Designing And Building Our Net-Zero Home: Knowledge Gained And Lessons Learned

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VANDEMUSSER DESIGN PLLC

Topics to be discussed

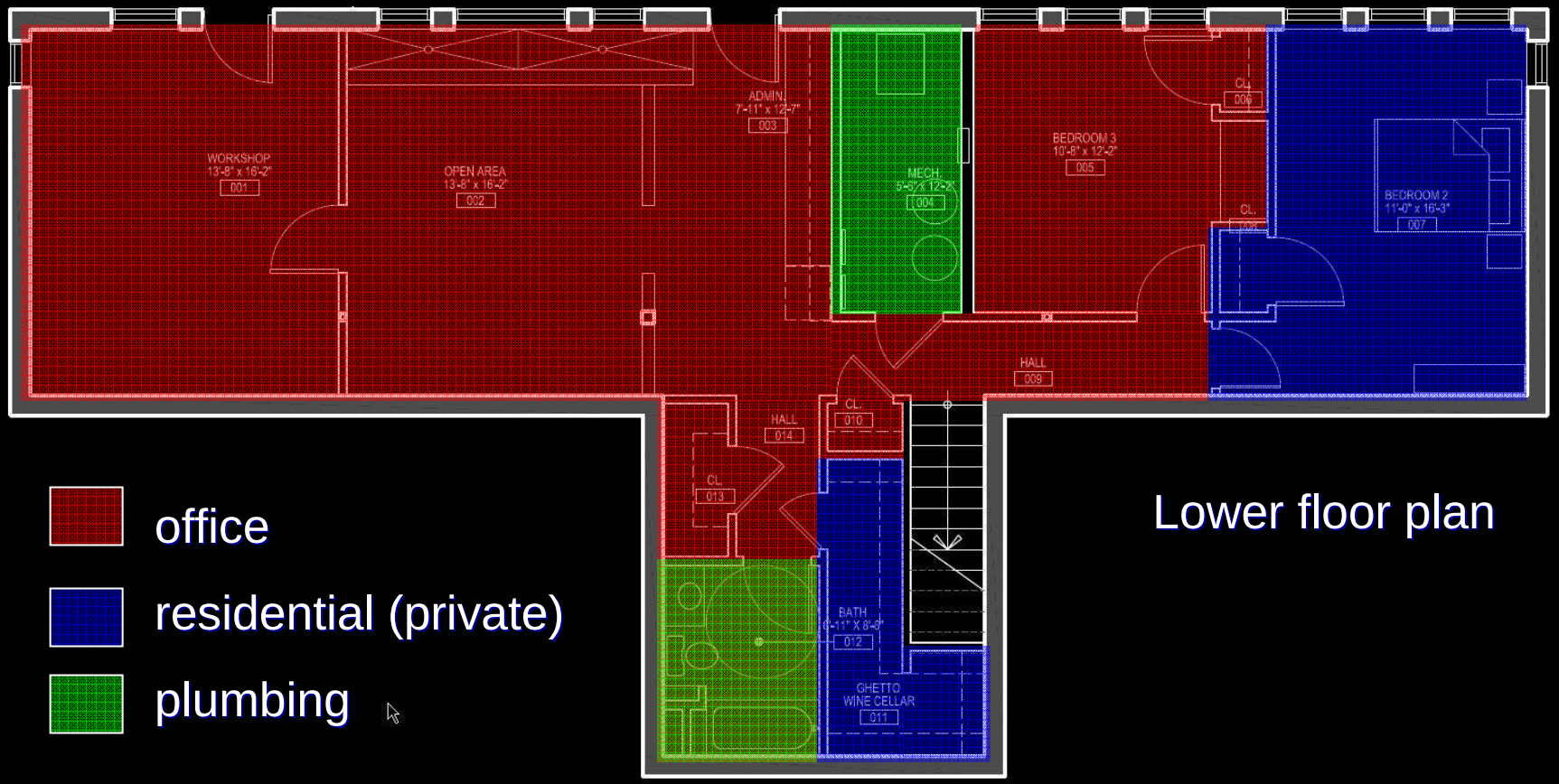
- General Information About Our House
- Construction / Design Strategies
- How We Got To Net-Zero
- Successes… And Some Lessons Learned
- Q&A

VandeMusser Residence

- Location: Asheville, NC
- Climate Zone 4
- 1900 SF home / 1200 SF office
- 3 bed / 2.5 bath
- Passive / active solar
- All-electric home

- HERS Index w/o solar = 44
- Final HERS Index = 12
- Certifications: Energy Star, LEED for Homes (Platinum), EPA Indoor AirPlus, NC HealthyBuilt Homes (Platinum)

VandeMusser Residence



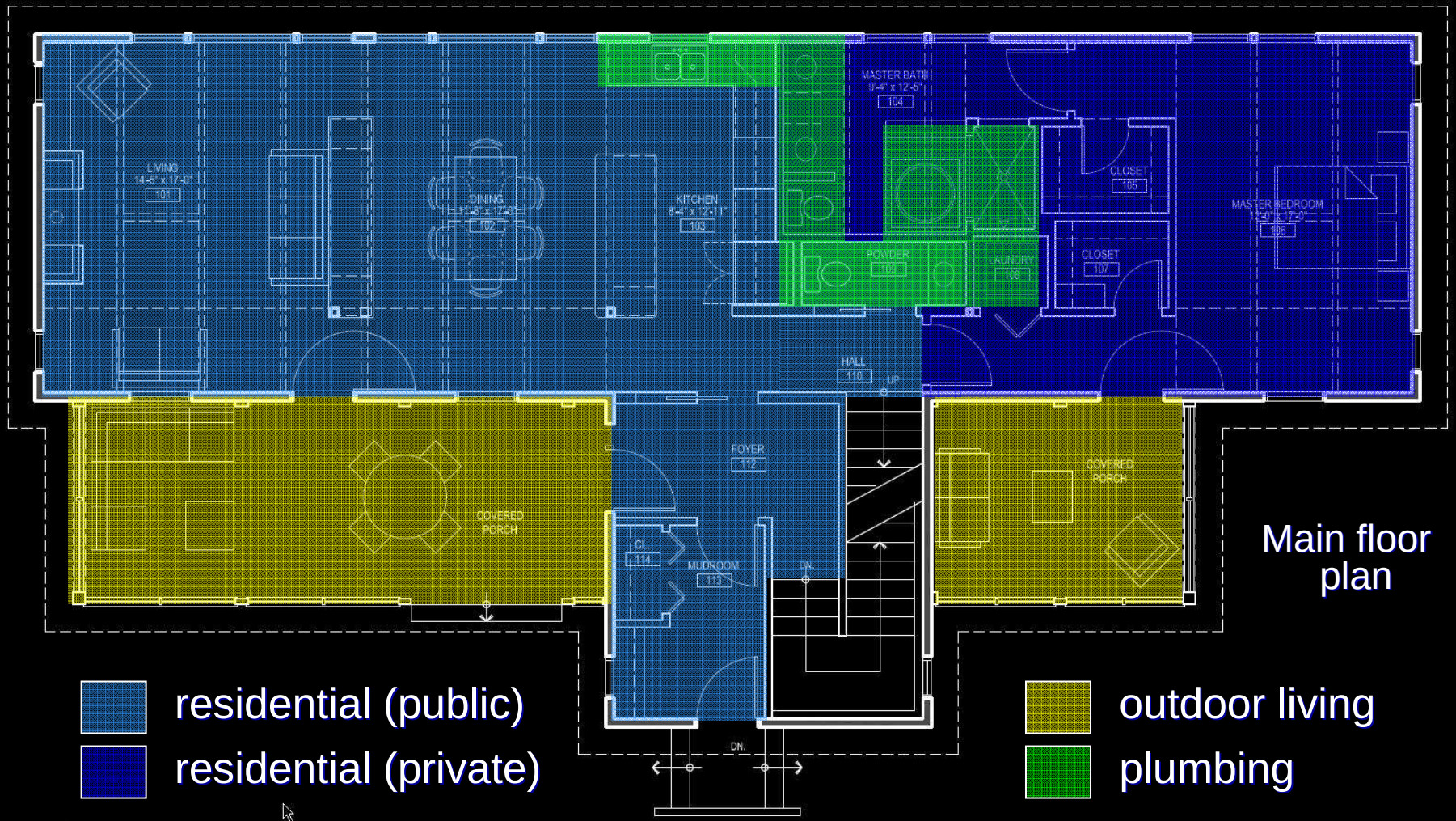
office

residential (private)

plumbing

Lower floor plan

VandeMusser Residence



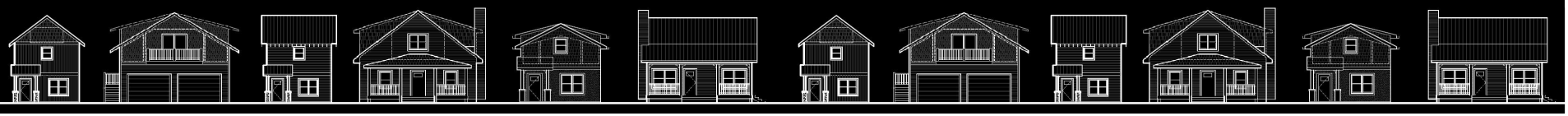
Main floor plan

residential (public)

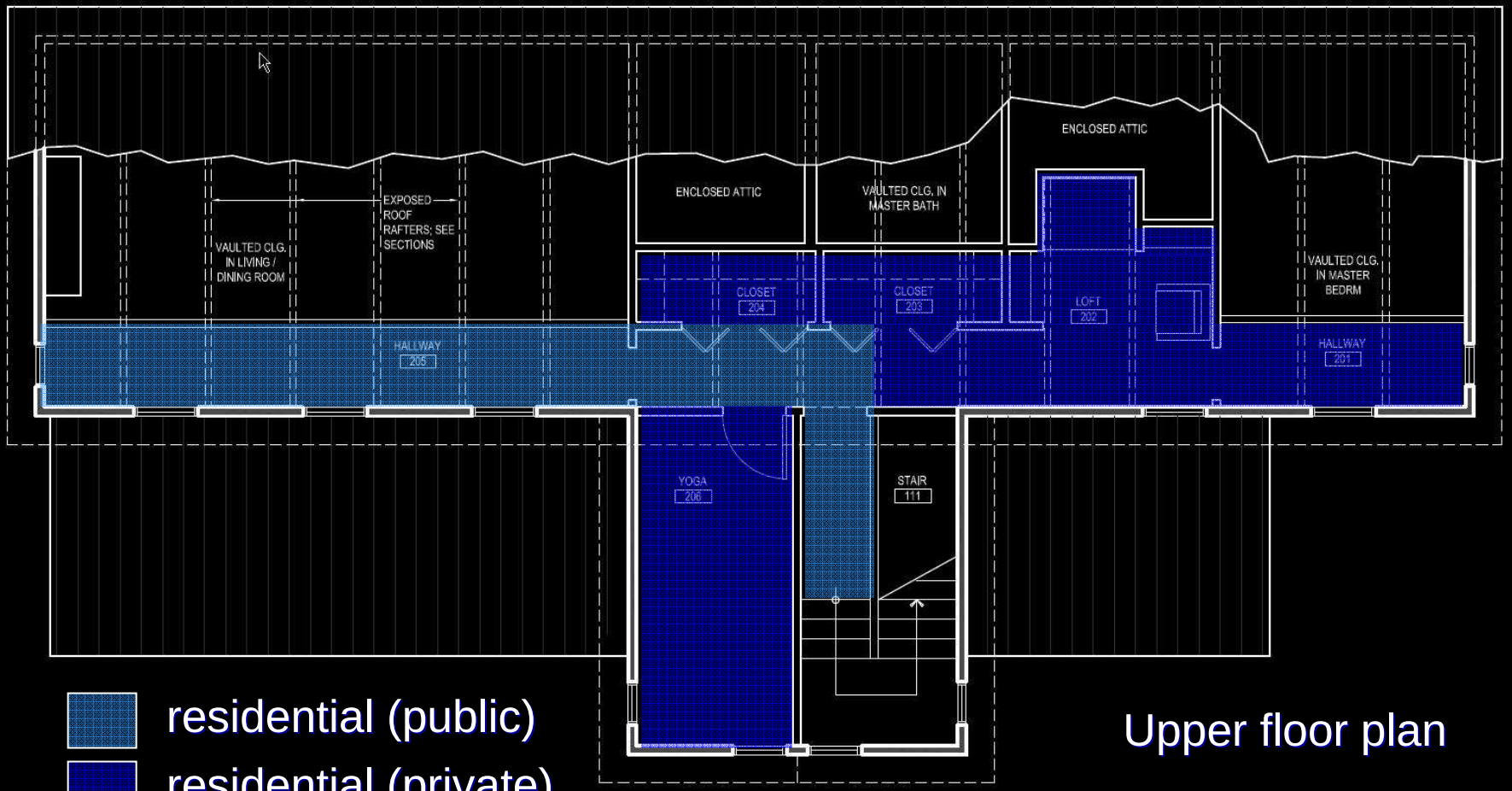
residential (private)

outdoor living

plumbing



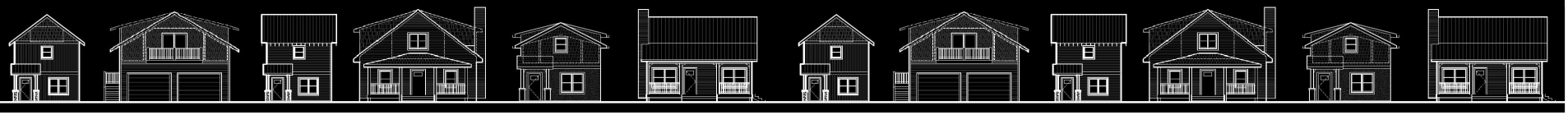
VandeMusser Residence



residential (public)

residential (private)

Upper floor plan



VandeMusser Residence

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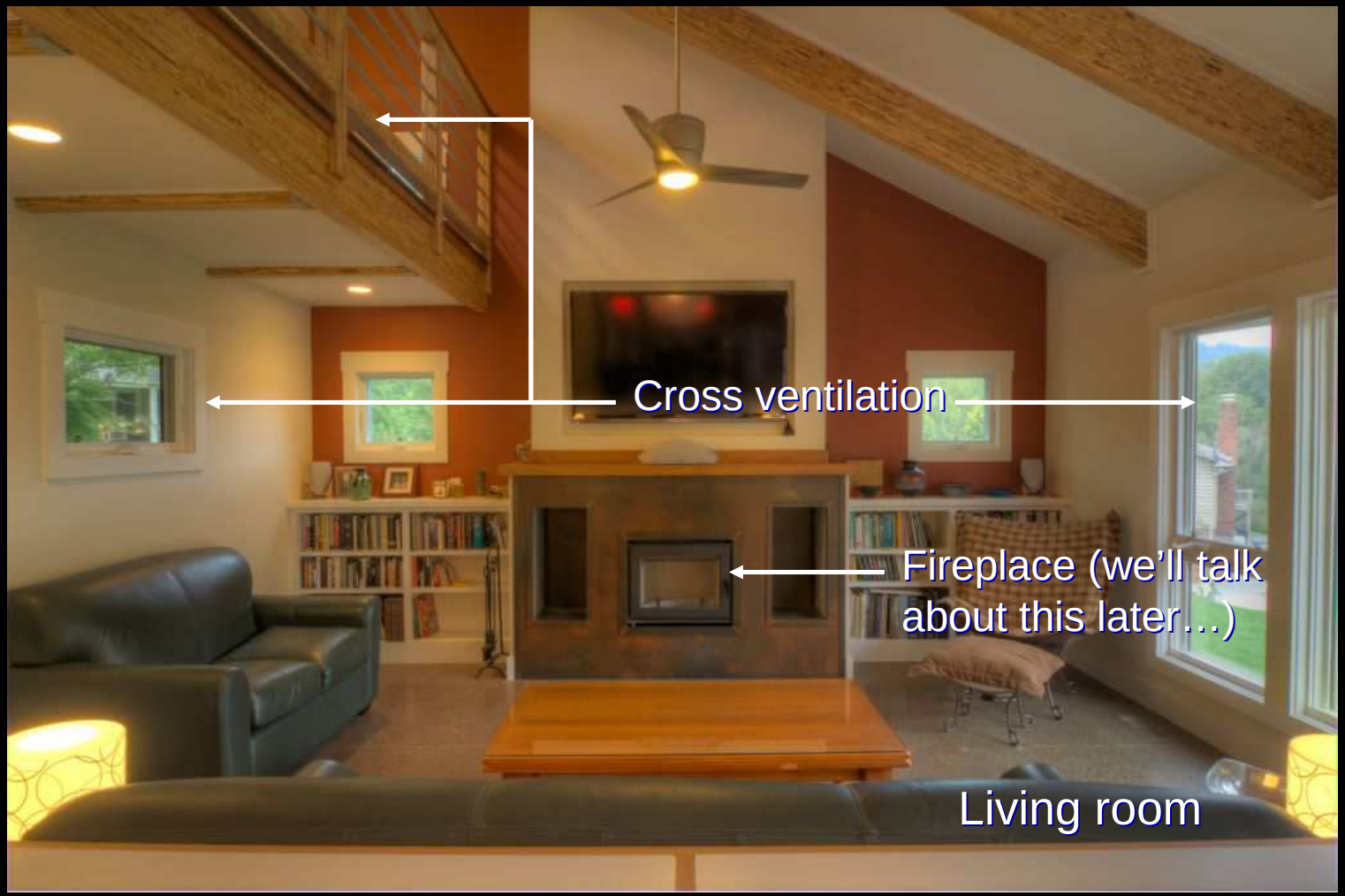


VandeMusser Residence

VandeMusser Residence

Strategies – Passive / Active Solar

- 418 SF glazing on south (70%) -
- 182 SF glazing on other sides (30%)
- 17.7% WWA
- 17.5% WFA

Strategies – Passive Solar

- Double-pane (triple-pane problematic for high SHGC)
- North, east, and west windows: U-value = 0.33 / SHGC = 0.23
- South windows: U-value = 0.36 / SHGC = 0.53
- Properly sized overhangs over all south windows

Strategies – Foundation Walls

- Pre-Insulated (R12.5) Panelized Foundation with R19 FG (R31.5 total)
- Foundation was set in 3 hours
- Very easy to finish out
- Office is in walk-out basement (CHEAP SQUARE FOOTAGE!)

Strategies – Basement Slab

- Integral color
- 4” 2500 psi normal weight concrete over 2” rigid insulation (R10)
- 30% fly ash content
- Granite aggregate
- Ground and polished

Strategies – Main Floor Slab

- 3” 4000 psi normal weight concrete over ¾” rigid insulation (R3) over trusses
- 30% fly ash content
- Local river stone aggregate
- Semi-translucent surface-applied color
- Ground and polished

Strategies – HVAC

- 3-ton geothermal heat pump w/ 2 zones
- Able to switch between forced air and hot water (radiant)
- 2 vertical wells, each at 250 feet deep

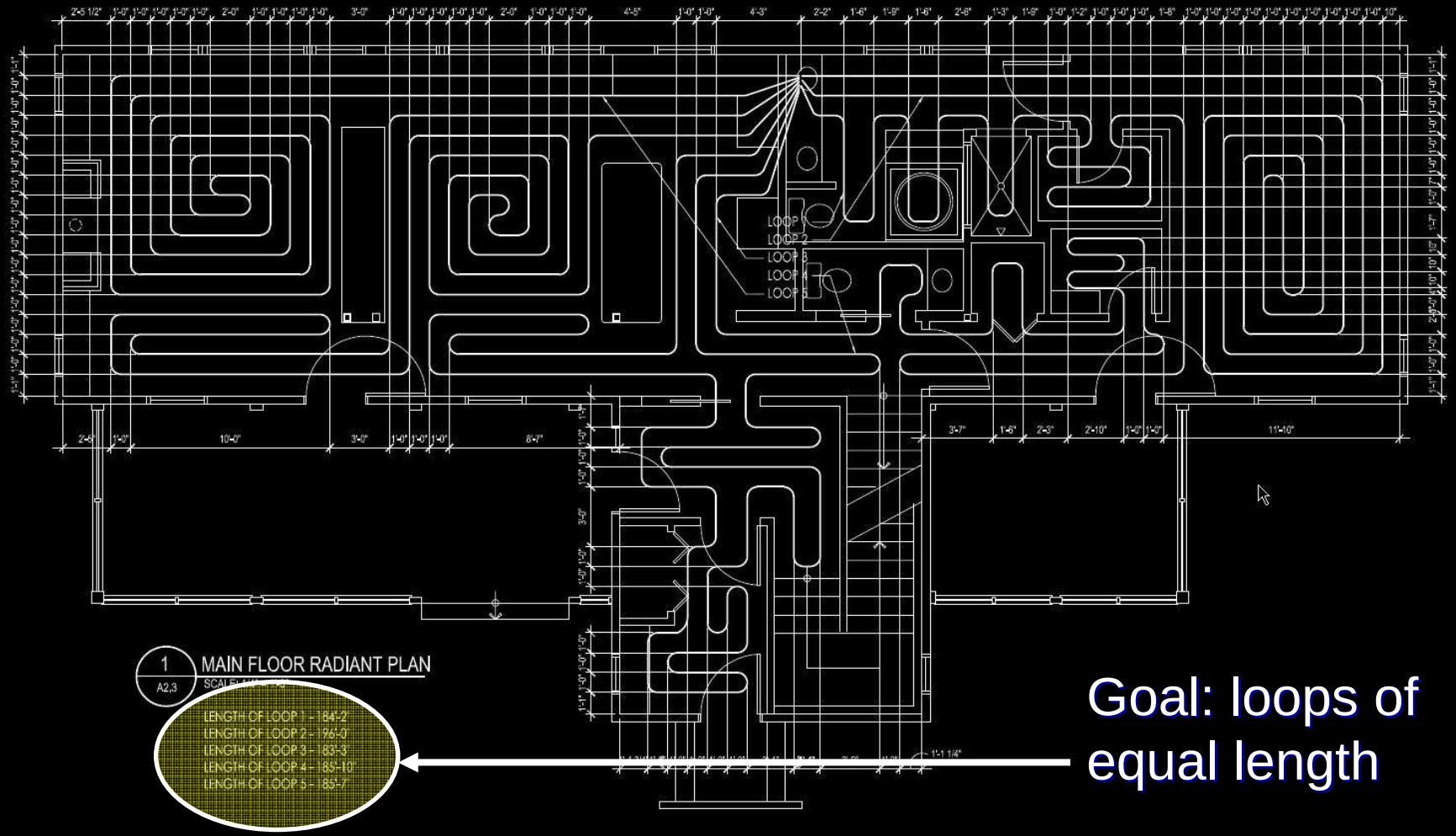
Strategies – HVAC

- Required ventilation (ASHRAE 62.2) = 62 cfm
- Fresh air ventilation – energy recovery ventilator (ERV)
- Low energy usage – approx. 40 watts

Strategies – Radiant Heat

- Comfort issue, not an energy saver.
- Radiant heat powered by geothermal heat pump (low temp)
- Lower and main floors are radiant slab
- Upper floor has radiant wall

Strategies – Radiant Heat

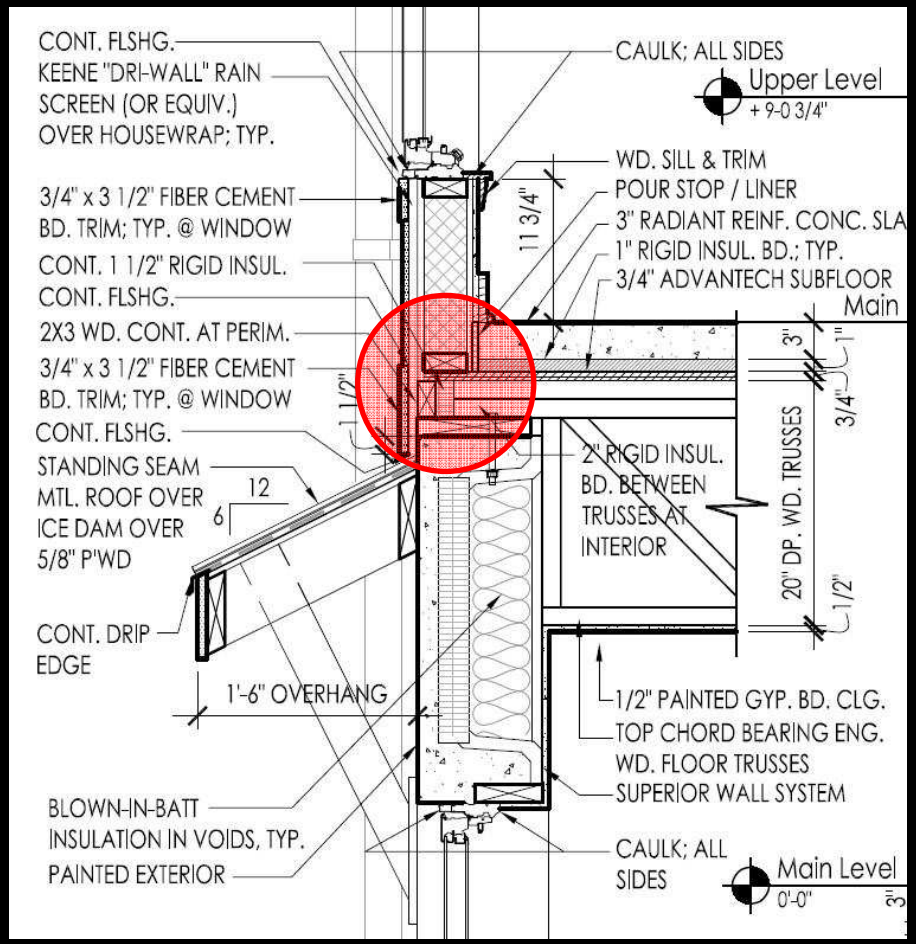


Goal: loops of equal length

Strategies – SIP Walls / Roof

- Urethane Structural Insulated Panels (SIP) panels
- 4.5” walls (R24)
- 6.5” roof (R38)

Strategies – Rim Joist



Strategies – Rafter Tails

- Rafters that penetrate through exterior walls tend to have a devastating effect on envelope leakage
- Rafter tails are false – separate piece lagged to SIP roof from above
- Exterior sheathing of SIP is continuous

Goal: To build for same amount as everyone else…

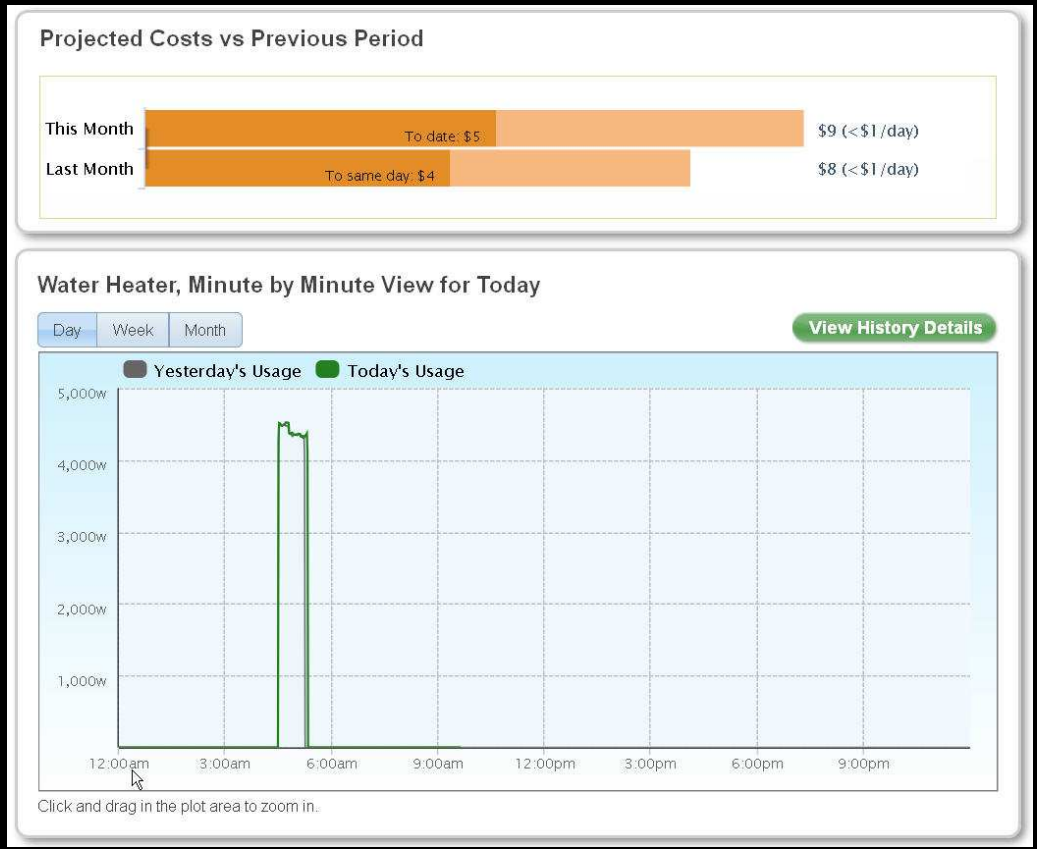
Getting to Net-Zero

- Electrical Circuit Monitoring
- First 12 months:
  - 5843 kWh used
  - 6147 kWh generated

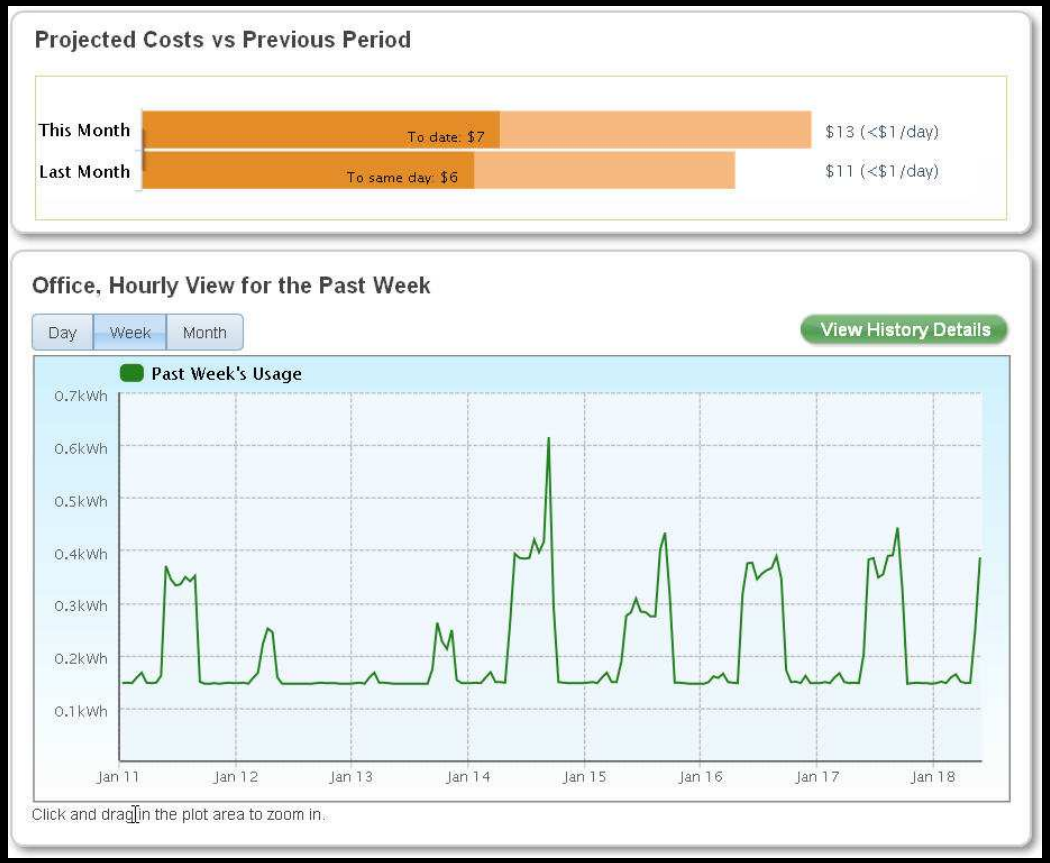
Getting To Net-Zero

Water Heater

- Electronic timer on water heater to force solar panels to do most of work
- Electric back-up only allowed to heat from 4:00 to 6:00 (cheaper power) if tank temperature is low
- Most of our hot water use is early morning



Getting To Net-Zero



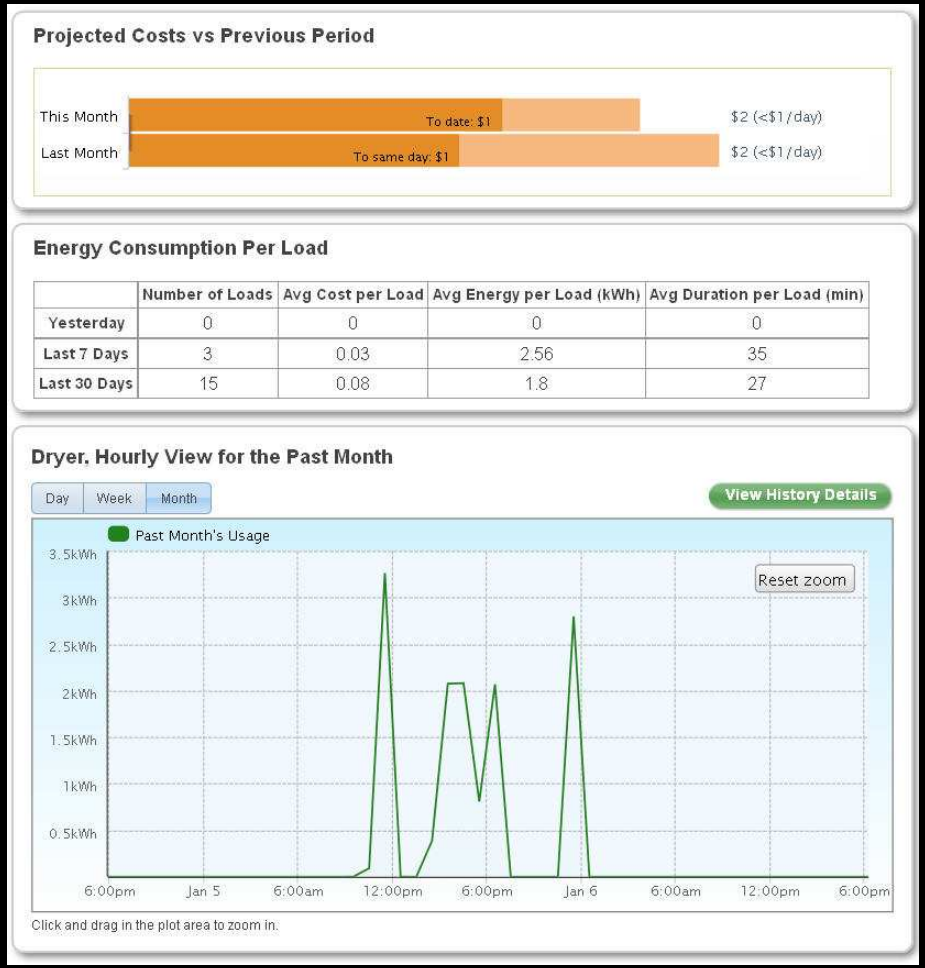
Office Electrical Use

- Before we installed the eMonitor, computers in office left on 24/7
- After installation, turned off most computers at end of work day (60% reduction in office power usage)
- Monthly savings - $20 to $25

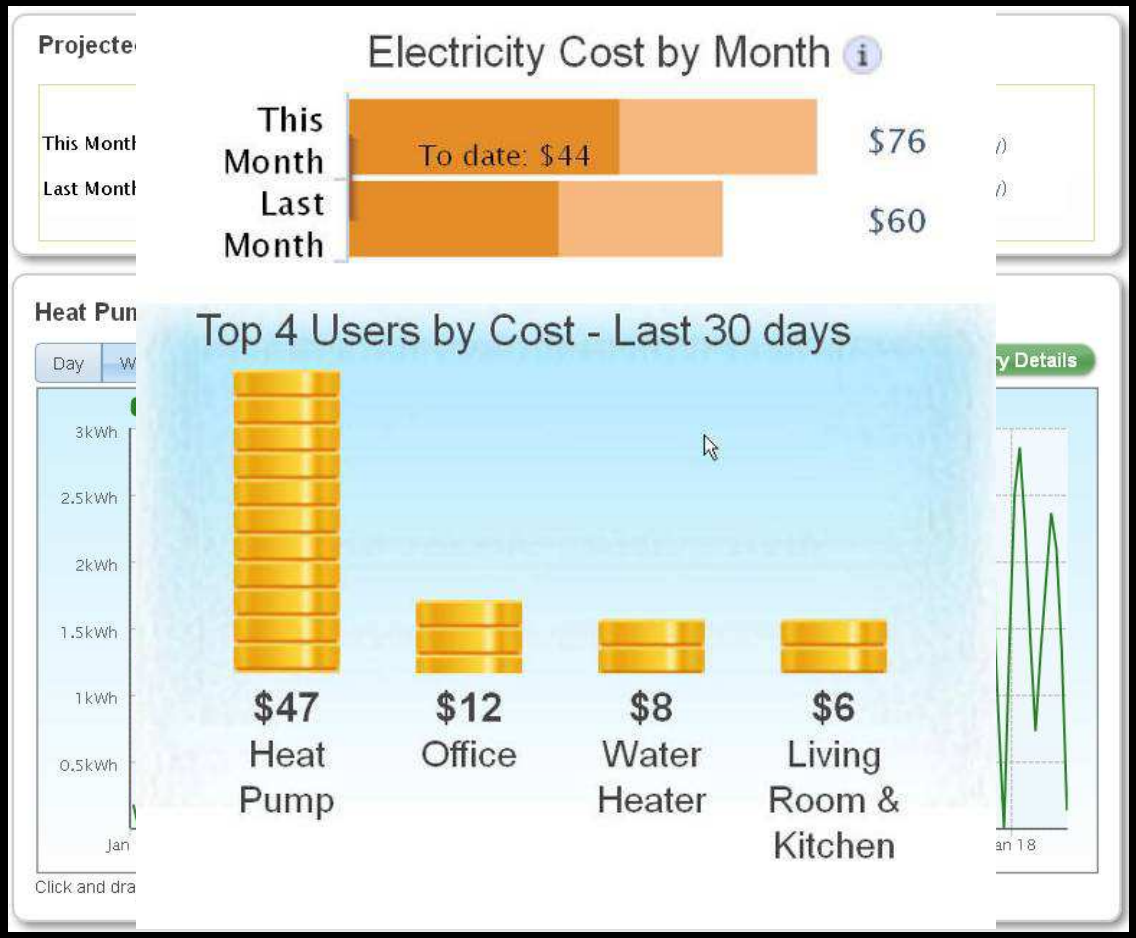
Getting To Net-Zero

Clothes Dryer

- Fairly significant power user when running
- We only use it at night and on weekends (cheaper power)
- If the sun is out, we dry our clothes outside on a clothes line instead.



Getting to Net-Zero



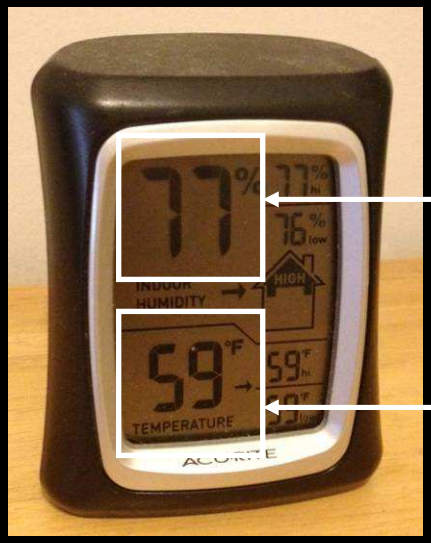
Heat Pump

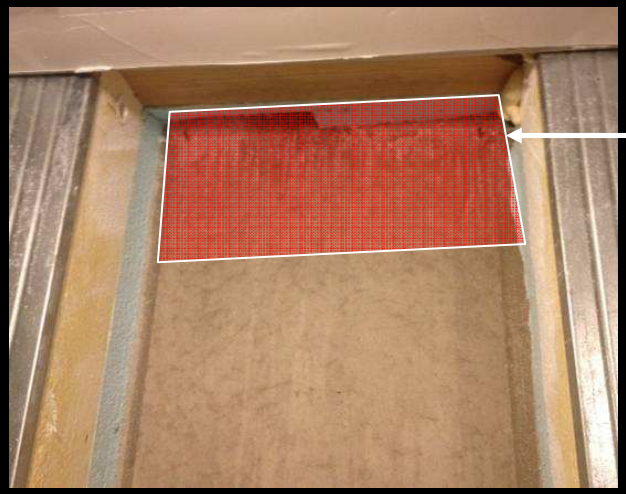
- In cold weather, our biggest energy user (by a lot!)
- Winter thermostat currently set at 71 degrees
- Could likely eliminate a lot of heat pump activity if we lowered it to 68 degrees…

Lessons Learned – Mech. Room

- NOT BIG ENOUGH!
- Electrical panel and PV inverter had to be relocated to workshop
- ERV is not ideally located
- Radiant manifold for main floor tubing is above ceiling in office
- A/V controls are in adjacent closet

Lessons Learned – Ghetto Wine Cellar





- Intentionally left area in basement under stairs unconditioned / removed foundation insulation
- Relative humidity too high (typically 73% - 80% RH)
- Temperature swing too large (59° winter -70° summer)
- Ideal wine storage: 50-70% RH / 55°-57°F
- Removed too much insulation at top of foundation wall above grade (condensation in Winter / overheating in Summer)
- Air leakage from rest of house

Lessons Learned – Toilets

- Don’t be swayed by aesthetics only…
- Dual-flush - 1.6 / 0.8 gpf
- MaP rating = 600g
- Doesn’t flush worth a s***!
- 1.6 gpf x 2 flushes = 3.2 gal.

- http://www.map-testing.com
- ALWAYS get one that can flush >1000g
- ***Plenty*** of 1.28 gpf options

Lessons Learned – Box Elder Beetles

- Property had several box elder trees (we still have 1)
- Spring and Fall breeding seasons
- They LOVE south-facing masonry walls to lay eggs
- Totally harmless - don’t have interest in coming inside
- Spray with a mix of dish soap and water to kill them

Lessons Learned – Effects Of A Bad Economy

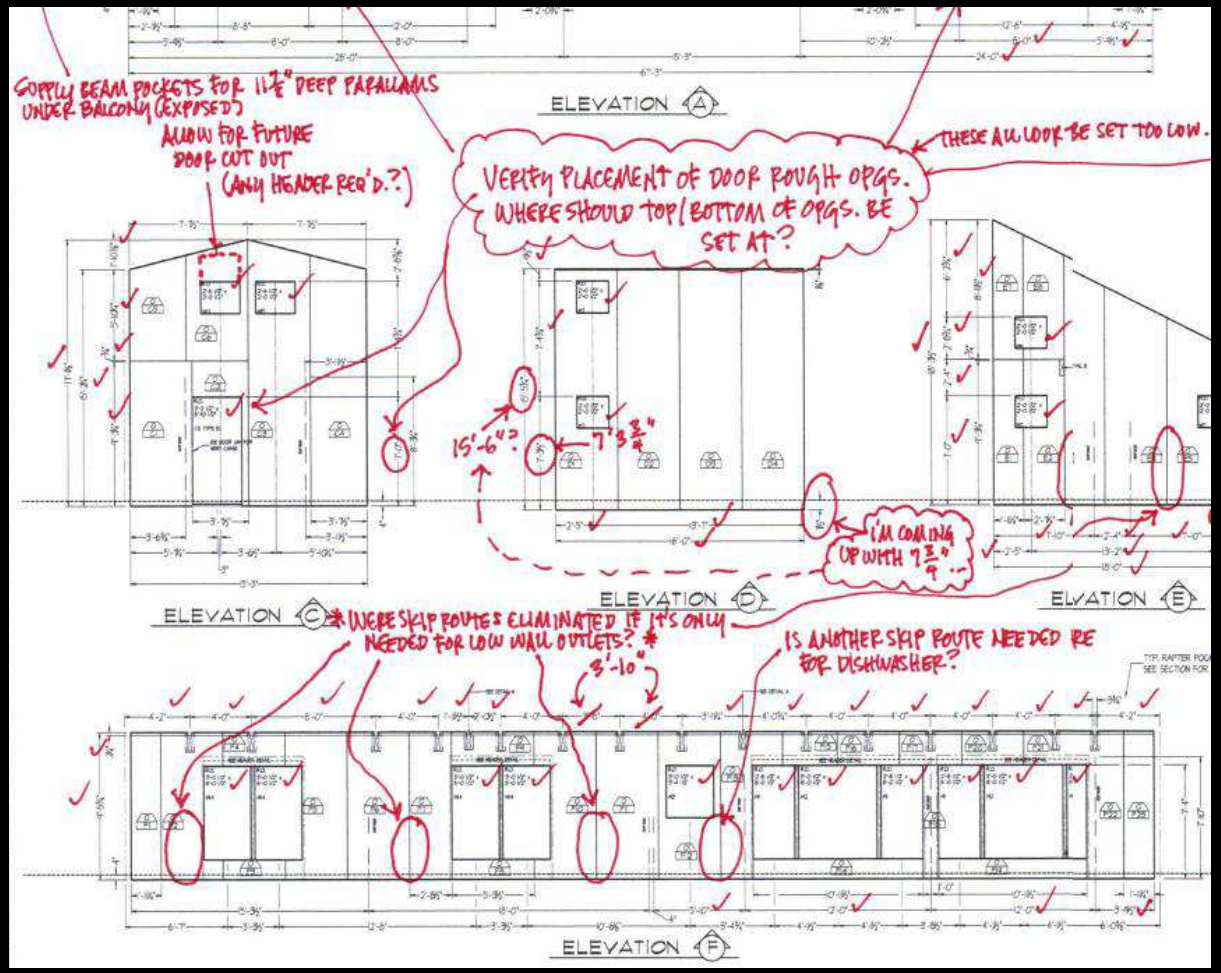
- Built in worst part of the recession
- Bank loan was problematic – needed HELOC to pay contractor for materials (bank took too long)
- We thought subcontractor labor would be cheaper, building materials would be plentiful and immediately available
- Subcontractors were actually running skeleton crews (and often letting most experienced / expensive employees go)
- Building supply companies were extremely under-stocked
- To build with any quality, it was going to be both slow ***and*** expensive.

Lessons Learned – Radiant Heat

- Consciously did it knowing it was not an energy saver
- Coordination of tubing with floor penetrations/saw cuts
- Doesn't run very often due to thermal mass (in Winter, if sunny the day before, usually comes on around 3:00 AM)
- ***COST*** (of installing tubing storage tank, and specialized equipment) - $11000 +/-

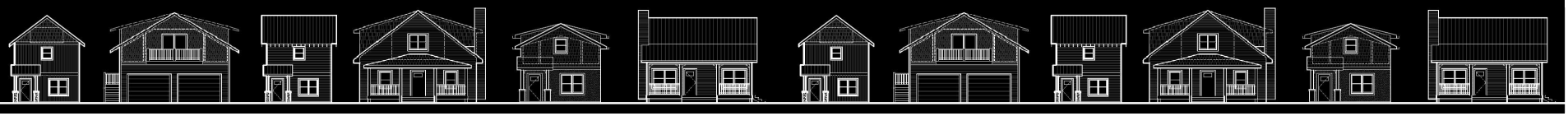
Lessons Learned – SIP's

- Coordination of window / door openings
- Electrical – whining, schedule
- Structural beam pockets
- Builder's learning curve
- ***COST***



Lessons Learned – SIP's

- Frame walls with 2x4 framing at 16" on center with R15 fiberglass batts in cavity / R10 continuous exterior insulation board AND change roof to TJI rafters at 16" on center with 8" open cell foam (R30): $18,000
- Additional cost of SIP roofs (R38) and walls (R24): $12,000
- Annual energy savings to make change to SIP's: $5
- Rate of payback: ***2400 years***



Lessons Learned – ERV

- In a tight house in Asheville, controlling humidity is an issue 12 months out of the year
- Prone to window condensation in winter
- Better choice probably would have been an HRV (more efficient in winter/less in summer/overall neutral)
- Our AC would handle the latent load in summer.
- HRV would also have been slightly cheaper - $150

Temperature / humidity in kitchen at 3:00 PM on February 14, 2013

Lessons Learned – Fireplace

- EPA-certified fireplace insert
- Wood burning - 70% efficient
- Did we need it? Original thought was backup heat in case of power outage.
- Works great, but we have had one small fire so far (2 winters in house) – mostly out of guilt…
- So efficient, it tends to overheat the living area
- Cost: $5000

Things we could have cost-optimized:

• Eliminate radiant heat (forced air only)	($11,000)
• Eliminate SIPS (use continuous exterior rigid ins.)	($12,000)
• HRV in lieu of ERV	($150)
• Eliminate fireplace	($5,000)
• Eliminate rainwater harvesting (city water is very cheap in Asheville)	($3,000)
TOTAL	***($41,150)***
• Original cost / SF (including incentives)	$156 / SF
• Optimized cost / SF (no change in performance)	$143 / SF

Successes – Natural Light

- HUGE impact on mood and productivity
- Has changed our sleeping patterns
- Almost never need lights on during the day, even when cloudy
- Overhangs sized to fully shade windows at noon on Summer solstice
- Sun penetrates full depth of house at noon on Winter solstice

Successes – Thermal Mass Floors

- Thermal mass floors heat up dramatically on sunny Winter days
- Polished concrete floors are durable, low-VOC, and contain recycled fly ash
- Similar finished cost to high-end hardwood or tile floors

Successes – Rainwater Harvesting

- 3000-gallon rainwater cistern
- Collects water off 80% of roof area
- Standing seam metal roof reduces contaminants
- Toilets and outside hose bibbs only (non-potable) / independent plumbing lines
- Booster pump in mechanical room for easy maintenance
- Reduced city water usage by 50%

Successes – Financial Incentives

• Geothermal (30% Federal / 35% State)	$17,150
• Geothermal + Energy Star (Utility Rebate)	$1,000
• Solar Thermal (30% Federal / 35% State)	$2,535
• Solar Thermal (Utility Rebate)	$1,000
• Photovoltaic (30% Federal / 35% State)	$19,400
• Photovoltaic (Utility Rebate)	$5,150
• EPAct $2000 Federal Builder Tax Credit	$2,000
• Passive Solar Tax Credits (State)	$3,500
• Local Permit Fee Rebates	$200
total incentives	$51,935
reduction in cost / SF	($16.72) / SF
estimated rate of payback	7 to 10 years

Any Questions?

Progress Energy

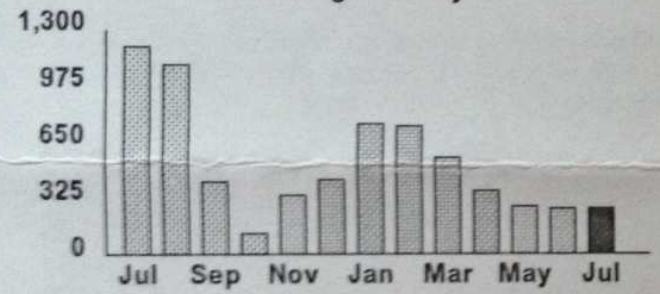
Customer Bill page 1 of 1

0050931 01 SP 0.450 051

AMY B MUSSER
26 CRABAPPLE LN
ASHEVILLE NC 28804-1733

Account number		
Total due		**$1.19**
Current charges past due after		**Jul 30**
Thank you for your payment	Jun 13	$1.83
Usage period		Jun 4 - Jul 3
This bill was mailed on		July 6, 2012

kWh Usage History



Usage

Meter number			RC9717
Readings: Jul	3		4708
Jun	4	-	4434
kWh usage			**274**

Days in period 29 Average kWh per day 9

Total Peak Registration

On-peak KW	Jul	2 at 8:59 pm	2.21
Off-peak KW			6.14