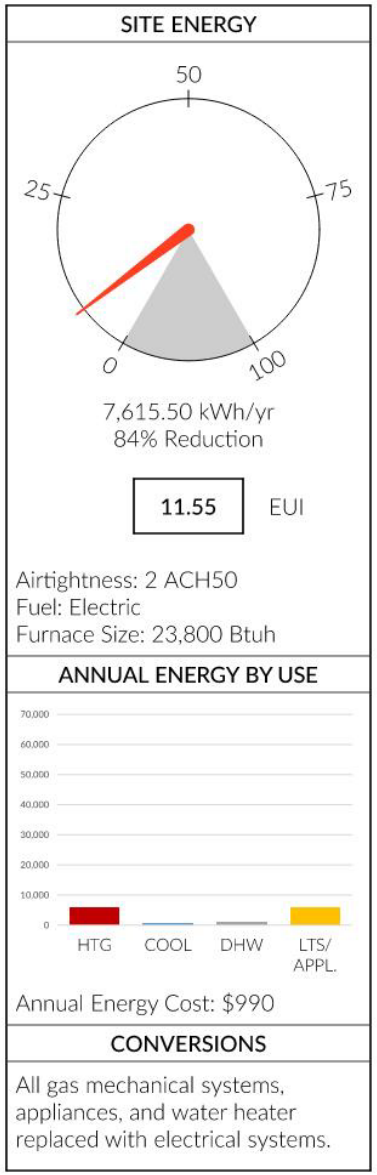
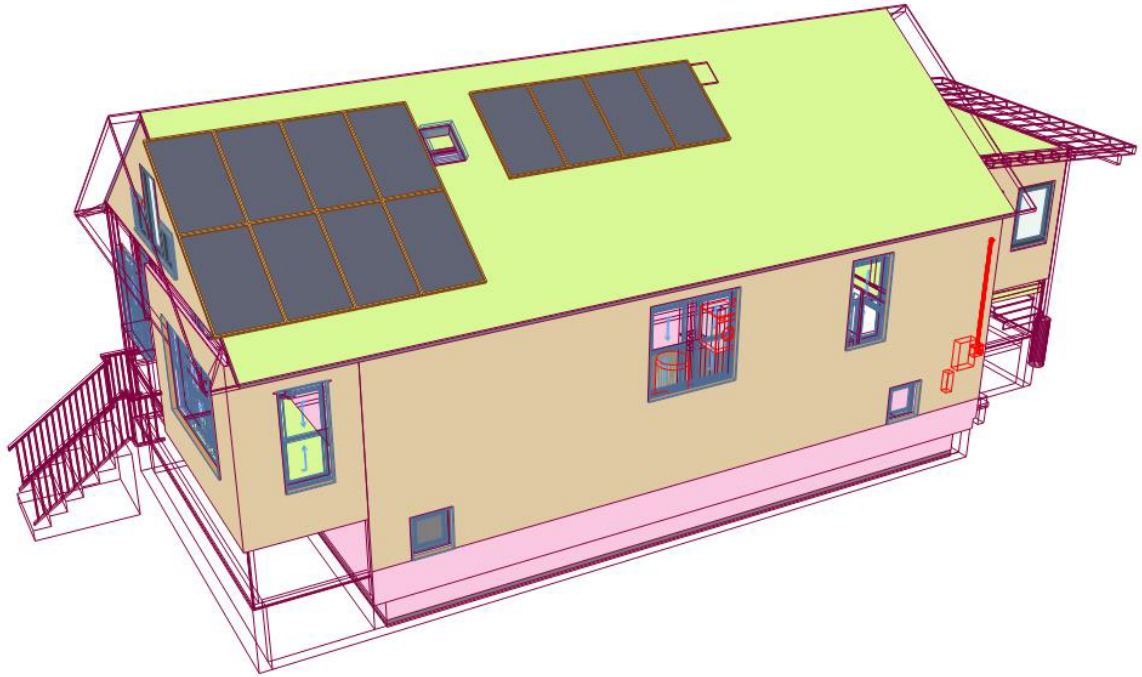
Residential Retrofits
Phius Retrofit Summit

Tom Bassett-Dilley, AIA CPHC

President, TBDA, Ltd.





TBDA TOM BASSETT-DILLEY ARCHITECTS









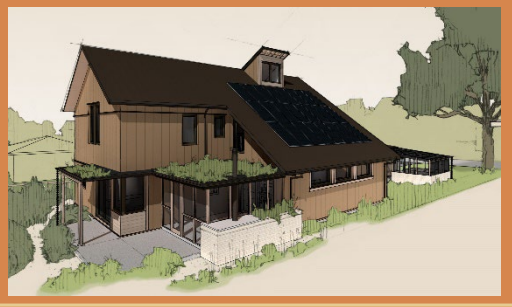










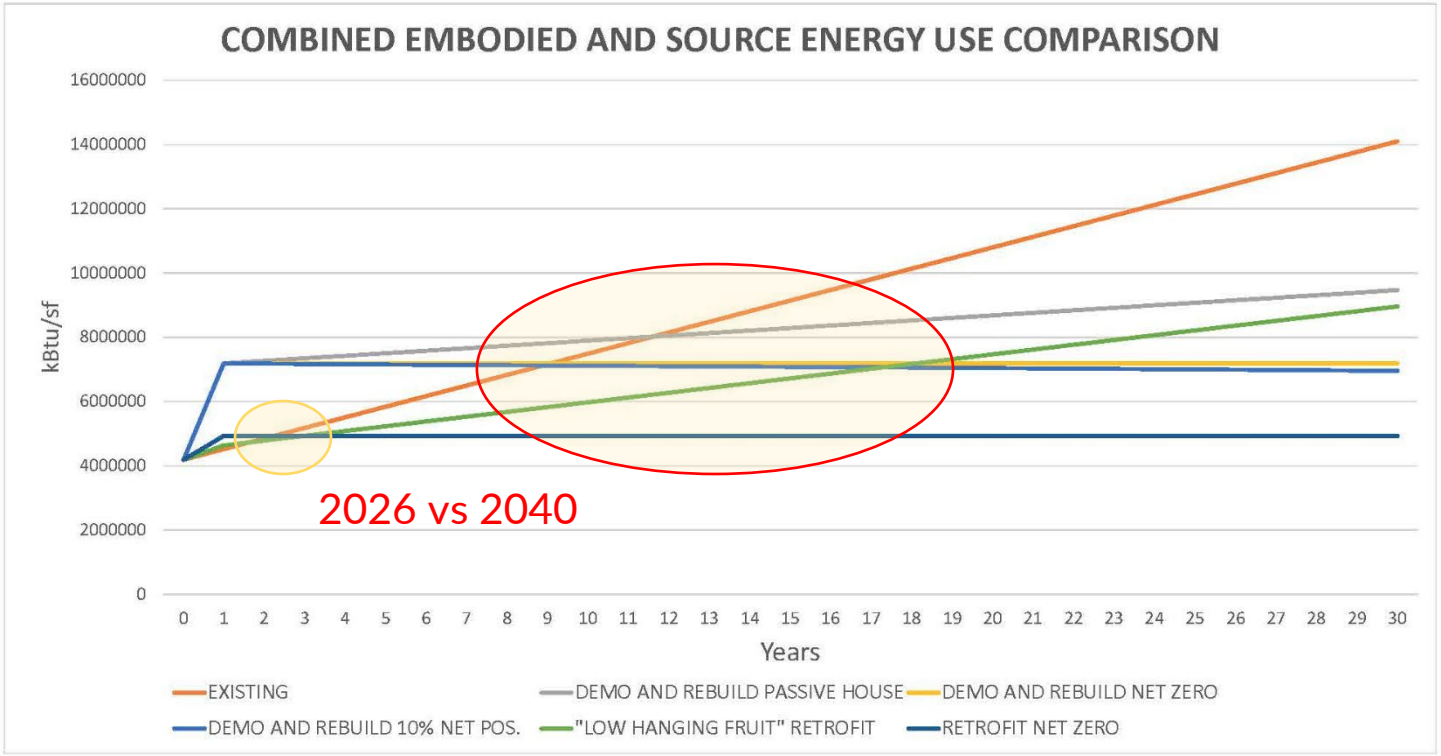


TBDA TOM BASSETT-DILLEY ARCHITECTS

Most TBDA Phius/Zero Energy/Capable Projects*, 2011-current (*excluding ~10 in-progress, mostly retrofits)

Retrofits vs New Construction: Embodied Carbon is important

Good retrofits, especially in cold climates, are the answer for carbon reduction, short- and long-term.



Retrofit big-picture stuff

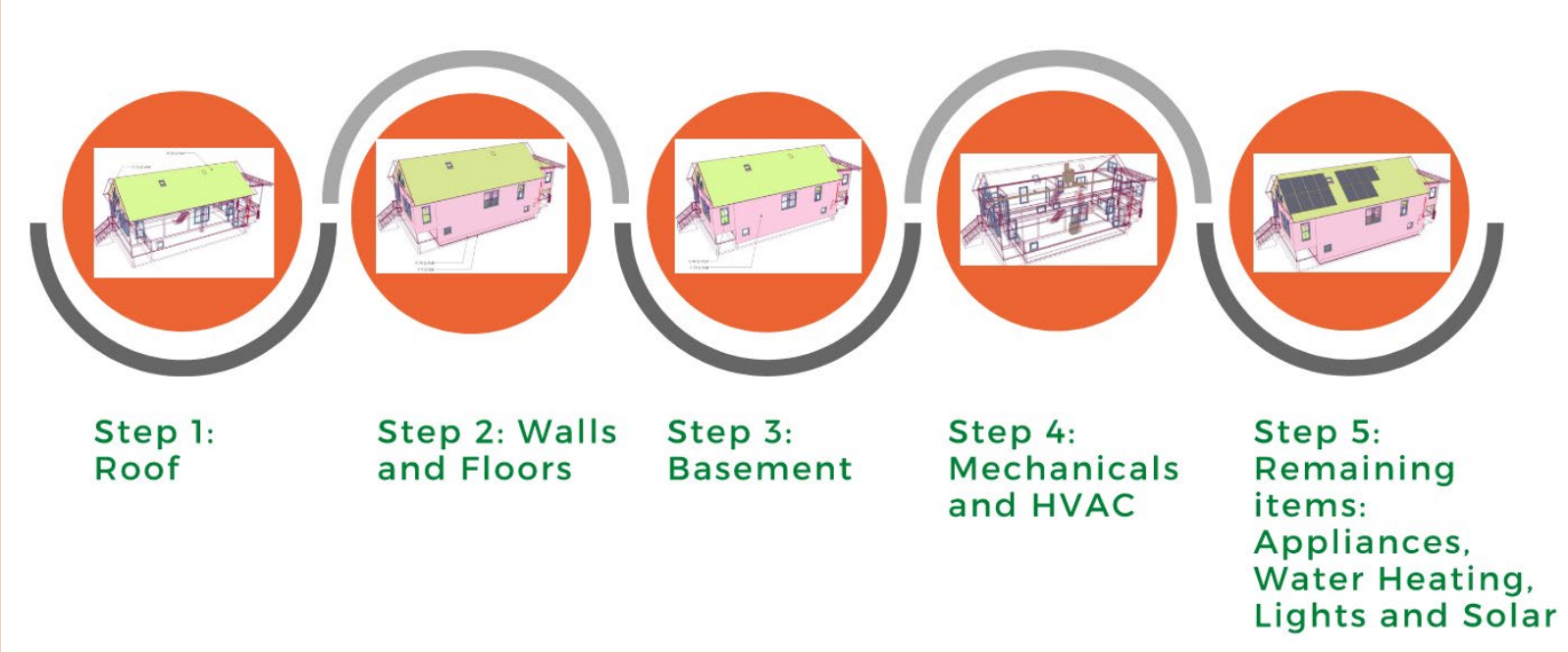
Ideal project flow

Limiting Factors

- People living there
- Historic preservation
- Cost

Enabling Factors

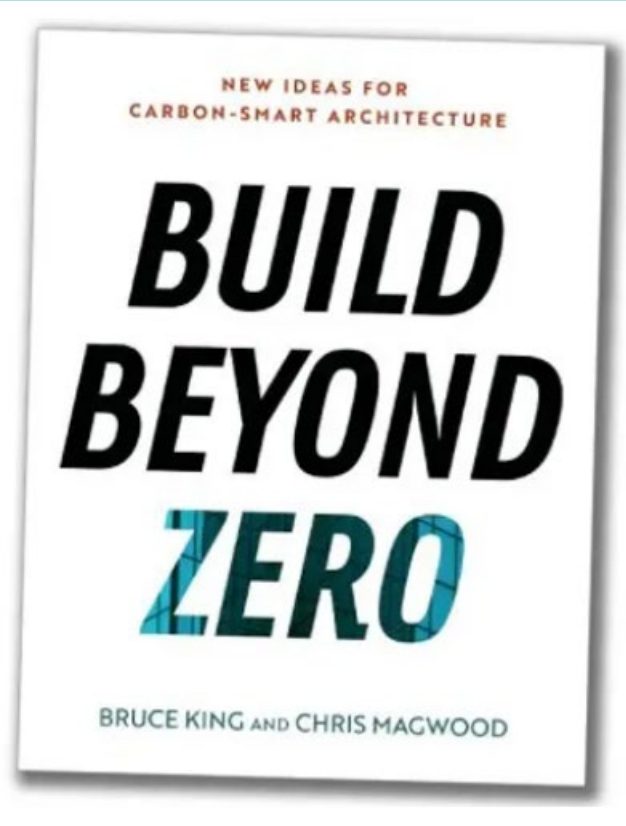
- End of service life: surfaces, equipment
- Change of ownership
- Incentives (tax, rebate etc.)
- Desire for a good building (by contemporary standards)



Retrofit big-picture stuff

That Embodied thing again

From GBA, Martin Holladay review of “Build Beyond Zero” 3/3/2023:
“For the solutions suggested by King and Magwood to be effective, they need to be implemented right now. Unfortunately, most of the materials discussed by King and Magwood either haven’t been developed yet or are not yet being mass produced.”



Five DER projects…

FLlWright Balch House, 1909

Chicago Bungalow, early 1900's

Early 1900's Chicago 2-flat

- 2 clients: NZE request
- 2 clients: gut reno
- Me: mostly exterior; Phius would be great, but Phius Source Energy sufficient

c.2000 Suburban

1919 frame Bungalow

TBDA

Goals:

- Insulate for energy savings and resilience
- Airtighten for durability and health
- Decarbonize (HVAC, DHW, appliances) for all-electric
- Plan for/incorporate solar PV
- Shoot for Phius Source Energy limit at worst

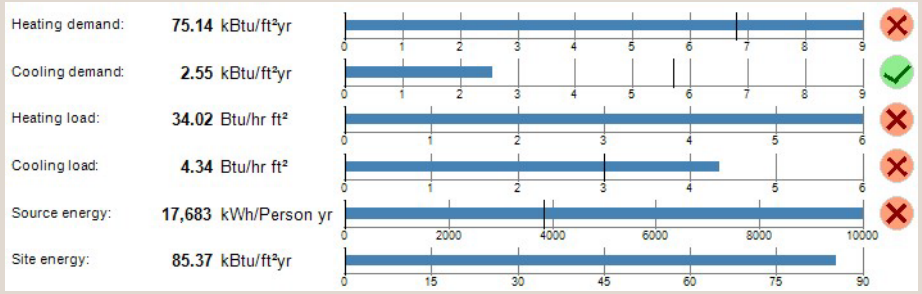
...in other words, employ a Passive approach to the retrofit, and make these houses relevant for the next generation.

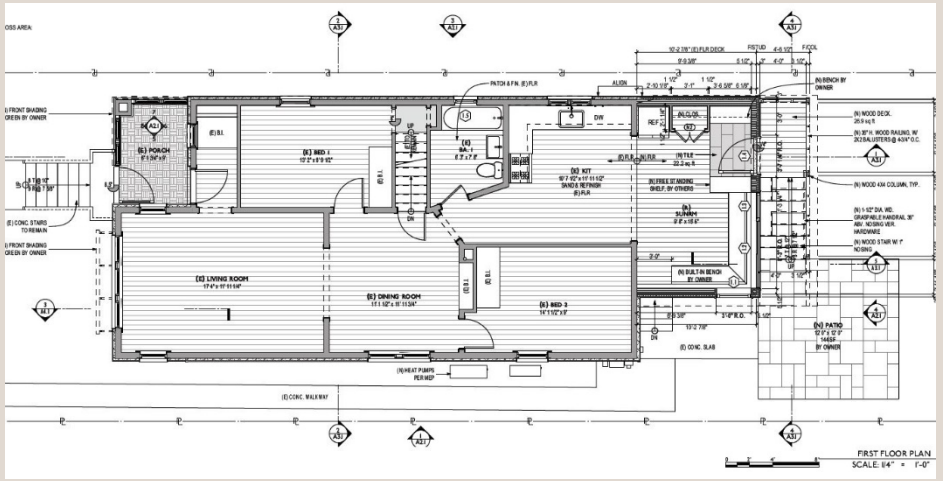
In these projects we reduced overall energy use by 70-100% from where we found it

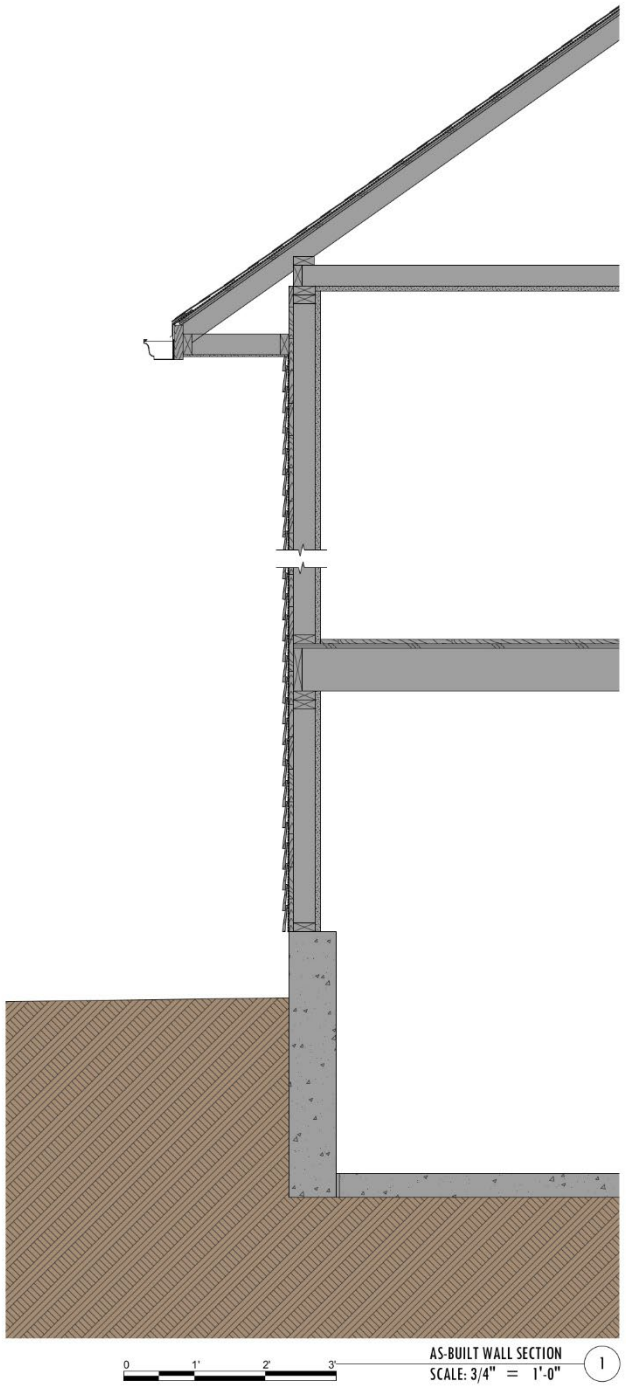
1919 frame Bungalow

1919 frame bungalow Before

- Virtually no insulation anywhere
- About 10ACH50
- Old gas furnace and water heater
- Only ventilation is a kitchen hood
- Exterior in disrepair—good candidate for exterior retrofit
- Windows had previously been replaced with double glazed, still in decent shape



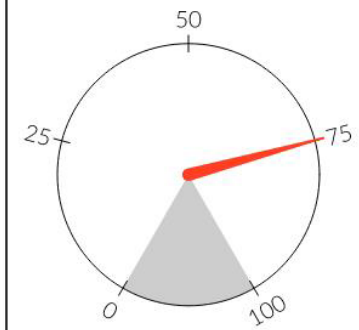




Retrofit: using energy modeling

Typical starting point on old houses: a diagram of energy flow

SITE ENERGY

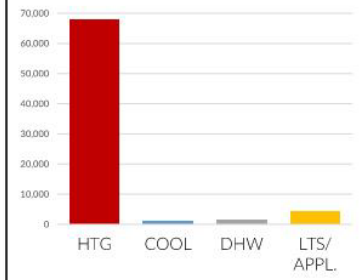


74,924.12 kWh/yr
0% Reduction

113.62 EUI

Airtightness: 10 ACH50
Fuel: Gas + Electric
Furnace Size: 100,700 Btuh

ANNUAL ENERGY BY USE

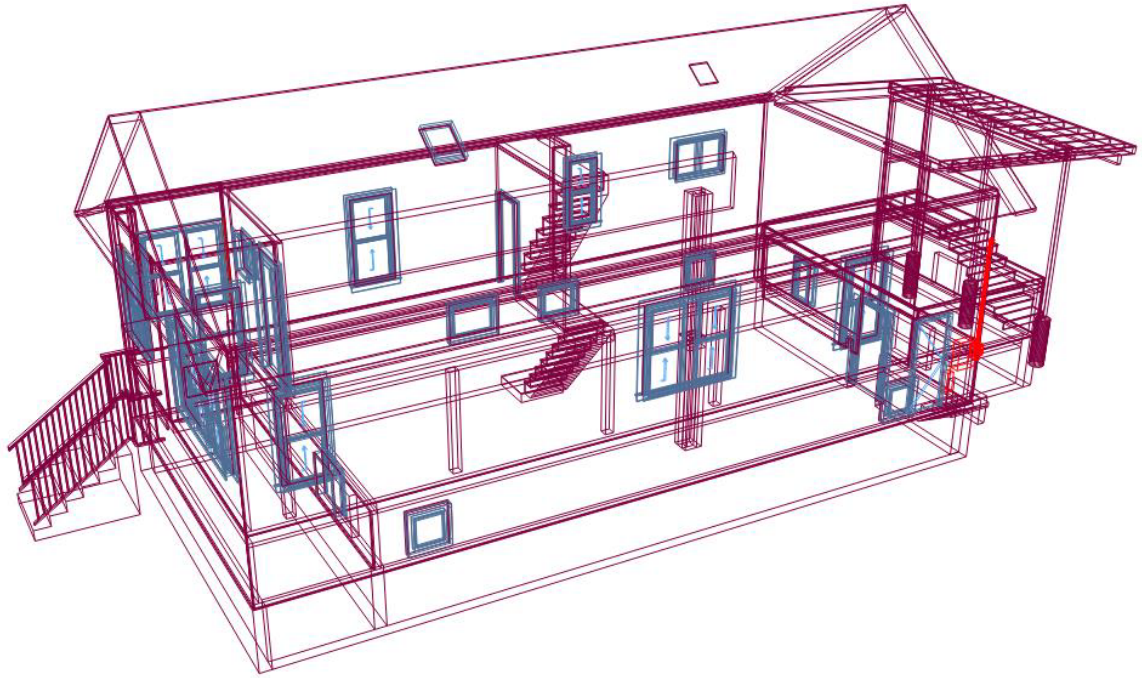


Annual Energy Cost: $1,650

CONVERSIONS

kWh/yr uses kWh equivalent for gas use (1 Therm = 29.3 kWh)

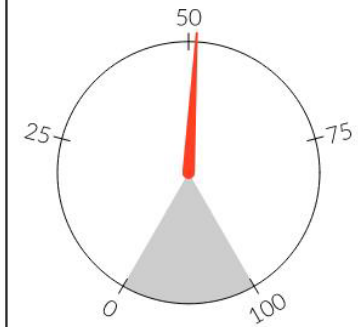
UNINSULATED EXISTING



WUFI-Passive modeling

Spray foamed the roof in 2014 when I knew very little about anything

SITE ENERGY

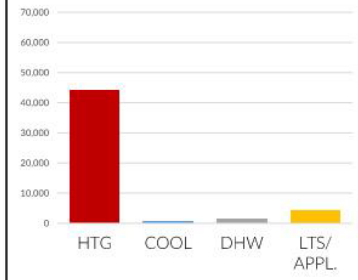


51,115.97 kWh/yr
30% Reduction

77.51 EUI

Airtightness: 6 ACH50
Fuel: Gas + Electric
Furnace Size: 65,800 Btuh

ANNUAL ENERGY BY USE

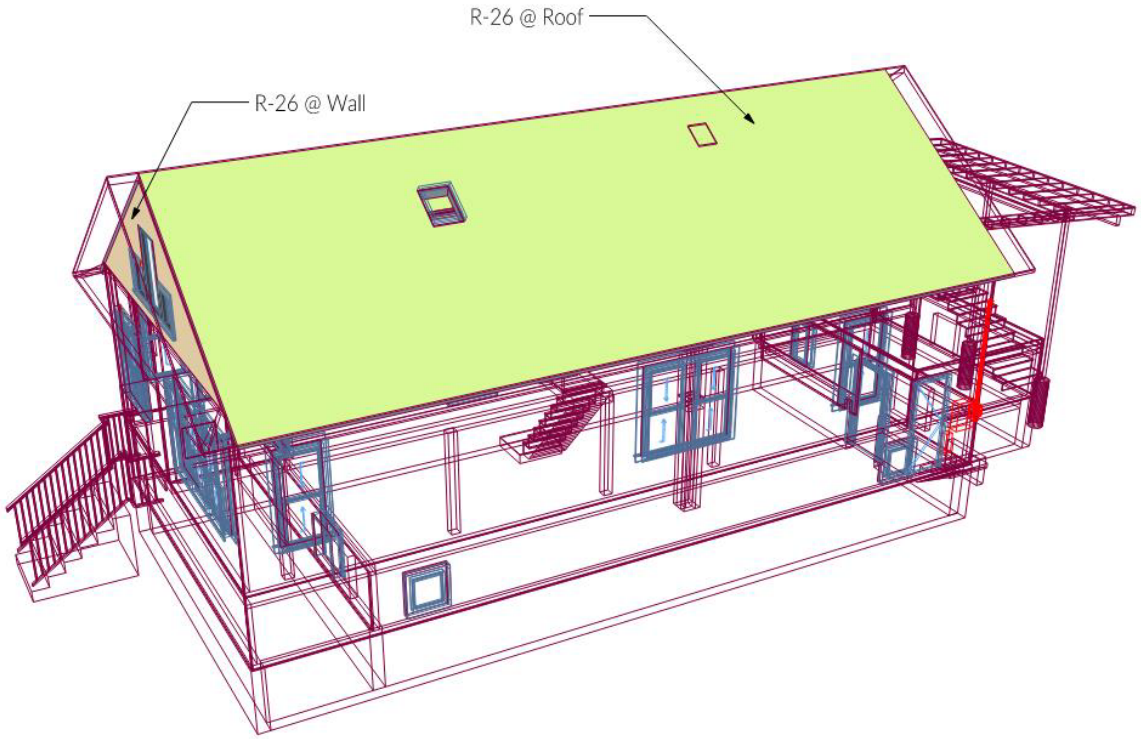


Annual Energy Cost: $1,390

CONVERSIONS

kWh/yr uses kWh equivalent for gas use (1 Therm = 29.3 kWh)

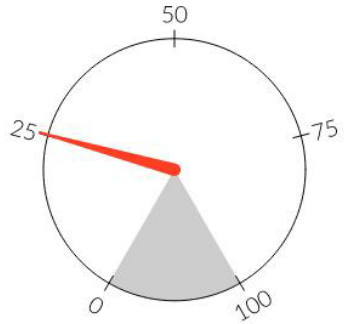
INSULATE ROOF



WUFI-Passive modeling

The biggest opportunity here is to **air seal** the majority of the perimeter. Cellulose goes in the walls from outside, and continuous wood fiberboard exterior insulation (Steico) gets rainscreen and new siding.

SITE ENERGY

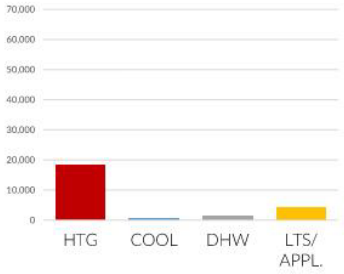


25,139.97 kWh/yr
64% Reduction

38.12 EUI

Airtightness: 2 ACH50
Fuel: Gas + Electric
Furnace Size: 26,300 Btuh

ANNUAL ENERGY BY USE



Annual Energy Cost: $1,140

CONVERSIONS

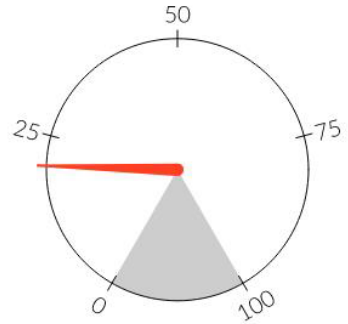
kWh/yr uses kWh equivalent for gas use (1 Therm = 29.3 kWh)

INSULATE WALLS & FLOORS

WUFI-Passive modeling

Basement slab isn't a huge energy bonus, but I needed to fix the cracked, wet, uninsulated mud slab. I get usable, comfortable space now.

SITE ENERGY

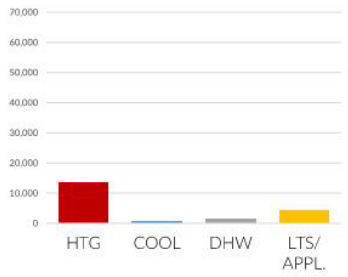


20,556.11 kWh/yr
69% Reduction

31.17 EUI

Airtightness: 2 ACH50
Fuel: Gas + Electric
Furnace Size: 22,600 Btuh

ANNUAL ENERGY BY USE

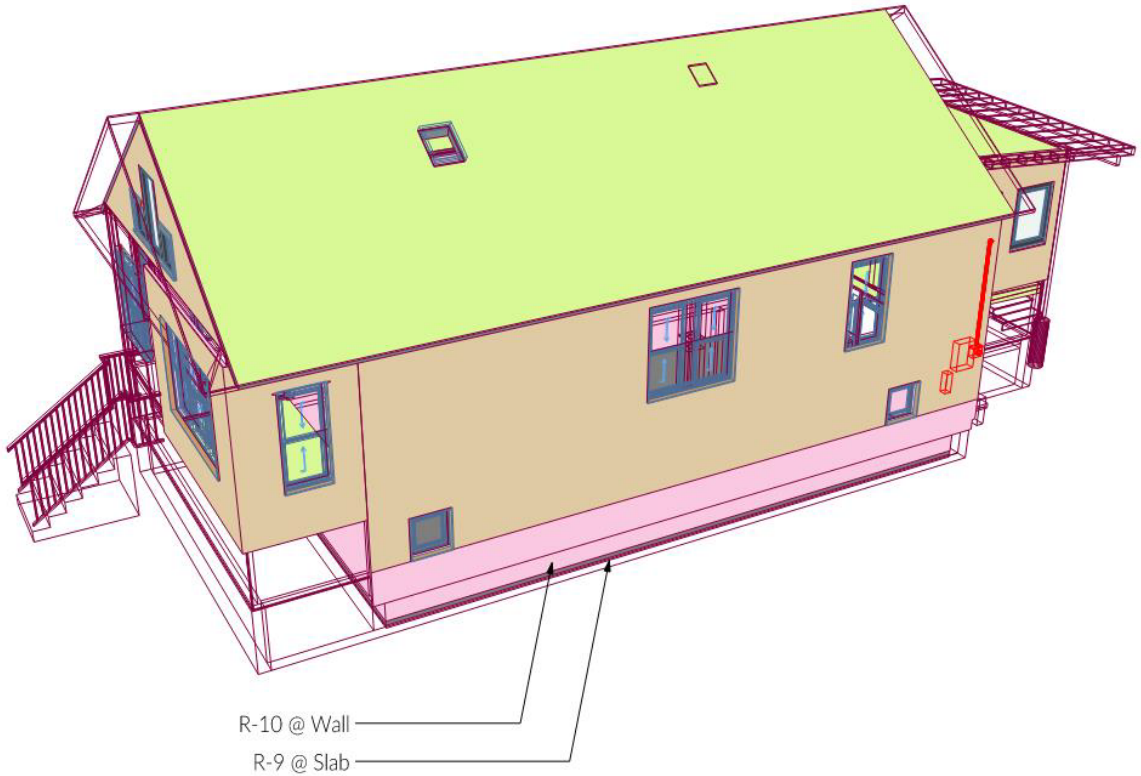


Annual Energy Cost: $1,120

CONVERSIONS

kWh/yr uses kWh equivalent for gas use (1 Therm = 29.3 kWh)

INSULATE BASEMENT

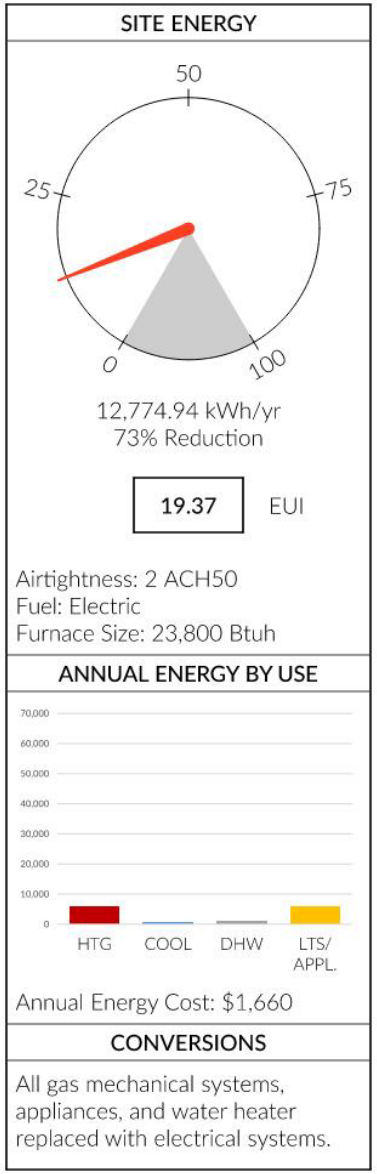


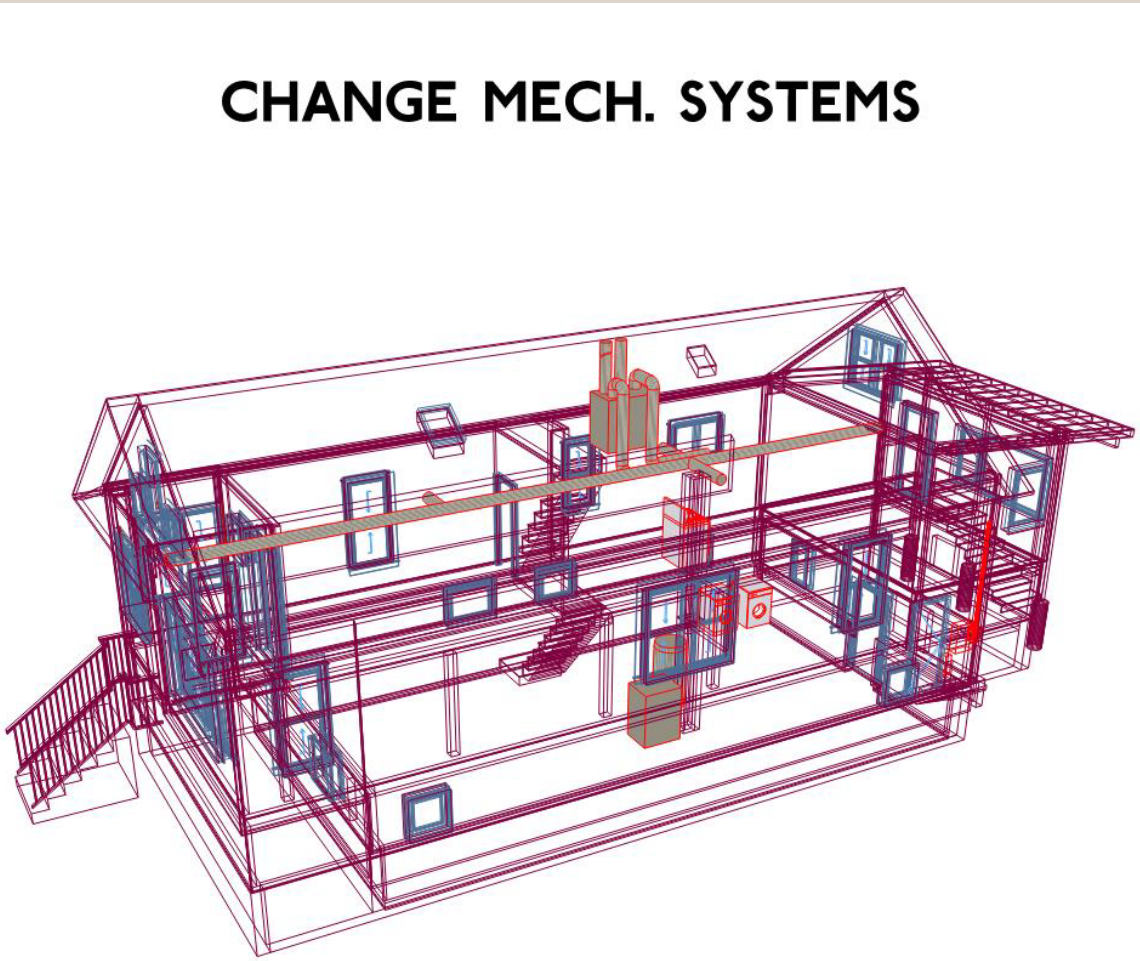
WUFI-Passive modeling

I got rid of my gas line (and the $30/month taxes and fees) and am going with heat pumps and a ventilation system (CERV).

This decreases my energy use but increases the expense since electricity is more expensive than gas….

But—with this and other appliance selections, it qualified me for ComEd's all-electric homes incentive ($2,000)



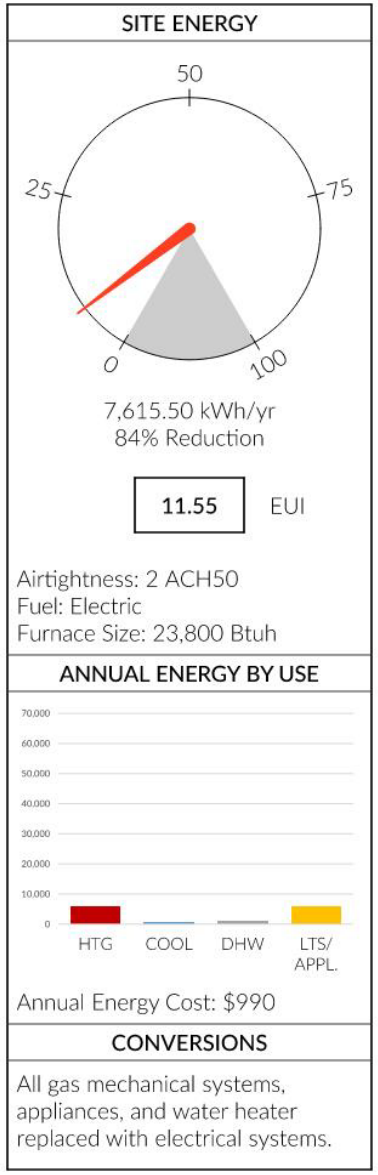


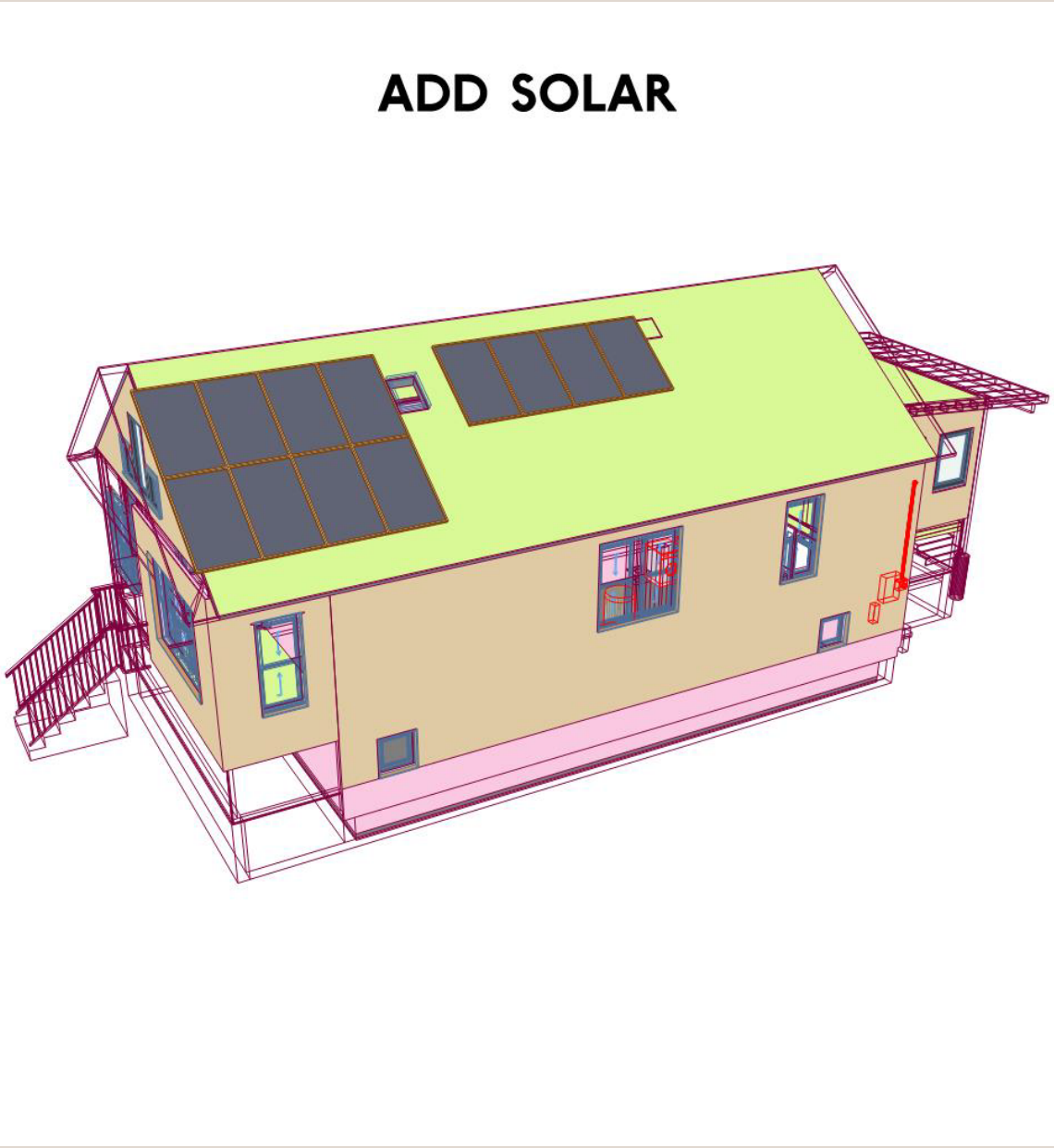
WUFI-Passive modeling

…but adding solar makes it less expensive, and I can add more solar to get closer to zero.

While this isn't net zero, my goal was to meet the Phius Source Energy Limit, which we easily do with this retrofit (7,615kWh divided by 4 people, 1,903kWh/person per year, almost half the Phius limit)

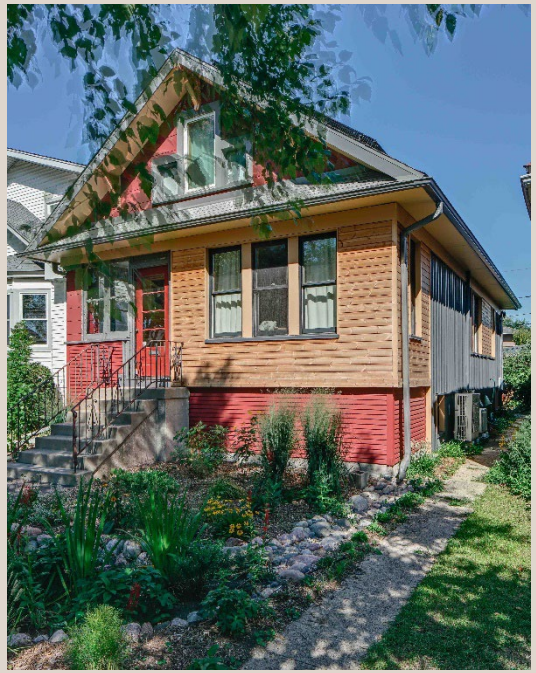
But then I went and added PV, and am now at zero (kids are out of the house, pro tip)





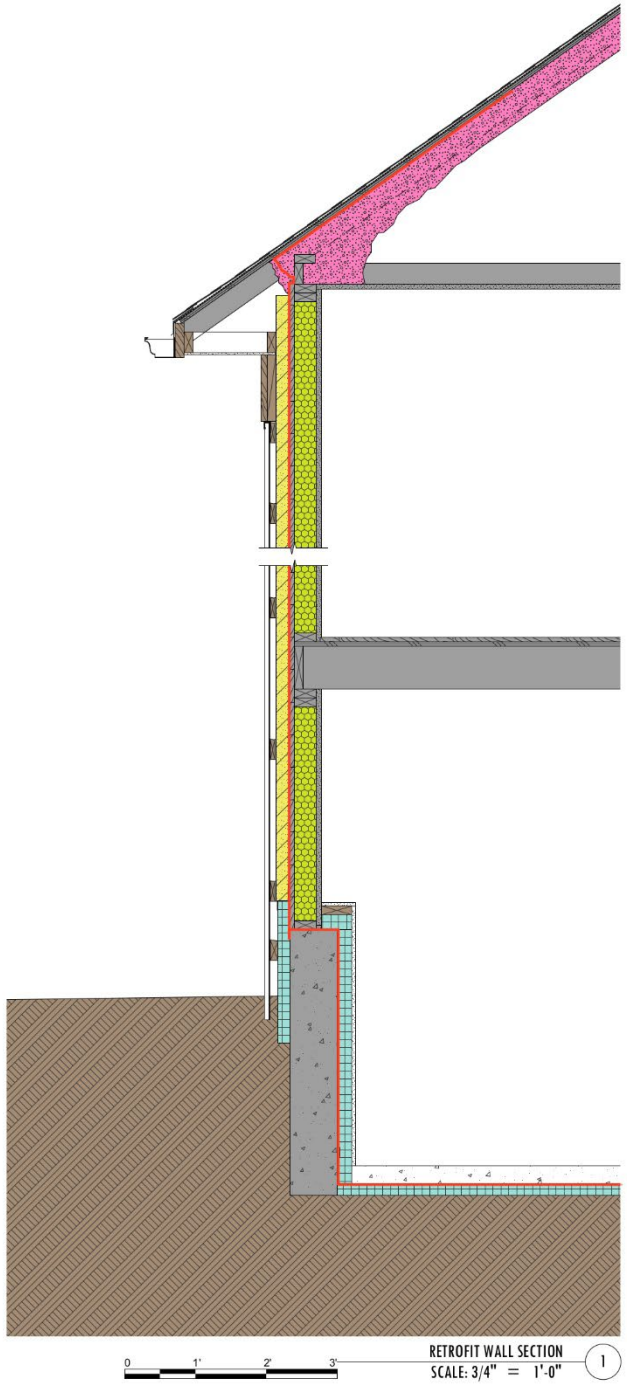
1919 frame bungalow After

- Continuous insulation
- New ACH50: 2.0
- New Heat pump H/AC and DHW
- CERV2 ventilation
- 8kW PV array, annual NZE
- New EUI: 0



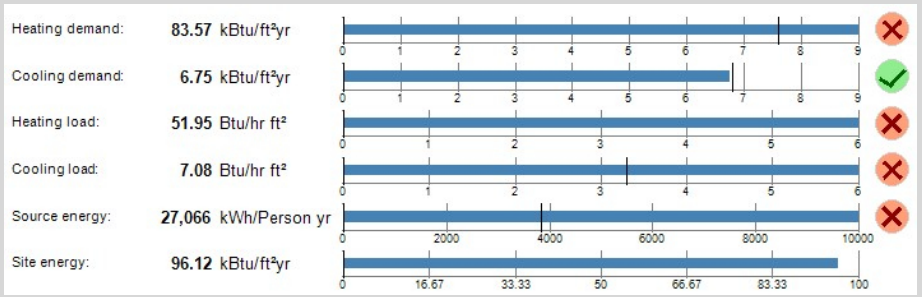
PASSIVEHOUSE REQUIREMENTS

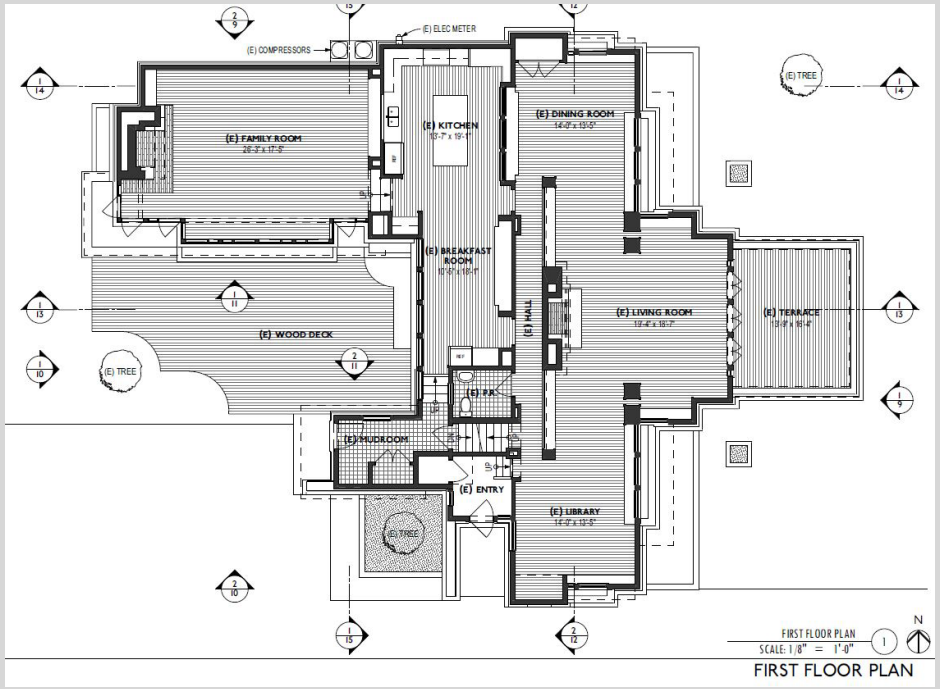
Certificate criteria:	**PHIUS+ 2018**	
Heating demand		
specific:	**19.34** kBtu/ft²yr	
target:	**7.4** kBtu/ft²yr	
total:	43,518.61 kBtu/yr	
Cooling demand		
sensible:	**1.68** kBtu/ft²yr	
latent:	**0.87** kBtu/ft²yr	
specific:	**2.55** kBtu/ft²yr	
target:	**6.4** kBtu/ft²yr	
total:	5,730.06 kBtu/yr	
Heating load		
specific:	**9.89** Btu/hr ft²	
target:	**5.7** Btu/hr ft²	
total:	22,248.35 Btu/hr	
Cooling load		
specific:	**2.16** Btu/hr ft²	
target:	**3.4** Btu/hr ft²	
total:	4,869.96 Btu/hr	

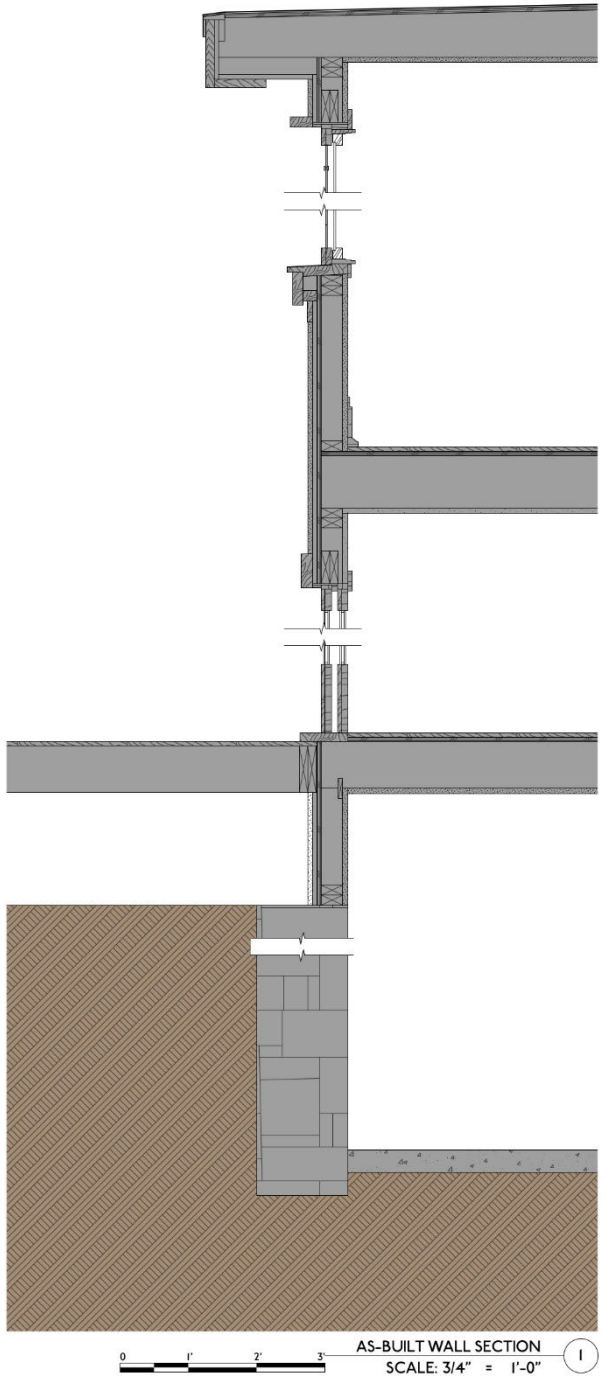


1909 FLI Wright Before

- Virtually no insulation
- About 10ACH50
- Gas boiler heat, only maintaining ~50F in -20F weather
- Space-Pak AC in roof joists
- Single glazed windows
- Rubble foundation
- Roof as air exchange mechanism





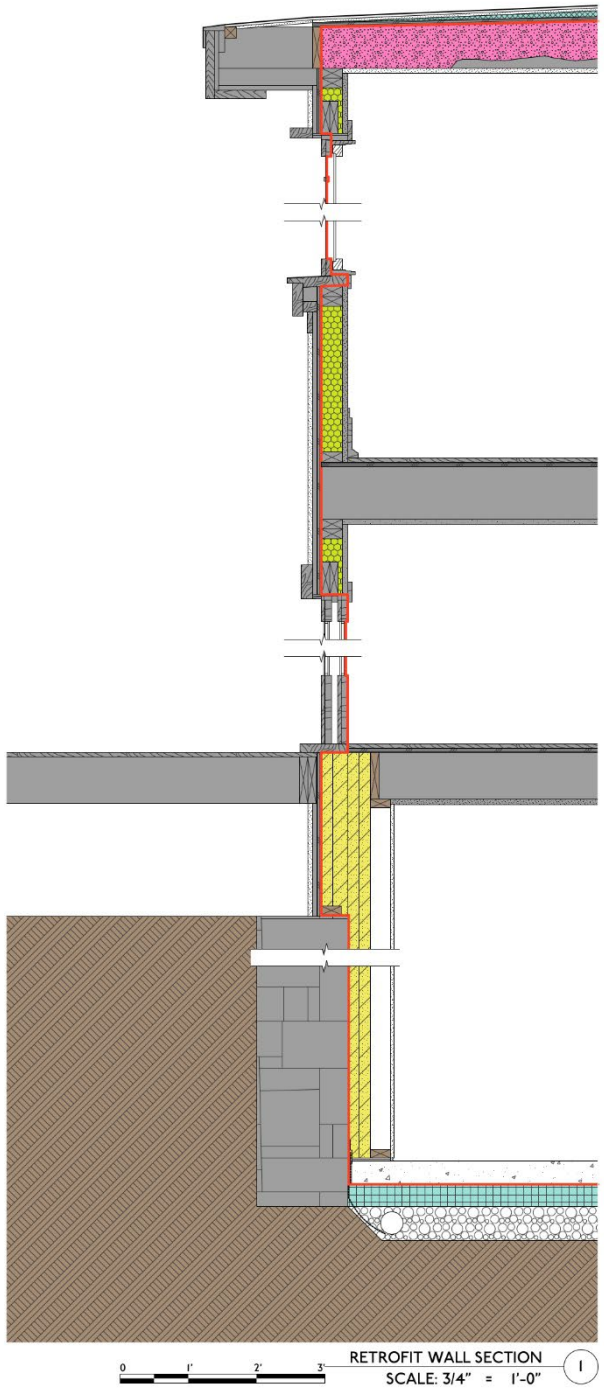


1909 FLI Wright After

- Nearly continuous insulation, but plenty of thermal bridges
- About 2ACH50?
- New Ground-Source heat pump H/AC and DHW, with heat to existing radiators and ducts
- New ERV
- Interior storm windows to preserve existing historic windows
- 18kW solar PV (on house and garage, not visible from street)
- New EUI: 1.2

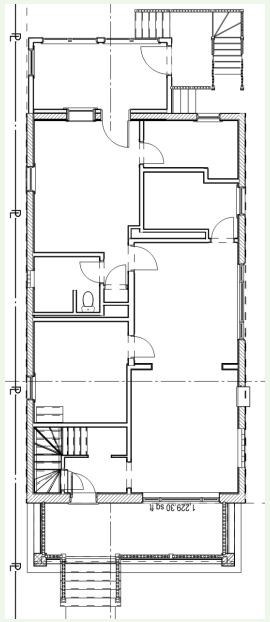
PASSIVEHOUSE REQUIREMENTS

Certificate criteria:	**PHIUS+ 2018**	
Heating demand		
specific:	**23.47** kBtu/ft²yr	
target:	**7.6** kBtu/ft²yr	
total:	124,508.31 kBtu/yr	
Cooling demand		
sensible:	**4.03** kBtu/ft²yr	
latent:	**0.9** kBtu/ft²yr	
specific:	**4.93** kBtu/ft²yr	
target:	**6.8** kBtu/ft²yr	
total:	26,137.84 kBtu/yr	
Heating load		
specific:	**14.75** Btu/hr ft²	
target:	**6.5** Btu/hr ft²	
total:	78,271 Btu/hr	
Cooling load		
specific:	**3.21** Btu/hr ft²	
target:	**3.3** Btu/hr ft²	
total:	17,008.09 Btu/hr	



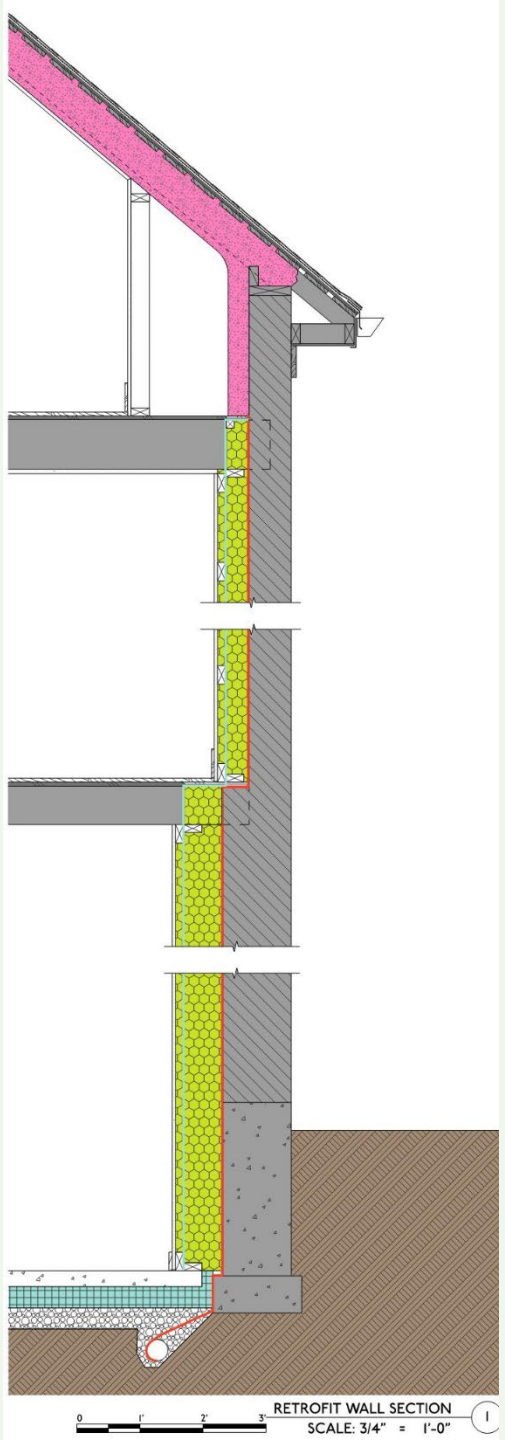
Chicago Bungalow

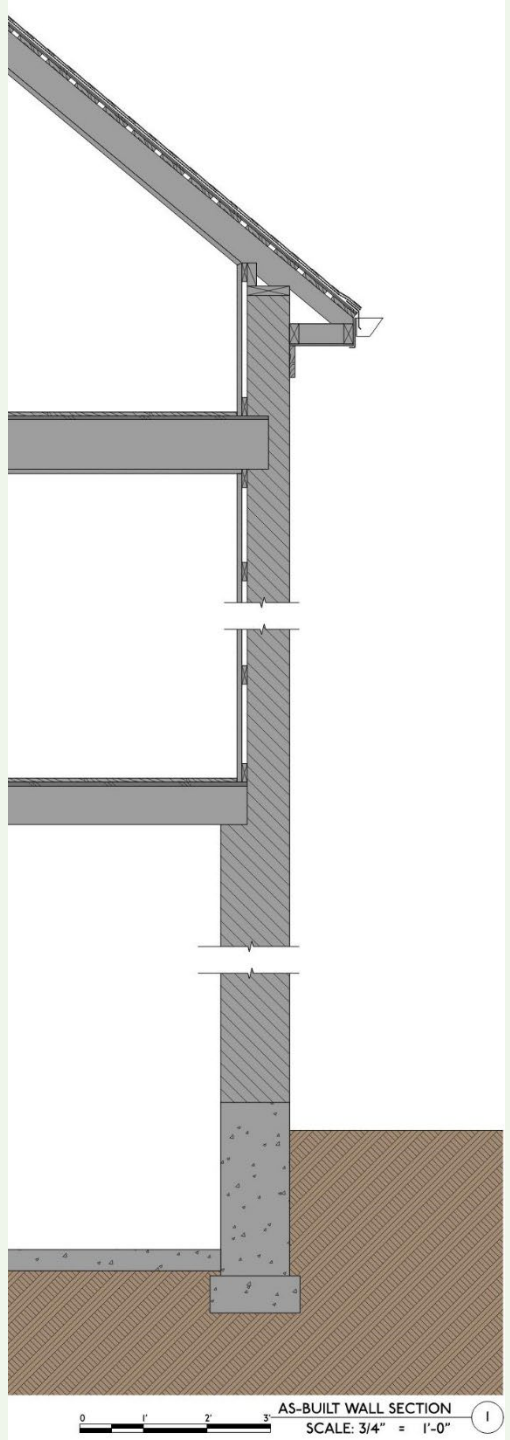
- New continuous insulation: Visconn, cellulose, Intello
- ASHP H/AC, HPWH
- New ERV
- New triple-pane windows
- New EUI: 12, w/o PV



PASSIVEHOUSE REQUIREMENTS

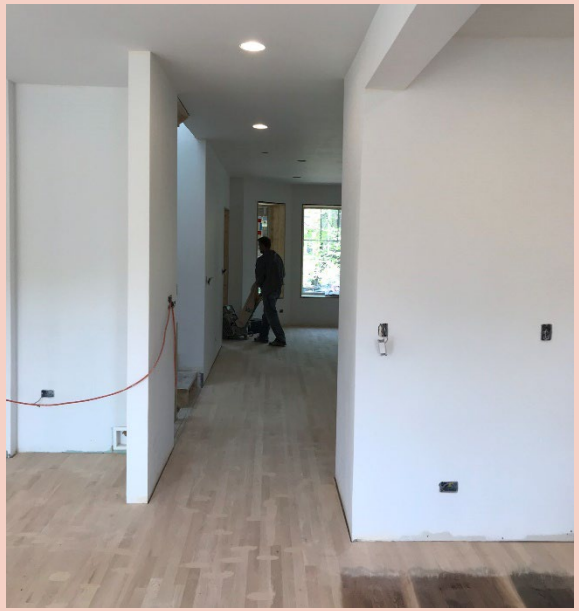
Certificate criteria:	**PHIUS+ 2018**	
Heating demand		
specific:	**17.49** kBtu/ft²yr	
target:	**6.7** kBtu/ft²yr	
total:	46,220.11 kBtu/yr	
Cooling demand		
sensible:	**0.14** kBtu/ft²yr	
latent:	**0.89** kBtu/ft²yr	
specific:	**1.03** kBtu/ft²yr	
target:	**5.2** kBtu/ft²yr	
total:	2,722.18 kBtu/yr	
Heating load		
specific:	**8.81** Btu/hr ft²	
target:	**4.8** Btu/hr ft²	
total:	23,281.48 Btu/hr	
Cooling load		
specific:	**1.82** Btu/hr ft²	
target:	**2.3** Btu/hr ft²	
total:	4,815.08 Btu/hr	

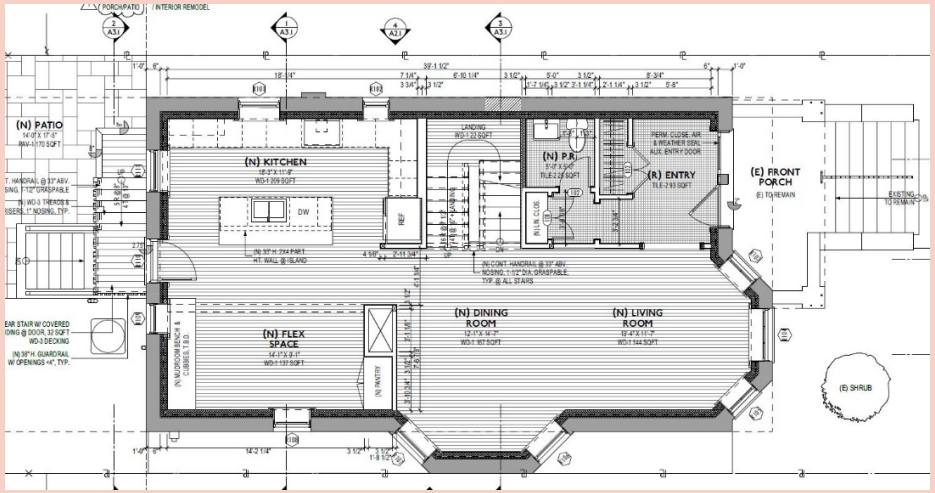




Early 20th c. 2-flat

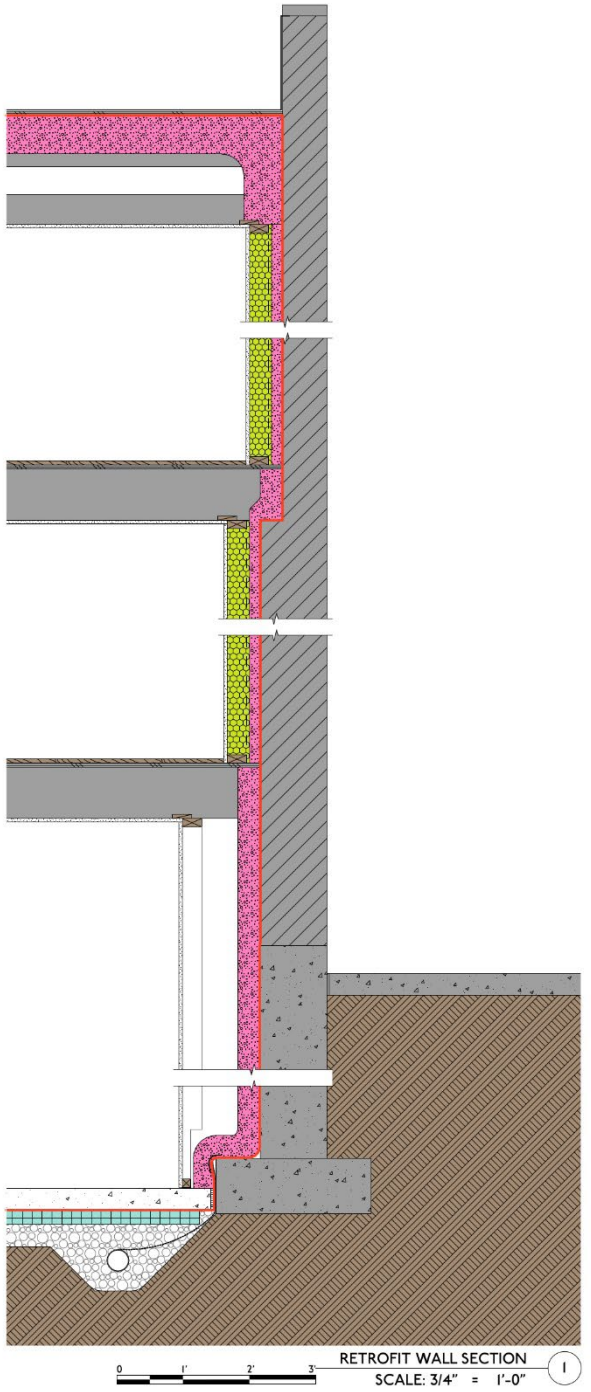
- CCSPF to interior of brick and roof
- New ASHP space and water heating
- New windows, only double-glazed
- New ERV
- Easily achieve Source Energy limit with a modest PV array
- New EUI: 8.7





PASSIVEHOUSE REQUIREMENTS

Certificate criteria:	**PHIUS+ 2018**	
Heating demand		
specific:	**20.89**	kBtu/ft²yr
target:	**7.4**	kBtu/ft²yr
total:	56,425.88	kBtu/yr
Cooling demand		
sensible:	**2.18**	kBtu/ft²yr
latent:	**0.88**	kBtu/ft²yr
specific:	**3.06**	kBtu/ft²yr
target:	**6.4**	kBtu/ft²yr
total:	8,263.77	kBtu/yr
Heating load		
specific:	**9.82**	Btu/hr ft²
target:	**5.7**	Btu/hr ft²
total:	26,521.99	Btu/hr
Cooling load		
specific:	**2.5**	Btu/hr ft²
target:	**3.4**	Btu/hr ft²
total:	6,758.24	Btu/hr

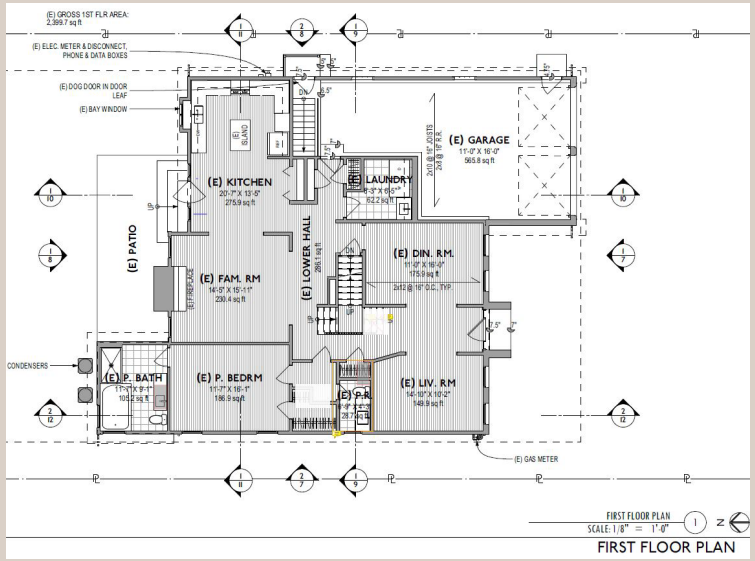


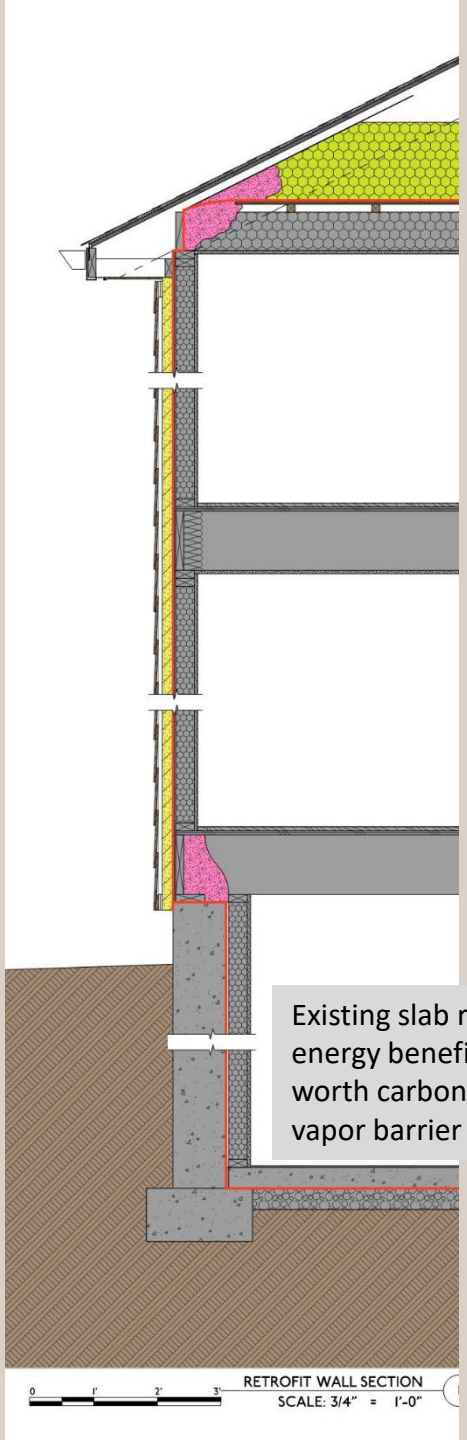
c. 2000 suburban

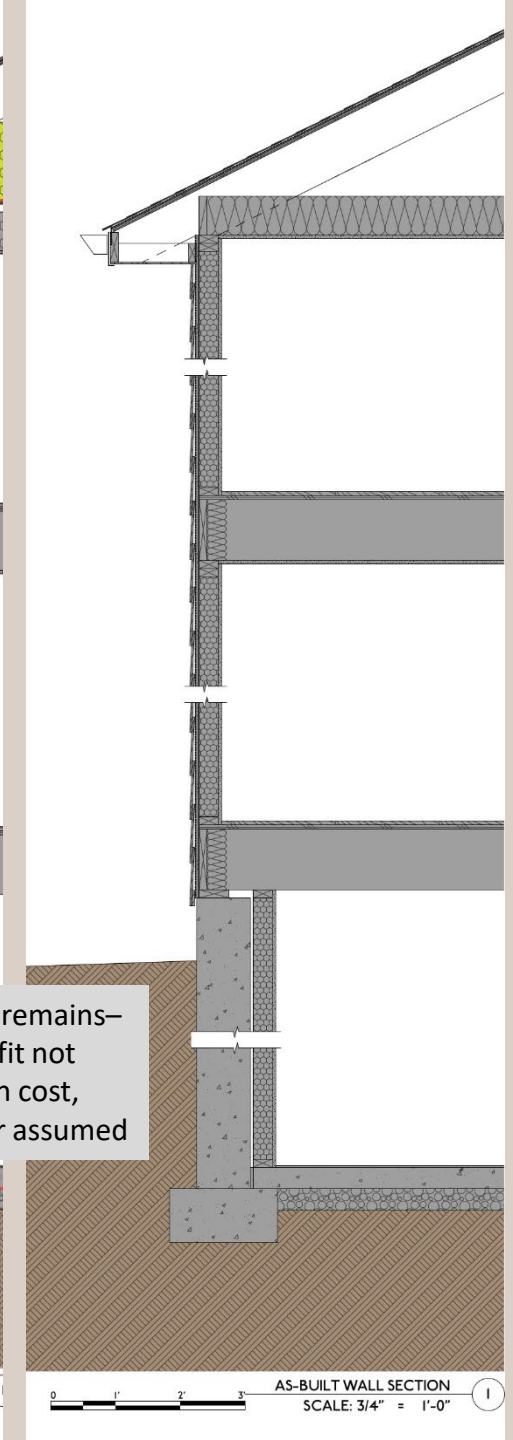
- New exterior wood fiberboard (diffusion open) over air barrier
- Clever attic: taped plywood, foam at edge, lots of cellulose
- New ASHP space conditioning and water heater
- New triple-glazed windows
- New ERV
- New ACH50: 1.09 !

PASSIVEHOUSE REQUIREMENTS

Certificate criteria:	**PHIUS+ 2018**	
Heating demand		
specific:	**14.36** kBtu/ft²yr	
target:	**6.2** kBtu/ft²yr	
total:	60,524.47 kBtu/yr	
Cooling demand		
sensible:	**0.31** kBtu/ft²yr	
latent:	**1.08** kBtu/ft²yr	
specific:	**1.39** kBtu/ft²yr	
target:	**5** kBtu/ft²yr	
total:	5,838.91 kBtu/yr	
Heating load		
specific:	**7.86** Btu/hr ft²	
target:	**5.6** Btu/hr ft²	
total:	33,119.92 Btu/hr	
Cooling load		
specific:	**1.4** Btu/hr ft²	
target:	**2.7** Btu/hr ft²	
total:	5,892.66 Btu/hr	







Existing slab remains– energy benefit not worth carbon cost, vapor barrier assumed

Summary Thoughts:

- Ideal: Start with the end plan based on continuous thermal enclosure and mechanicals, then figure out phasing based on service life of surfaces and equipment. Reality: a whole lot of piecemeal.

- Boilers/radiant heat are an issue: water temp from heat pumps…

- Retrofit ERVs can be tricky/invasive, but good ventilation is a must.

- Related to that, these projects are not about ROI: they're about making good homes that fit with contemporary expectations (health, comfort) and desires (smart controls, efficiency etc.)

TBDA

Finally,

- If we want to scale up we can't be energy modeling every house: we need a library of case studies and techniques that can be quickly implemented with confidence. We see these projects as the beginning of the library.

- We also need an army of local tradespeople to implement—to build these.

- And we will need significant incentives for many homeowners and landlords to want to take this on.

Thanks.