

Northwest Net Zero



Northwest Ecobuilding Guild Symposium
24 October 2010

Northwest Net Zero

Overview

- 3330 s.f. house (conditioned)
- 5 bedroom, 4-1/2 bath
- great room, library, guest/media room
- attached workshop and garage
- Northwest Lodge style
- LEED for Homes Platinum certified
- located in Washington state



Northwest Net Zero

Client goals

- (former house not performing well)
- net zero energy
- warm in winter
- cool in summer
- dry, dry, dry (no water leaks)
- excellent IAQ (allergic child)
- 100 year durability
- commercial quality construction



former house 4270 s.f.



Northwest Net Zero

Design team

- *VELOCIPEDA* architects inc
- Sliderule Engineering Works LLC
- Sound Mechanical Consulting Inc
- RDH Building Sciences Inc
- Concept Engineering Inc
- Geotech Consultants Inc
- Adjuvant Consulting

Construction team

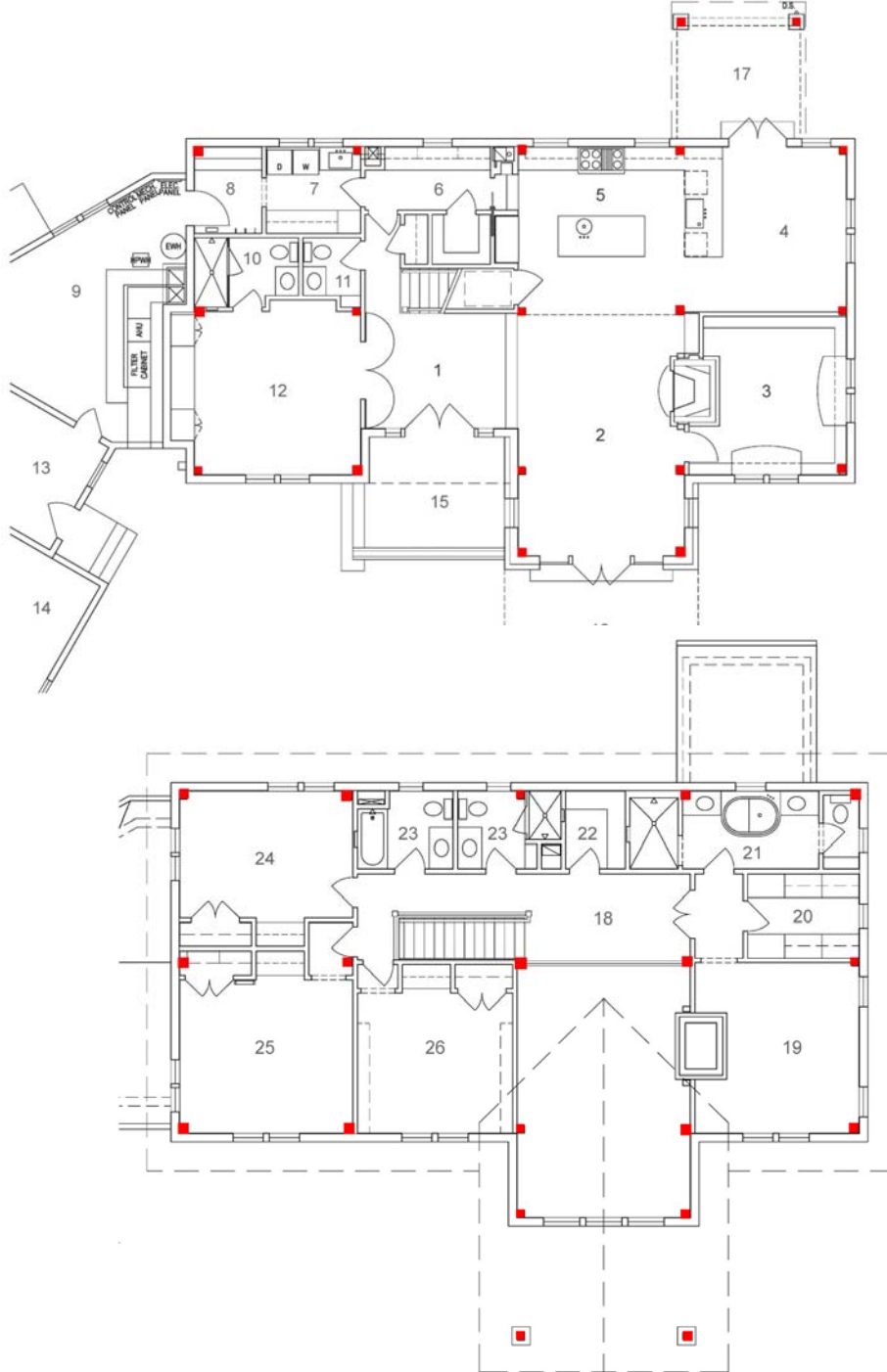
- Thomas Jacobson Construction Inc
- The Cascade Joinery, Inc.
- Davidson Concrete
- Worden Masonry
- Cardinal Heating and A/C Inc.
- Schultz and Associates
- Tiger Excavation & Trucking, Inc.
- Boley Electric
- Sunergy Systems
- Conservation Services Group



Northwest Net Zero

Building design

- eight timber frame bays per floor
- major spaces oriented to true south
- SIP walls and roof
- conditioned crawl space
- vaulted ceilings (no attic)
- garage and shop stick framed



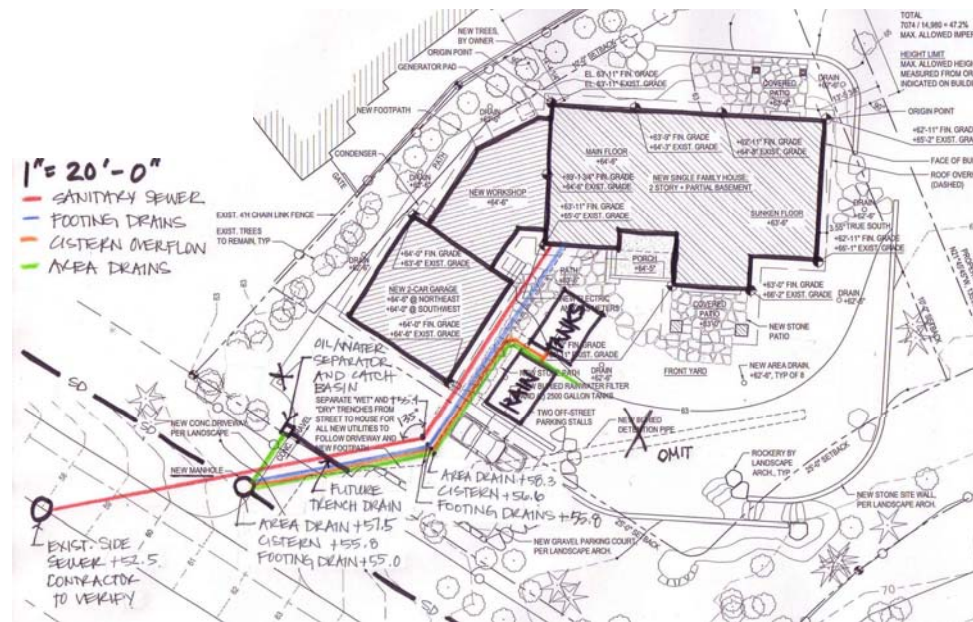
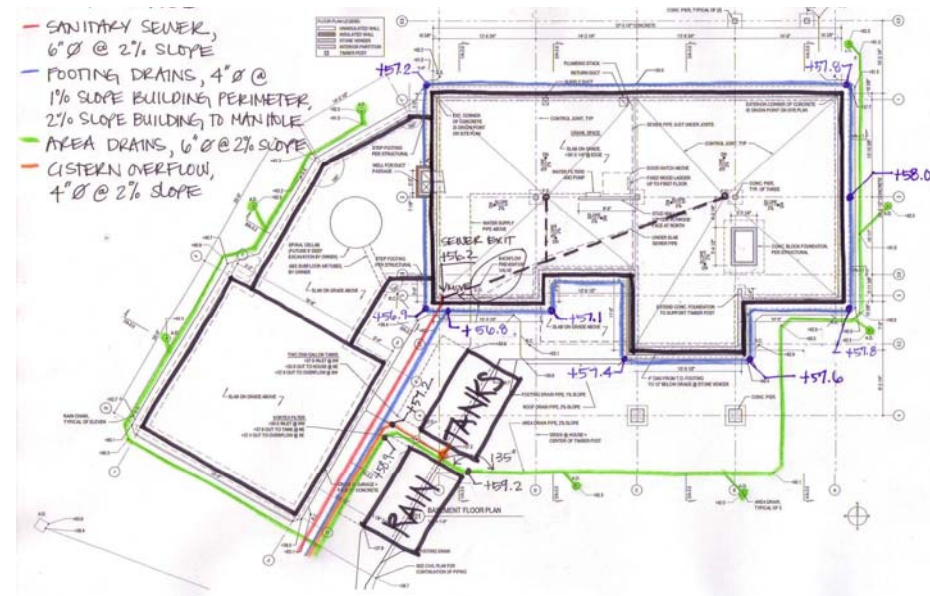


Northwest Net Zero



Infrastructure choices

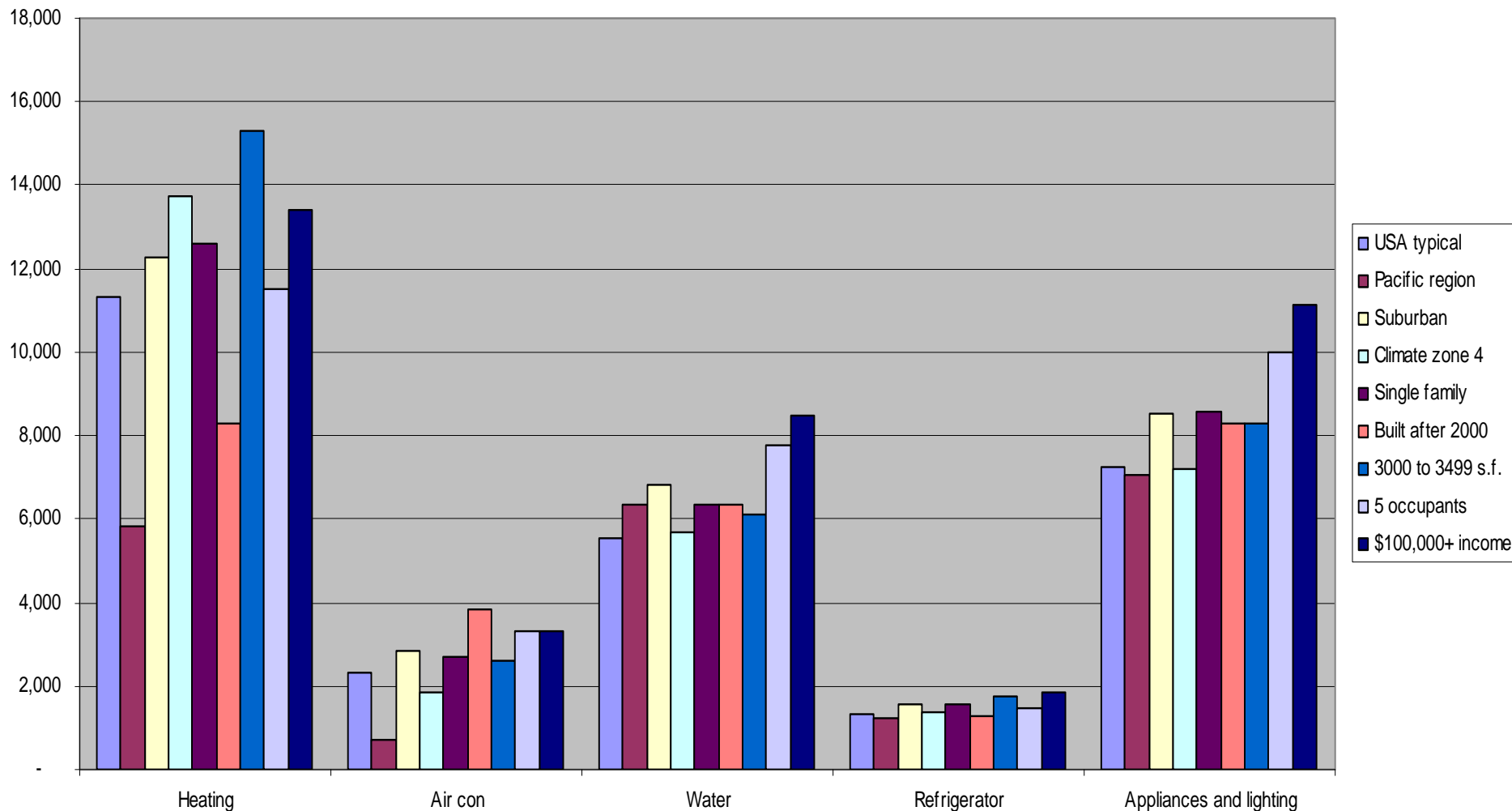
- developed suburban location
- municipal water meter
- municipal sanitary sewer
- municipal storm sewer
- grid tied electricity
- no gas meter
- no fire sprinklers



Northwest Net Zero

What is a “typical” house?

- 2005 RECS
- nine relevant categories

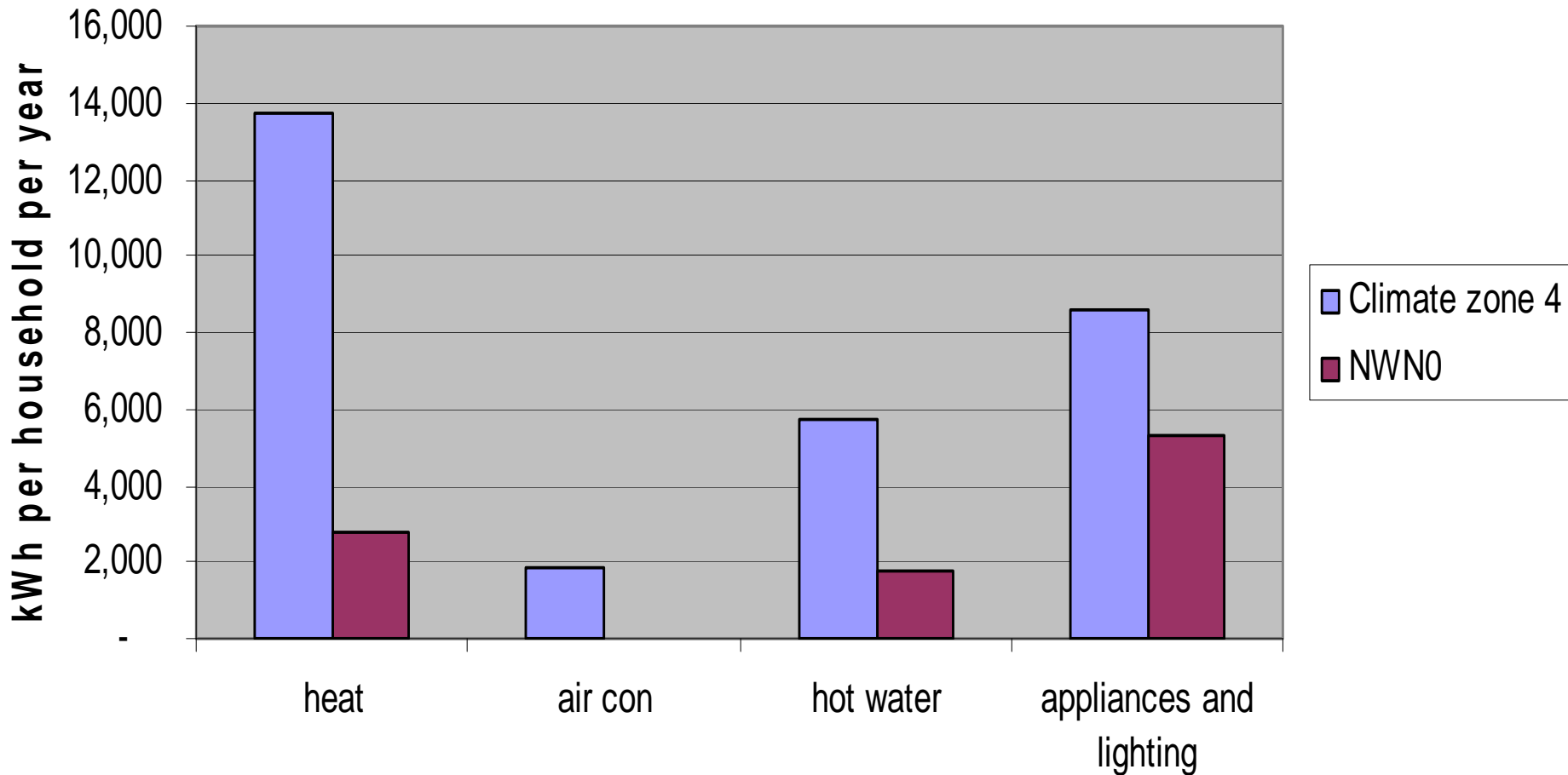


Northwest Net Zero



Energy reduction goals

- kWh per household per year
- benchmarked to Climate Zone 4

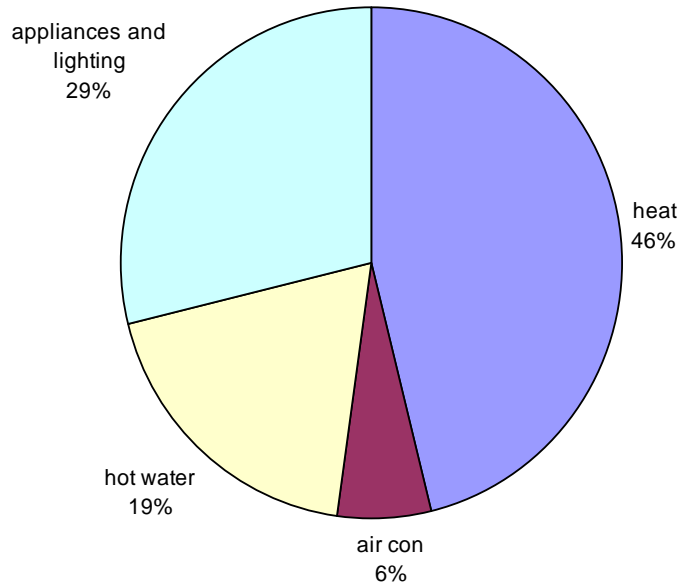


Northwest Net Zero



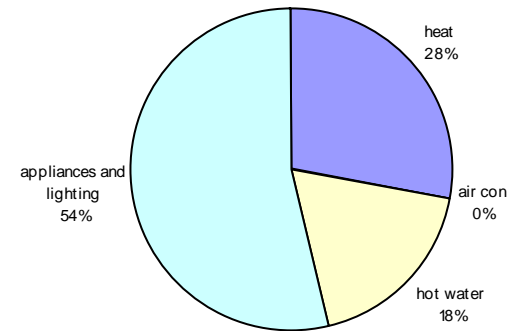
“typical” vs net zero

Climate zone 4



29,836 kWh / year
EUI 30 kBTU / s.f. / year

NWNO



9,915 kWh / year
EUI 10 kBTU / s.f. / year

Energy reduction strategy

1. excellent envelope
2. efficient HVAC and water heating
3. efficient appliances and lighting

Net zero energy strategy

1. enough PV to generate balance

Northwest Net Zero

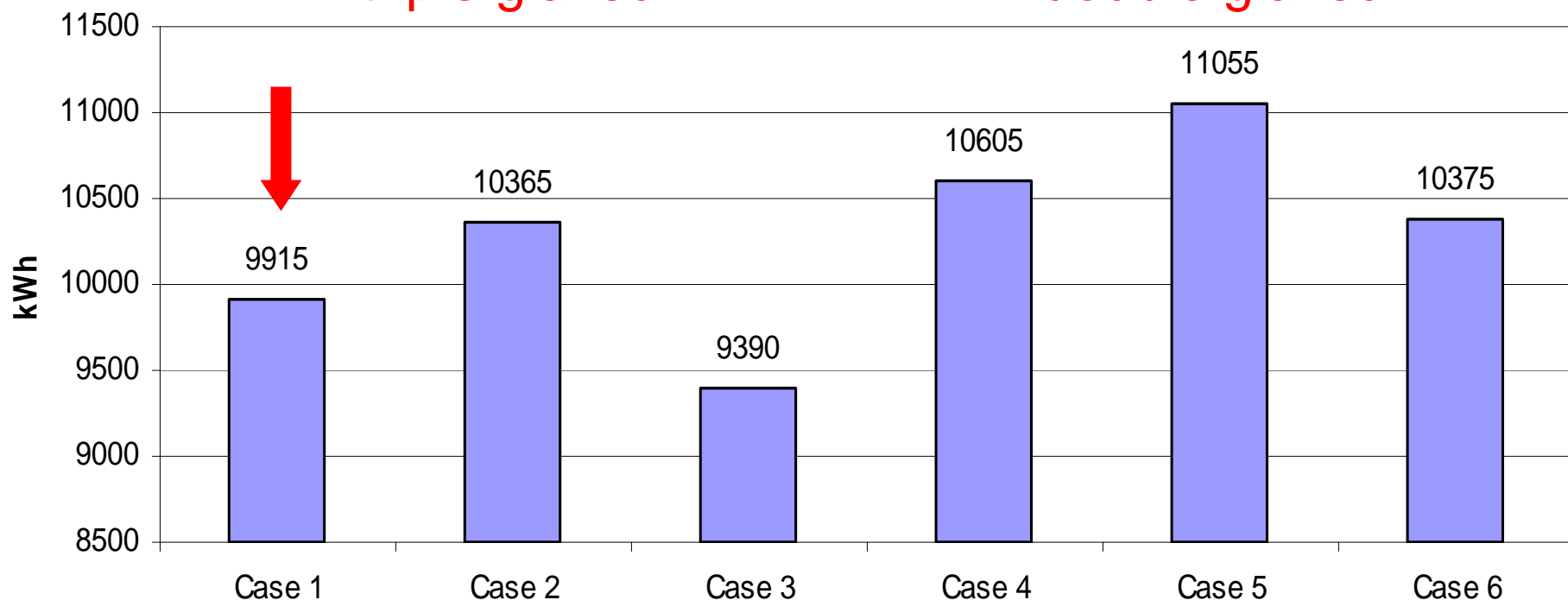
Energy simulation

- Adjuvant Consulting
- evaluated envelope / window options
- recommended mechanical system

| | Glazing | Walls | Roof |
|--------|---------|-------|------|
| Case 1 | U-0.20 | R-30 | R-30 |
| Case 2 | U-0.20 | R-23 | R-30 |
| Case 3 | U-0.20 | R-30 | R-38 |
| Case 4 | U-0.30 | R-30 | R-30 |
| Case 5 | U-0.30 | R-23 | R-30 |
| Case 6 | U-0.30 | R-30 | R-38 |

triple glazed

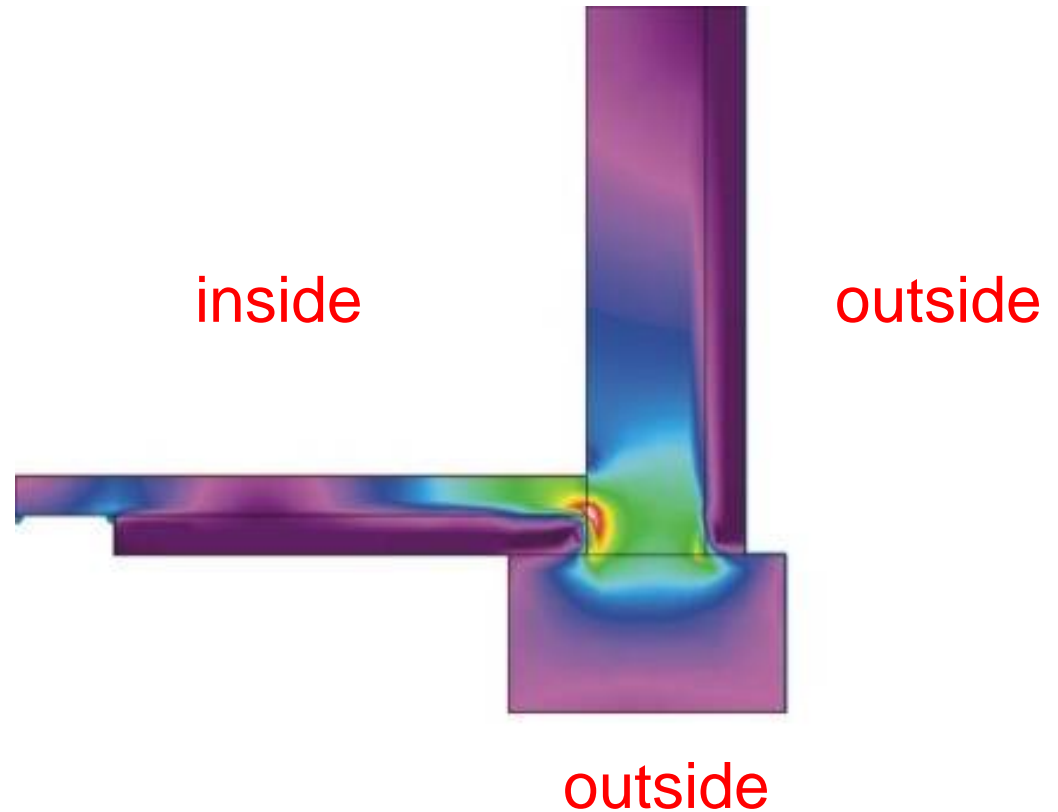
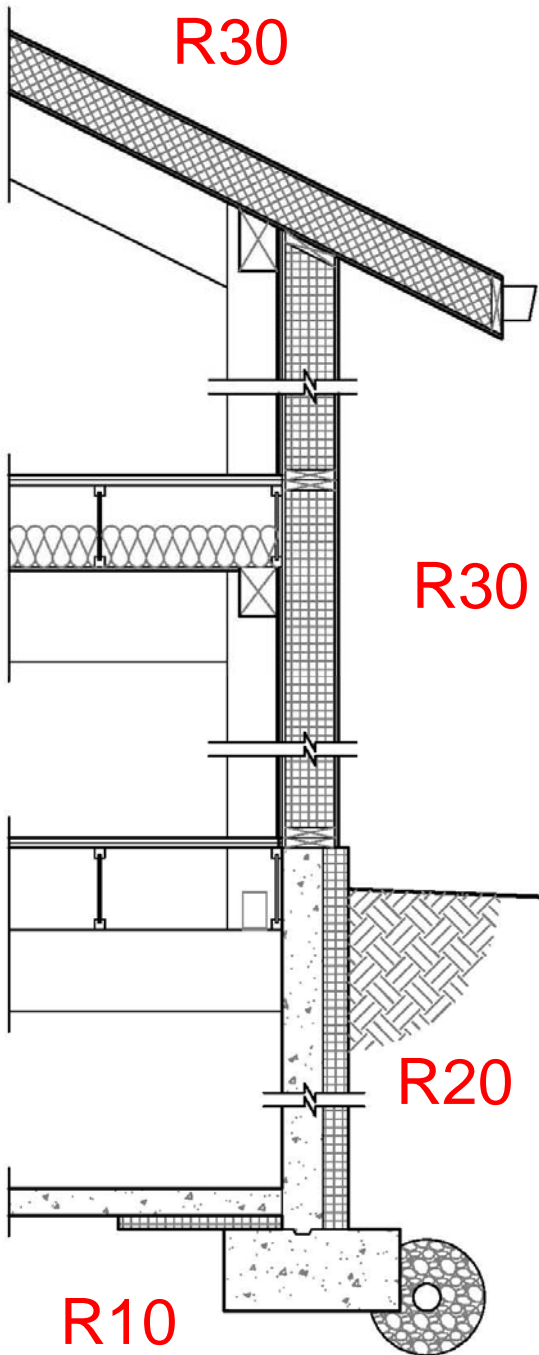
double glazed



Northwest Net Zero

Insulation strategy

- SIP walls and roof (EPS foam)
- XPS at foundation (outside)
- XPS at slab (perimeter)
- house stays 60°F in winter without heating



Northwest Net Zero

Air sealing techniques

- SIP walls and roof
- Tyvek commercial wrap, taped seams
- spray foam at shim spaces and gaps



Northwest Net Zero

Air tightness testing

- window install tested
- blower door test 1.7 ACH50
- duct blaster test
- thermal camera inspection



Northwest Net Zero

Window selection

- triple pane, low-E glass
- aluminum clad exterior
- fir interior
- low U value, low SHGC, low VT




LOEWEN

CASEMENT
LOW E TEMPERED
TRIPLE GLAZING
ARGON GAS FILL
ALUMINUM CLAD FRAME

ENERGY PERFORMANCE RATINGS

| | |
|---------------------|-----------------------------|
| U-Factor (U.S./I-P) | Solar Heat Gain Coefficient |
| 0.23 | 0.22 |

ADDITIONAL PERFORMANCE RATINGS

| | |
|-----------------------|--|
| Visible Transmittance | |
| 0.35 | |

Manufacturer stipulates that these ratings conform to applicable NFRC procedures for determining whole product performance. NFRC ratings are determined for a fixed set of environmental conditions and a specific product size. Consult manufacturer's literature for other product performance information. WWW.NFRC.ORG

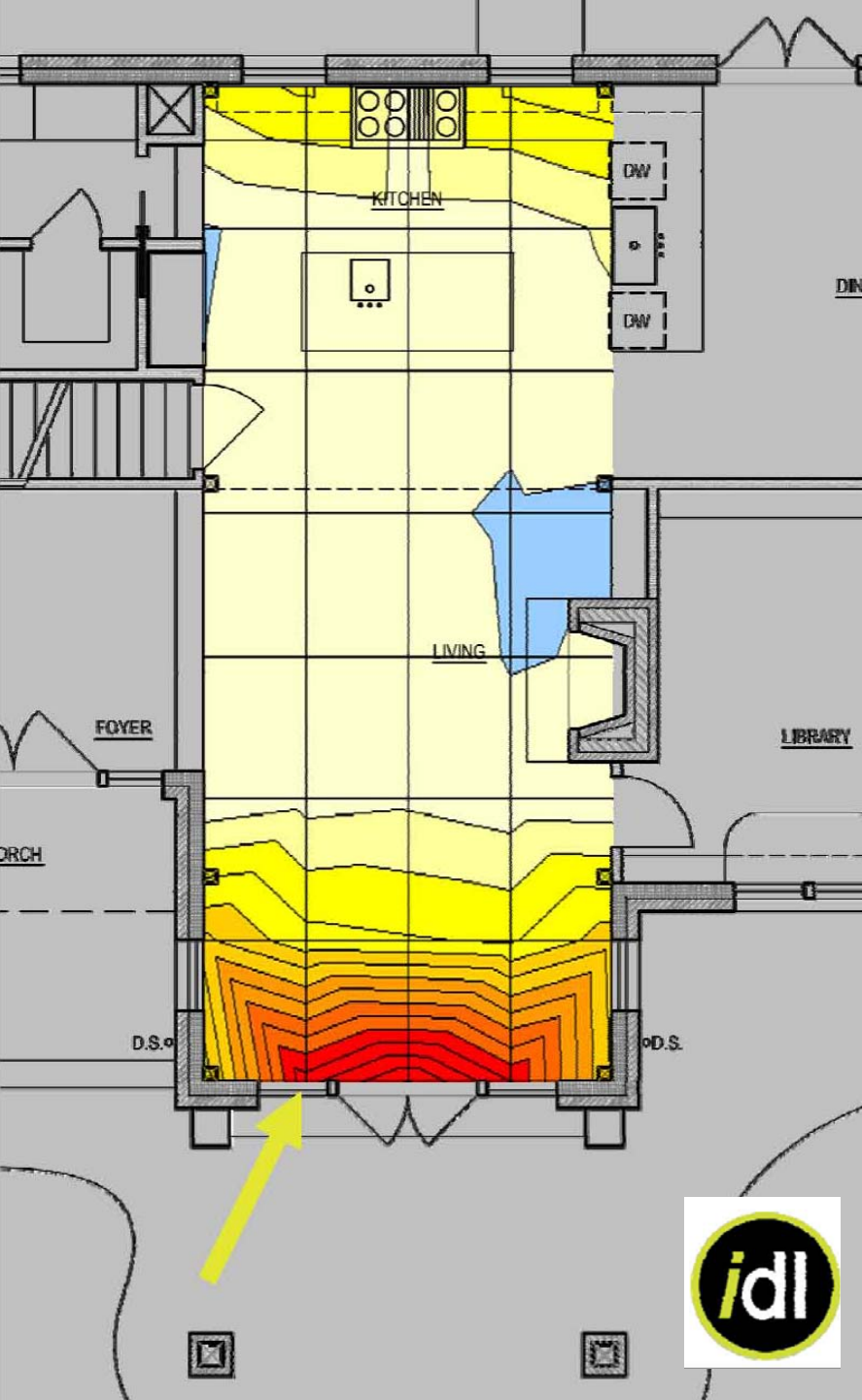
WO# 1010089.024 BATCH: OHM500
006-PC-MC NFRC PCA METAL CLD PERM LABEL
CA1-SINGLE CASEMENT

10/31/08 REMOVE PRIOR TO INSPECTION

Northwest Net Zero

Window placement

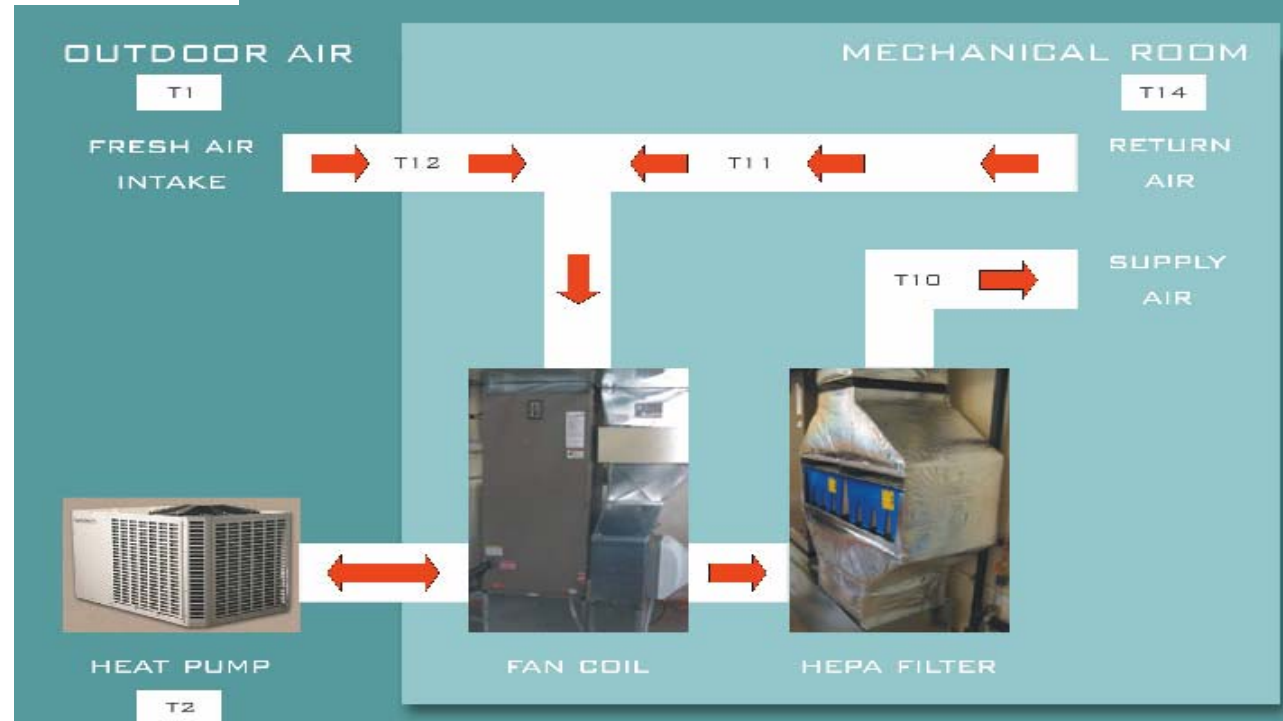
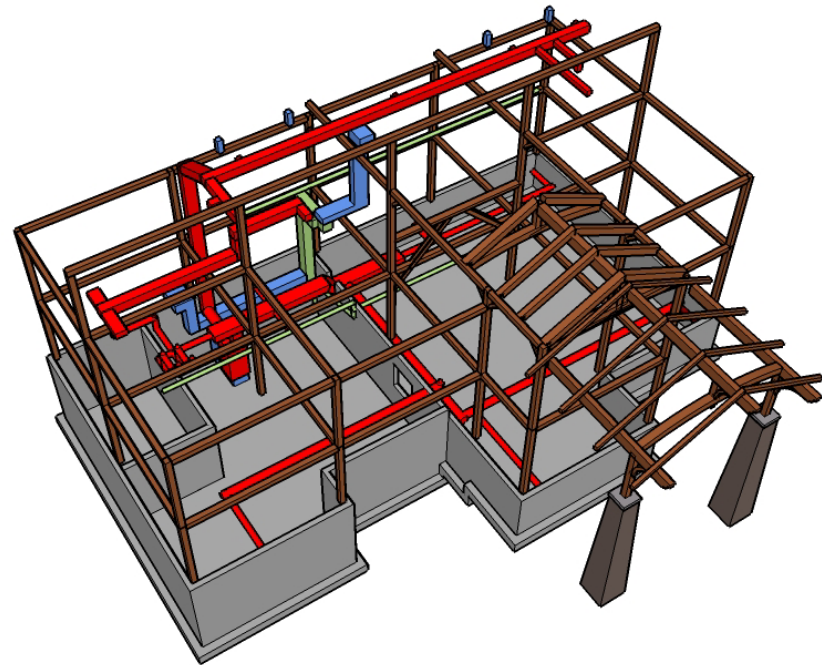
- daylighting study performed
- inside is bright without electric lighting
- overhangs sized for summer shade
- solar strategy: keep sun out



Northwest Net Zero

HVAC system

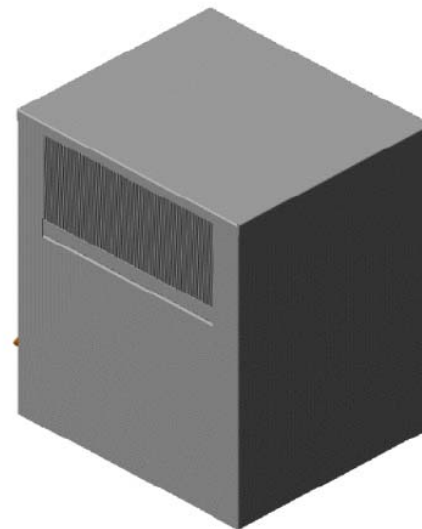
- Hallowell 42C46H air to air heat pump
- 4 cooling tons, 13.6 EER
- 3.9 COP at 47°F
- HEPA filters
- forced air distribution



Northwest Net Zero

Water heating

- AO Smith PXHT-80 electric fired
- 80 gallon tank
- recovery rate 21 gph
- E-Tech R060 heat pump attachment
- located in 60°F workshop
- recovery rate 11 gph
- heat pump water heater never worked



12.45 gpl



Northwest Net Zero



Water and energy fixtures

- LG WM2501HWA washer
- Miele 2430SC dishwasher (two)

Water fixtures Water Sense

- Toto Aqua CST414M dual flush toilets
- Oxygenics 60120 showerheads
- Elkay LK7420NK faucets

5.17 gpl



1.6 / 0.9 gpf



1.5 gpm



2.5 gpm



Northwest Net Zero

Appliances Energy Star

- LG WM2501HWA washer
- Miele 2432SC dishwasher (two)

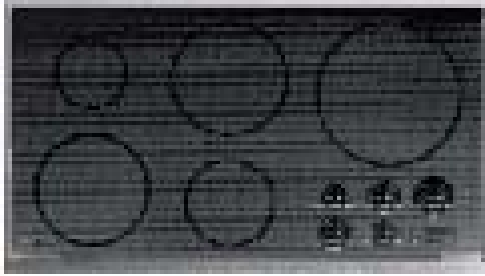
Appliances not Energy Star

- Subzero 632 refrigerator

Appliances never Energy Star

- LG DLEX2501W dryer
- Wolf QRCT36I electric induction cooktop
- Wolf SO30-2U/S-TH ovens (two)
- Wolf PW482418 range hood

?? kWh



684 kWh



?? kWh



339 kWh



124 kWh



Northwest Net Zero

Lighting (kWh / year)

- 69% compact fluorescent
- 30% LED
- 1% incandescent (range hood, security)
- 0.62 installed watts per square foot
- occupancy sensor switches

CFL
flame
\$12
5w

CFL
twist
\$12
23w

Cree
LR6
\$69
12 watts

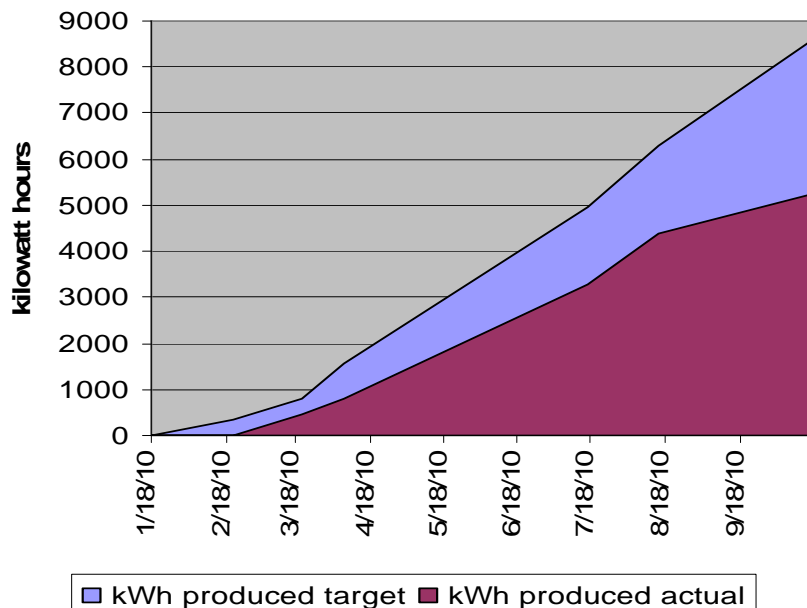


Northwest Net Zero

Photovoltaic power generation

- 8.6 kW array
- Day4 180W panels
- Xantrex GT4.0 inverter
- \$62,000 installed, less \$18,000 tax credit
- expected to generate 9800 kWh per year
- actual generation lower this year (haze?)

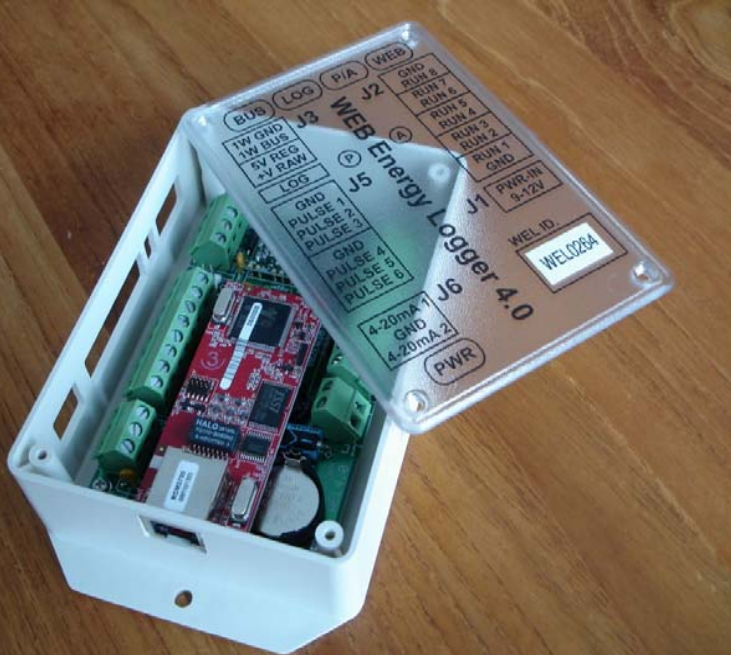
NWN0 PV ACTUAL VS. PROJECTED



Northwest Net Zero

Energy use tracking

- WEL processor / logger
- 14 temperature sensors
- 12 current sensors
- 1 water flow sensor
- www.welserver.com



\$325



\$15



\$200

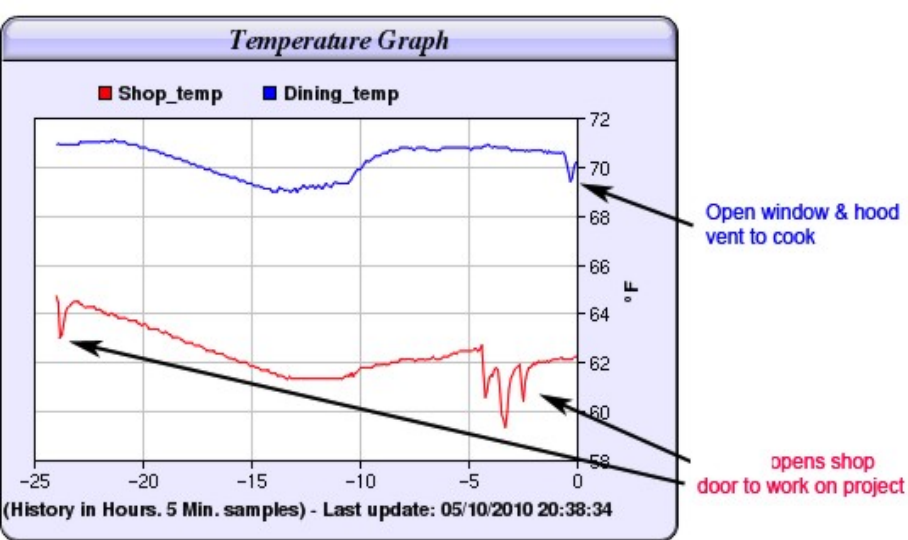


\$23

Northwest Net Zero

Energy use tracking

- customized web page
- logs by minute to by year
- will hit net zero target ?



EQUIPMENT



C1

HEAT PUMP



C3

FAN COIL



C2

WATER HEATER



C6

RAIN PUMP



C7

RAIN UV

Northwest Net Zero

Public education

- lectures
- publications
- no tours (owner wants privacy)
- video filmed for educational DVD
- donations to video welcome!



Northwest Net Zero

Project failures

- not tracking to net zero
- energy simulation overly optimistic
- energy monitoring not yet installed
- owner burnt out after construction
- GMP contract did not curb costs
- heat pump water heater defective
- HVAC equipment outside envelope
- PV panels underproducing
- mud in rainwater piping
- dust management in construction
- nanoparticle shingle stain failing
- disqualified from Built Green 4 Star

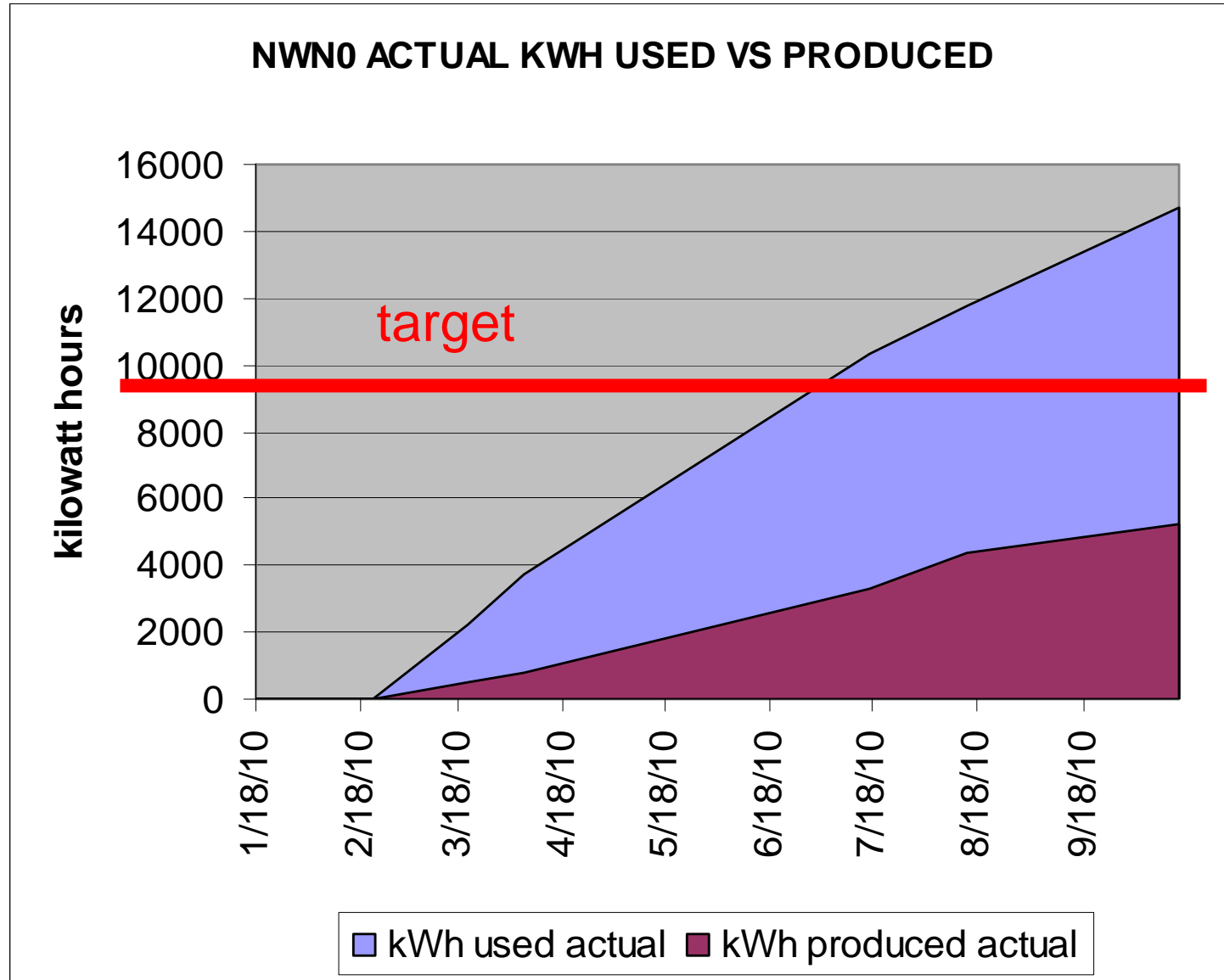
Project successes

- house is 1000 s.f. smaller than former
- house uses 1 / 4 the energy of former
- warm in winter
- cool in summer
- dry year round
- architecture is beautiful (per owner)
- room layout is functional (per owner)
- HVAC is quiet
- HVAC is clean
- airtight envelope (1.7 ACH50)
- commercial quality construction
- low water fixtures work fine
- earth coupled wine cellar stays cool
- LEED for Homes platinum certified

actual EUI
27 kBTU / s.f. /year

Northwest Net Zero

The bottom line



Question & Answer

Northwest Net Zero

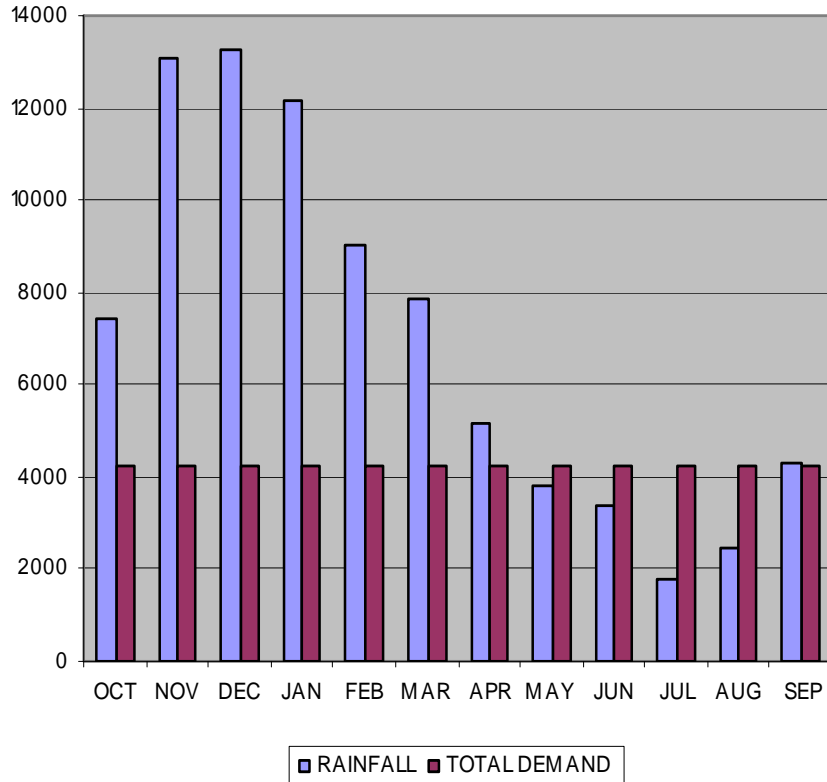


Northwest Net Zero

Rainwater harvesting systems

- 100% of indoor use, including potable
- 84,000 gallons of rain per year from roof
- 50,000 gallons of usage per year
- 5,100 gallon underground cisterns
- 1 micron filter, UV sterilization
- about \$25,000

MONTHLY COLLECTION VS. DEMAND



Northwest Net Zero

Dust management failure

- don't use wallboard saws
- do ventilate with fans out window
- do cover ducts
- it's a house not a construction site
- disqualified from Built Green 4 Star



Northwest Net Zero

Fireplace problem

- desired for lodge style
- heat source in power outage
- two stories tall
- built as a masonry heater
- draws fresh air from outdoor duct but...
- largest air leak through glass doors
- thermal bridge through roof
- thermal bridge at footing



Northwest Net Zero



Embodied energy of foundation concrete

- projected energy use of entire house for 1 year = 9915 kWh
- $9915 \text{ kWh} \times 3412 \text{ BTU/kWh} = 34 \text{ million BTU}$
- manufacturing 1 ton of Portland cement requires 6 million BTU
- 1 yard of typical concrete (5-1/2 sack) contains 517# of cement
- concrete mix for house used only 370# of cement per yard, saving 147#
- concrete quantity for this house is around 90 yards installed
- $90 \text{ yards} \times 147\# = 13230\# / 2000\# = \text{about } 6.5 \text{ tons of cement saved}$
- $6.5 \text{ tons of cement} \times 6 \text{ million BTU / ton} = 39 \text{ million BTU saved}$ by using low cement, high flyash concrete mix
- 39 million BTU > 34 million BTU, which means the concrete mix alone saved enough energy to power the house for more than a year!