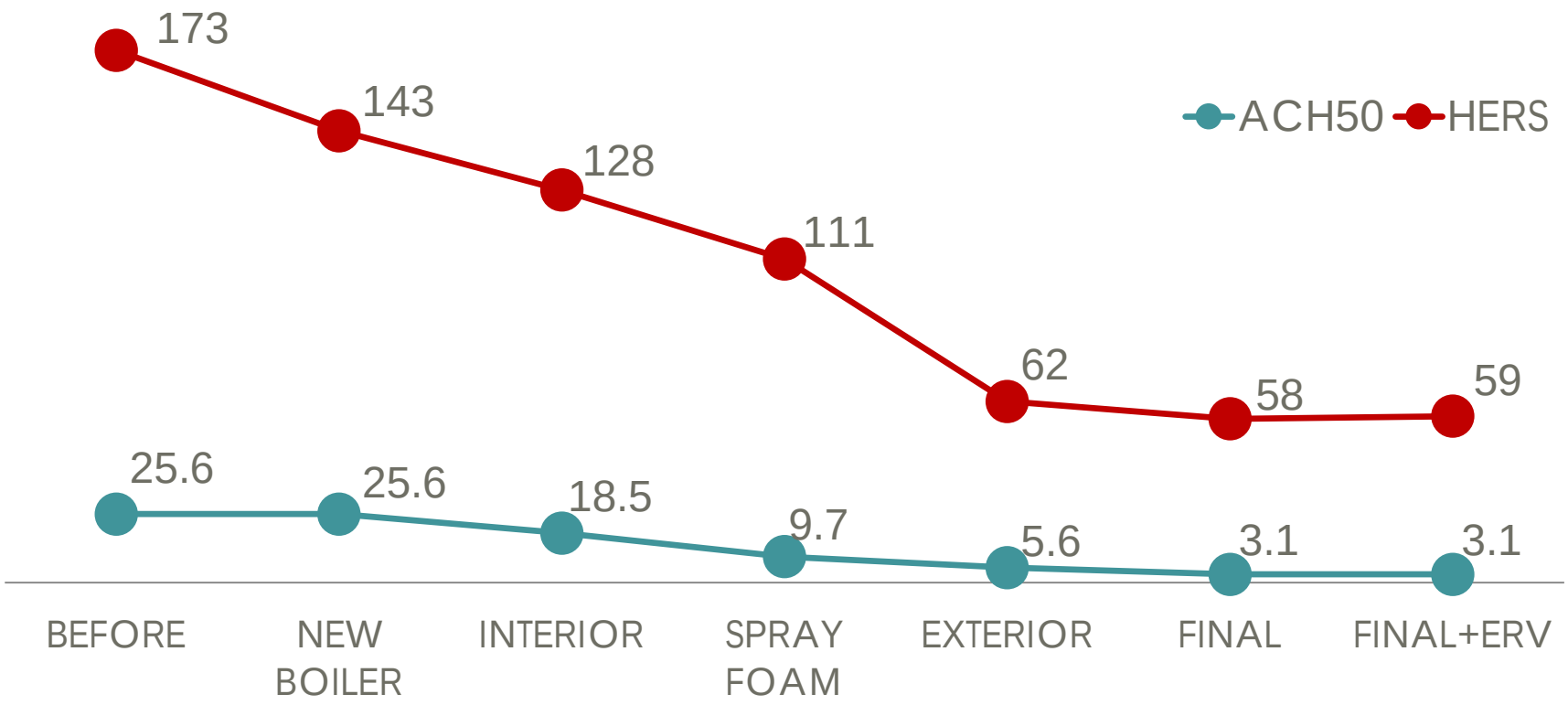
Next time, add REAL A/C!

By the Numbers

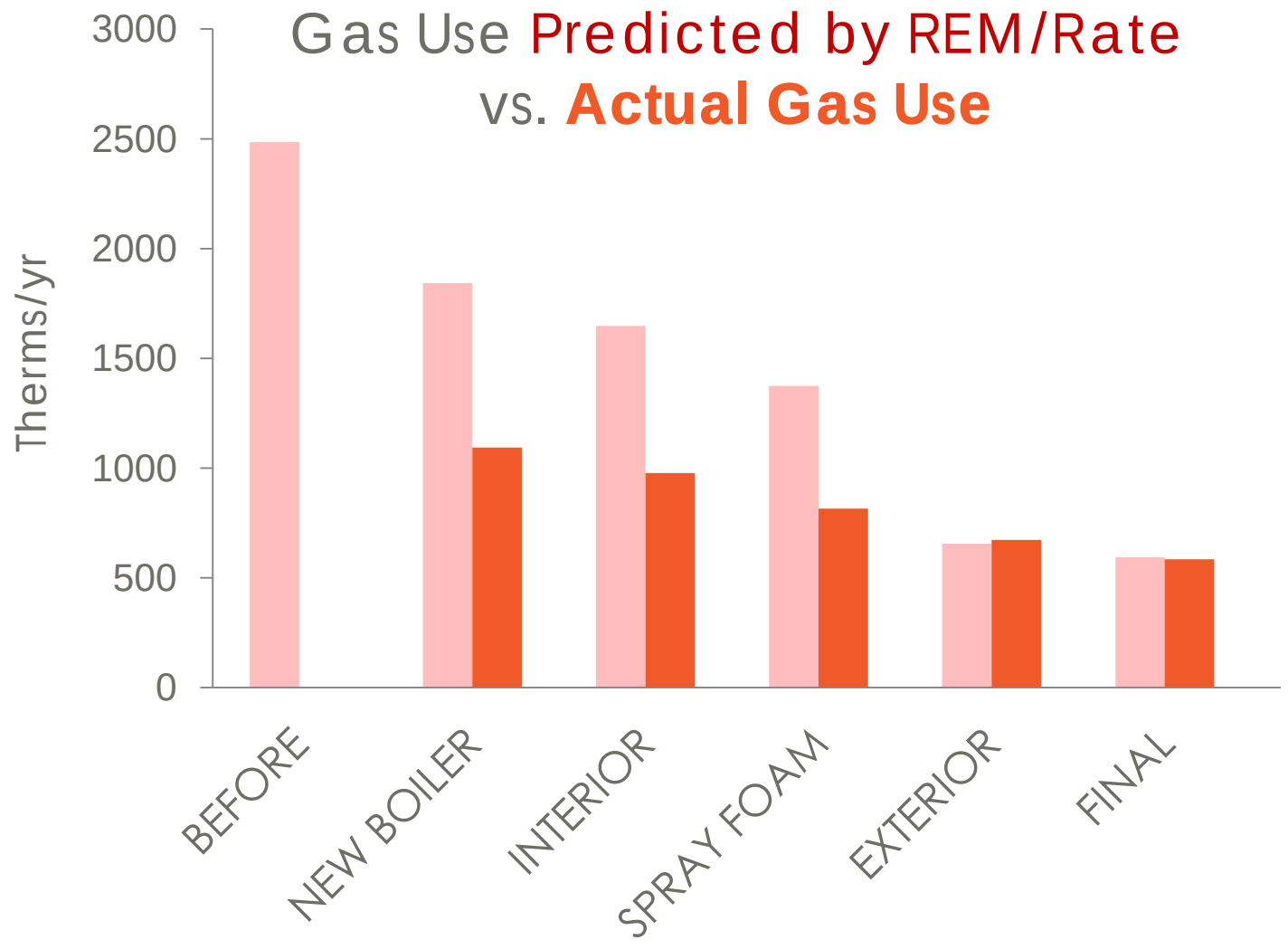
Drops in HERS Index and ACH50

HERS drops from 173 to 59

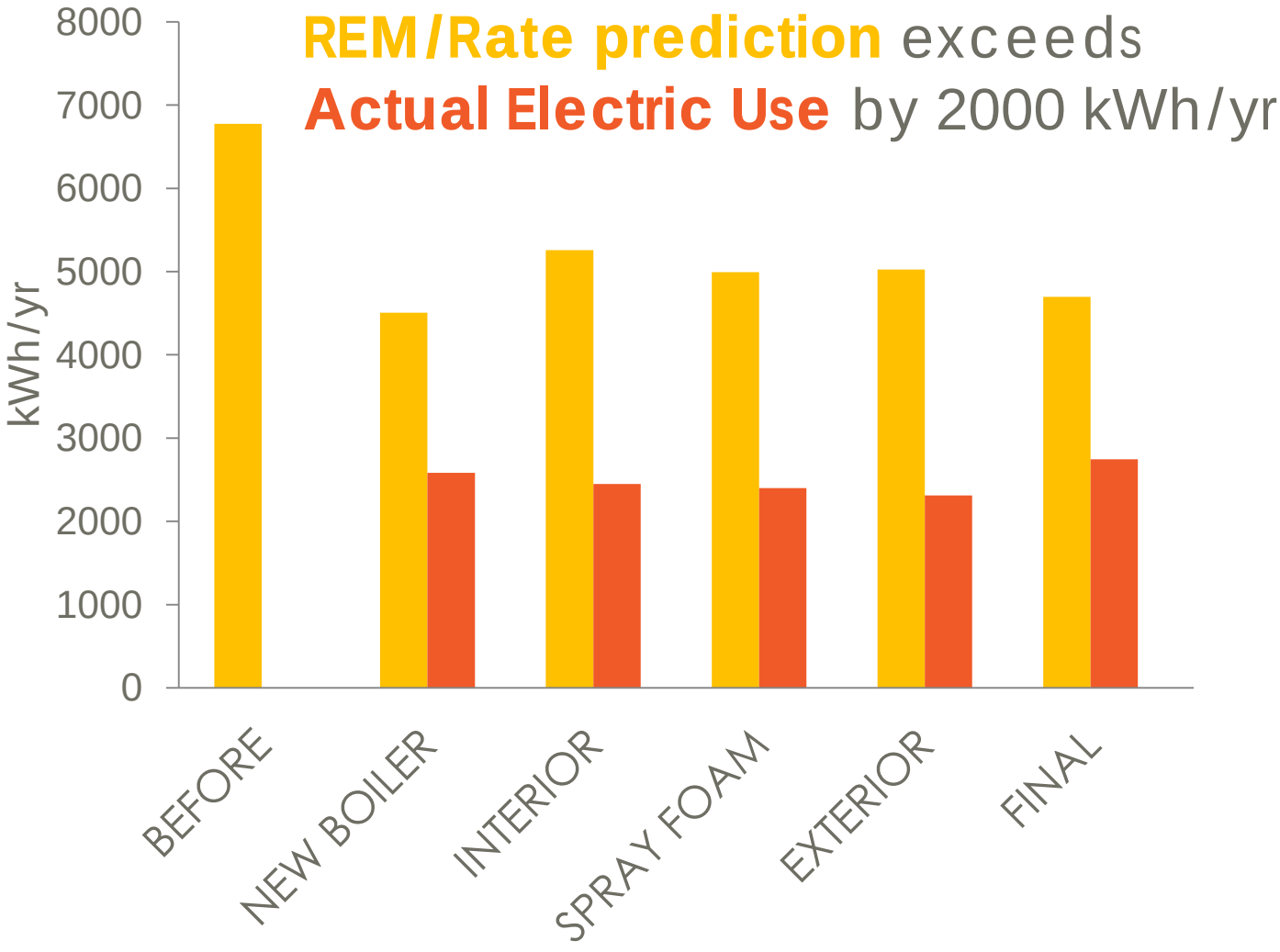
ACH50 drops from 25.6 to 3.1



Gas Use: now close to 600 Therms/yr



Electric Use: Predicted exceeds Actual



Utility Costs - Benchmark

Current Water: $160 /year

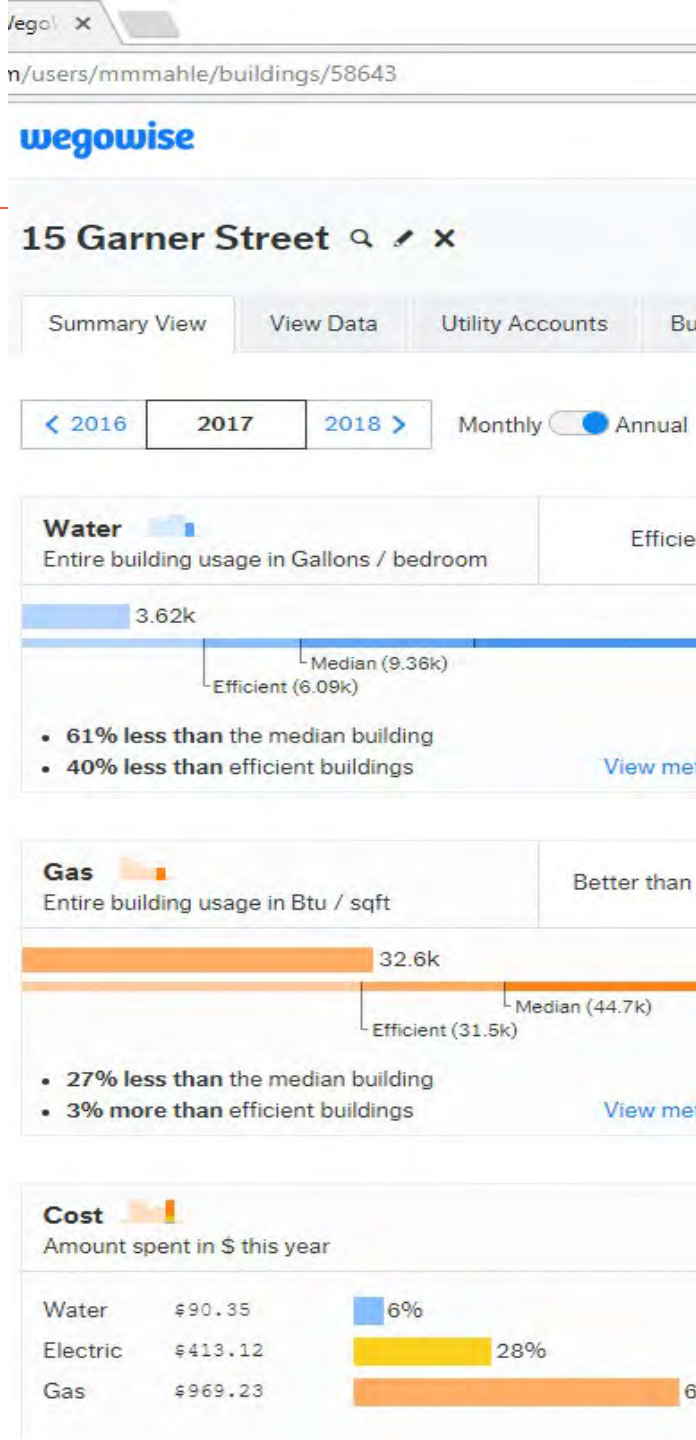
- $59/month after landscaping
- $37 / quarter winter/shoulder

Current Electric: $660 /year

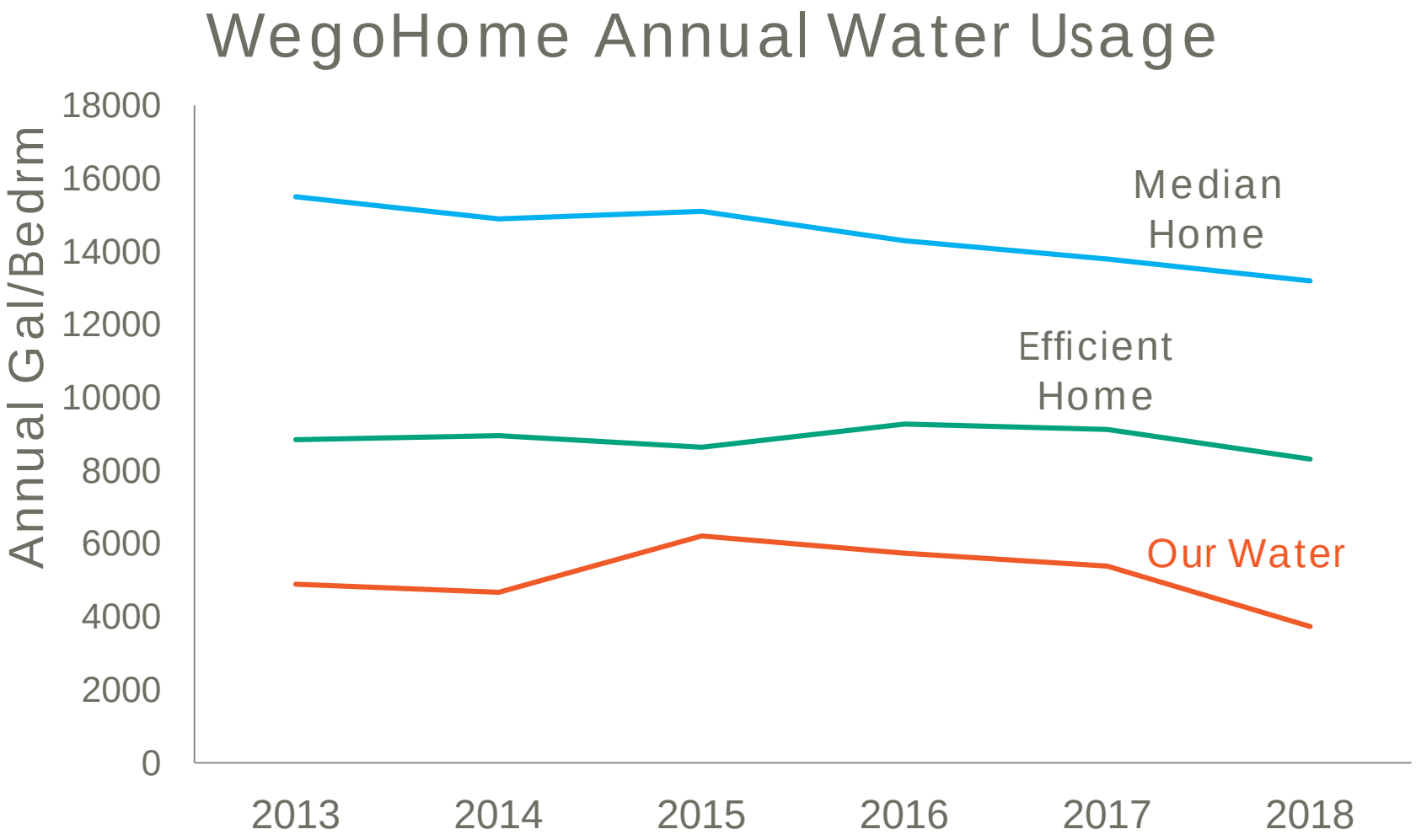
- 2013: $514/year
- $58 summer month
- $34 shoulder month

Current Gas: $975 /year

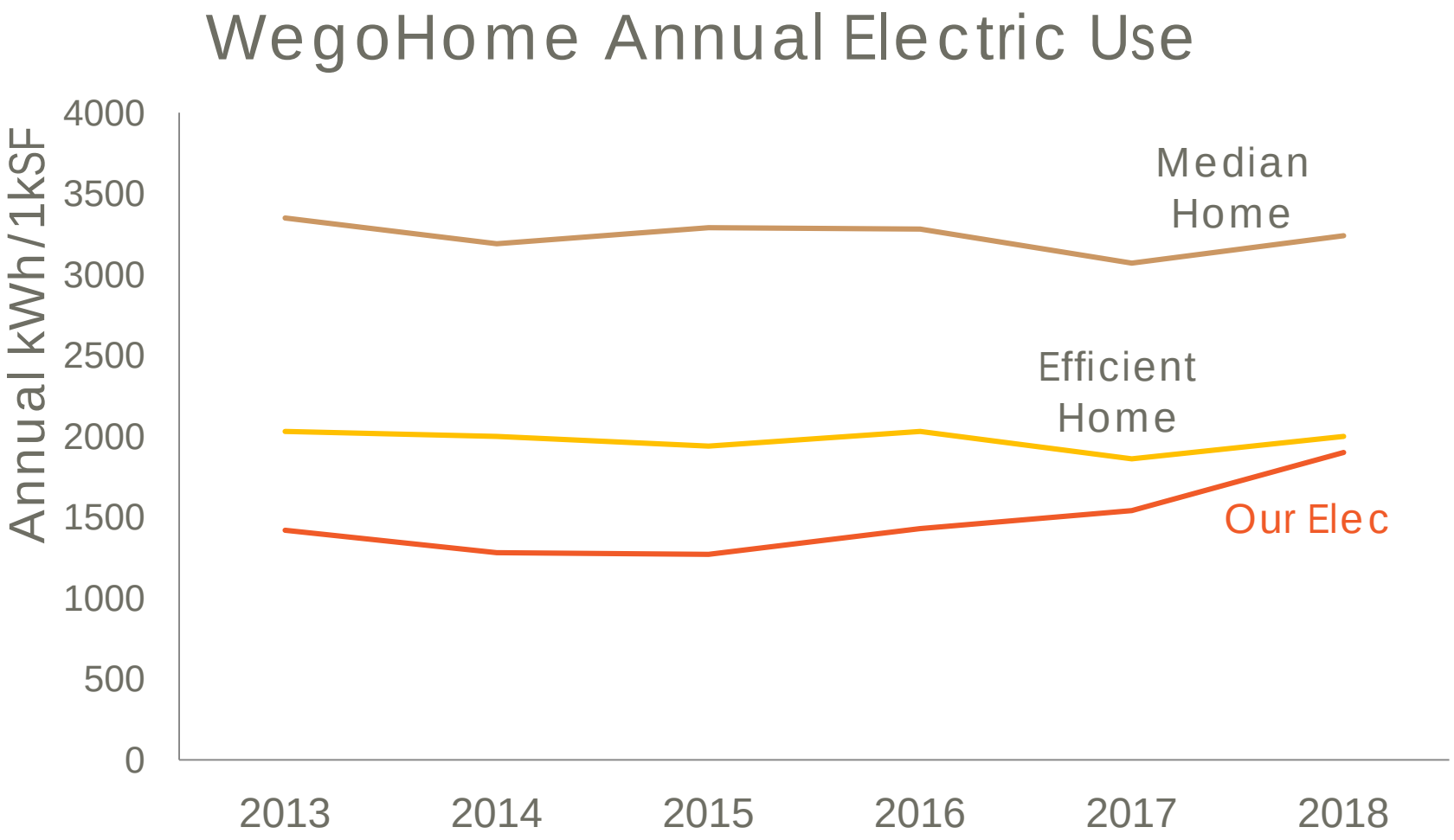
- 2013: $1525/year
- Was $280 winter high, now $180
- Was $30 summer, now $22



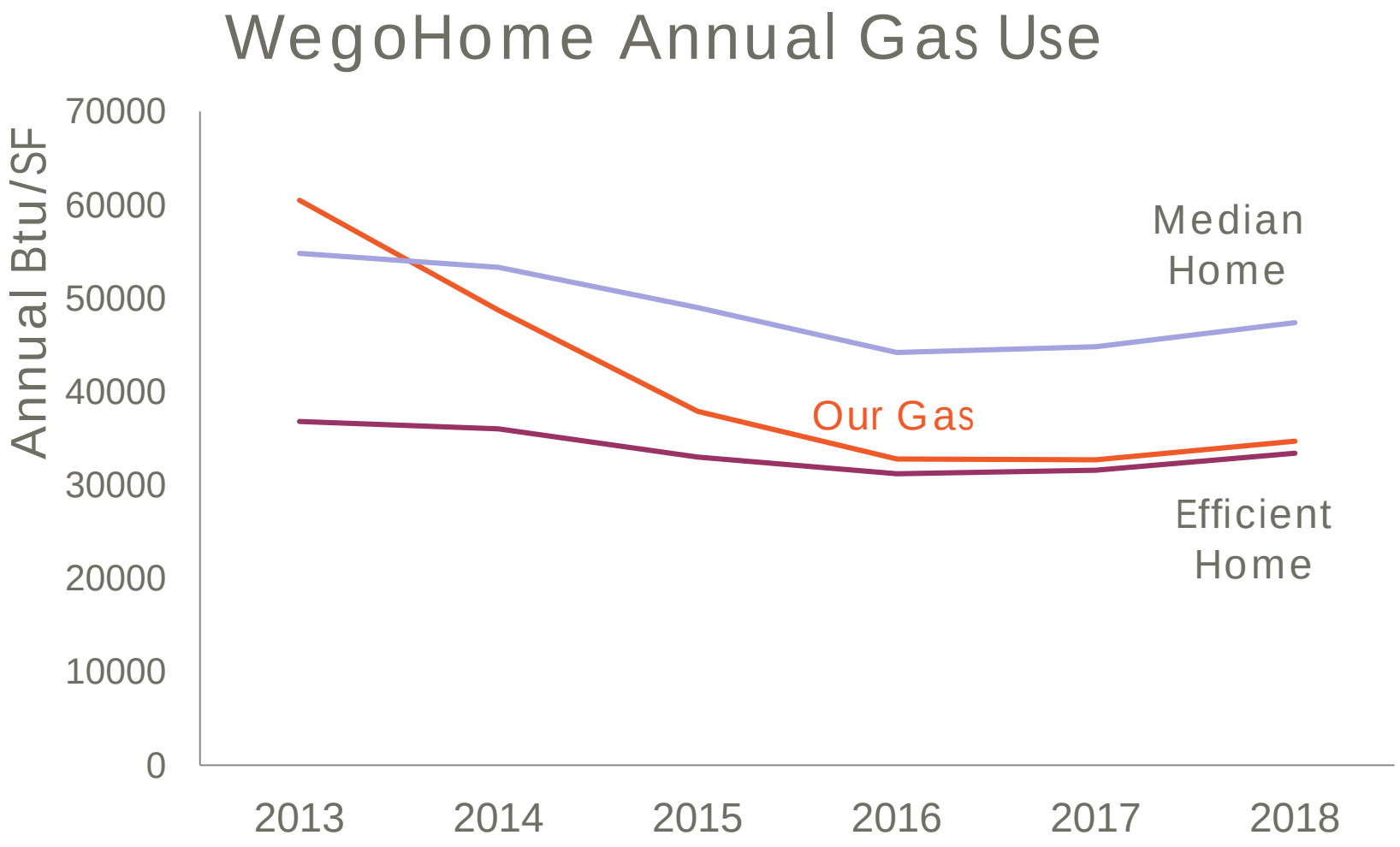
Water Use: 40% better than “Efficient”



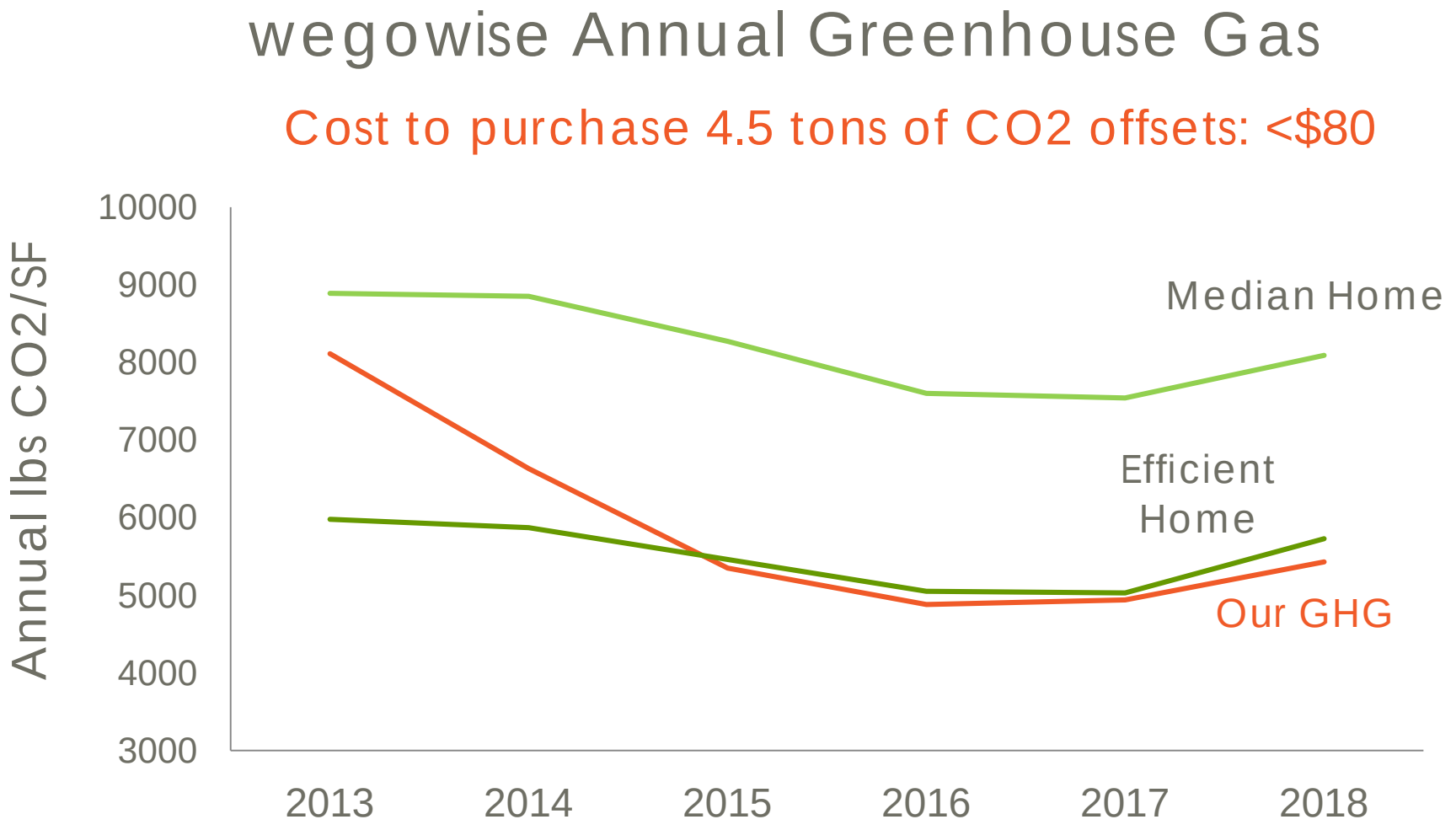
Electric Use: 20% better than “Efficient”



Gas Use: 2% worse than “Efficient”



Greenhouse Gas: 2% better than Efficient




STOP
THE TRANSFER STATION WILL NO LONGER ACCEPT
TOYOTA
TACOMA

Takeaways

My top 3 regrets

#1 Not managing combustion pollution well

#2 Not managing outside contaminants well, including ERV controls, filtration, and radon mitigation

#3 Not introducing higher levels of whole-house ventilation from the beginning

New health impact data should be changing the way you design and build

- Double fresh air for better cognitive function #THECOGFXSTUDY
- Avoid new chemicals of concern (e.g. phthalates)
- Stronger filtration (4" MERV 13)
- Dehumidification
- Circadian lighting (for better sleep)
- Design for active occupants
- Radon no more than 1-2 pCi/L
- FIX KITCHEN EXHAUST! Quieter, wider, deeper, lower, & with makeup

LEED Favors Rehabs

V4 recognizes the total environmental benefits of a rehab, even with modest energy savings.

To be replicable, be affordable

We met our goal to stay within the ‘market price’ of our home (free labor helps).

Recently appraised at $460,000.

Next step: rent this home out, do it again!

The next one!

$219,000 purchase... $250,000 reno budget

all-electric, near zero, & LEED-H Platinum

There is no silver bullet, but there are thoughtful decisions

Look for the option that meets the largest quantity of your objectives. Use multi-attribute analysis.

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!


Before...


... and after!

Thank you!
Any questions?

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