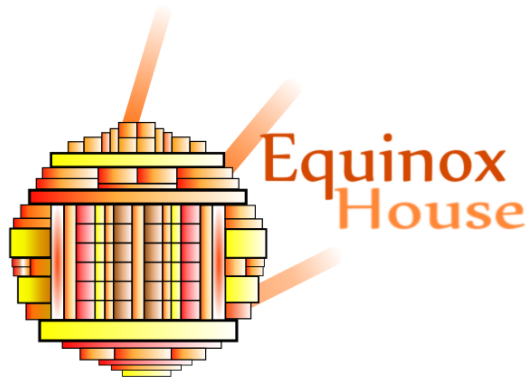


# Greener Homes National Summit

## Characteristics and Cost Effectiveness of Net Zero Residential Design

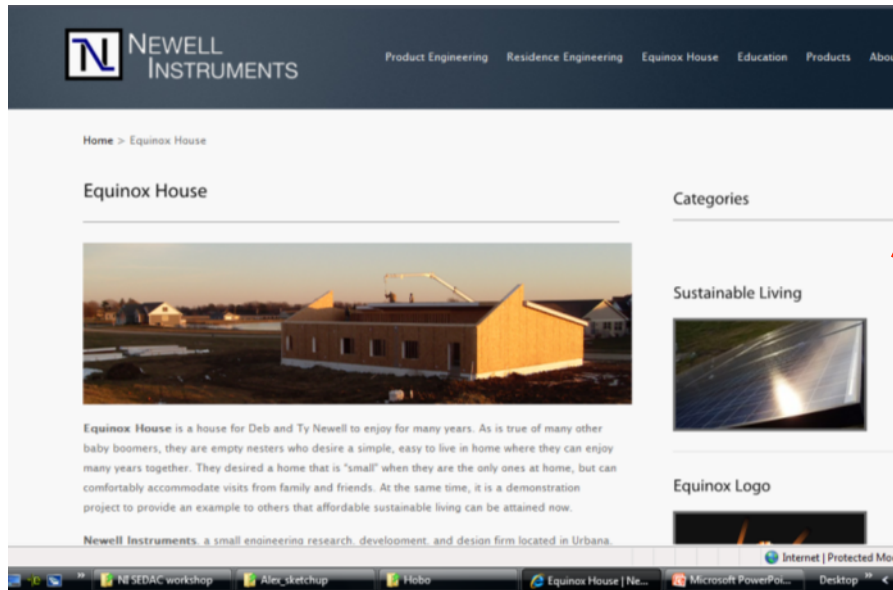


Net Zero and Passivhaus Session  
September 28 2011

Ty Newell  
Professor Emeritus  
Mechanical Science and Engr  
University of Illinois at Urbana-Champaign  
and  
Newell Instruments, Inc  
[newellinstruments.com](http://newellinstruments.com)

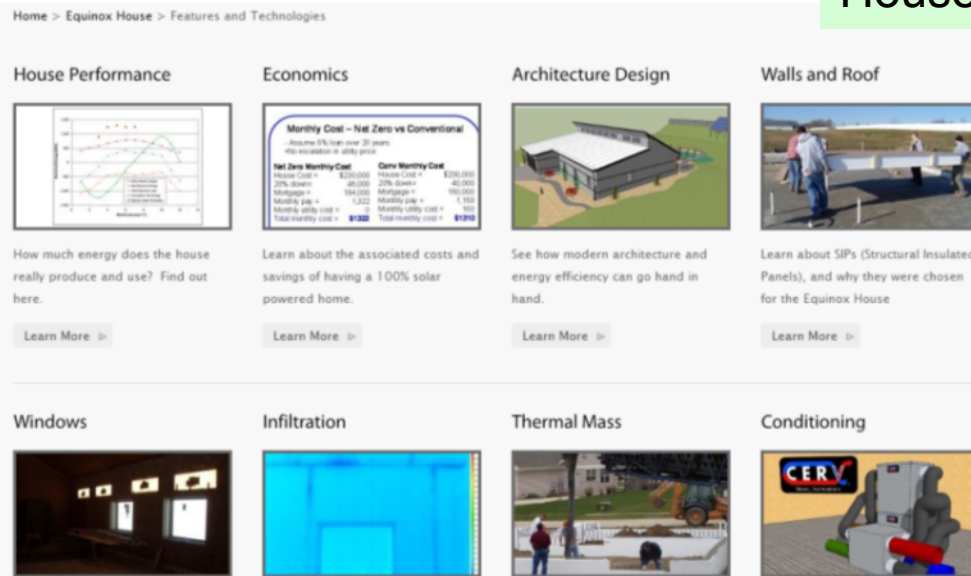
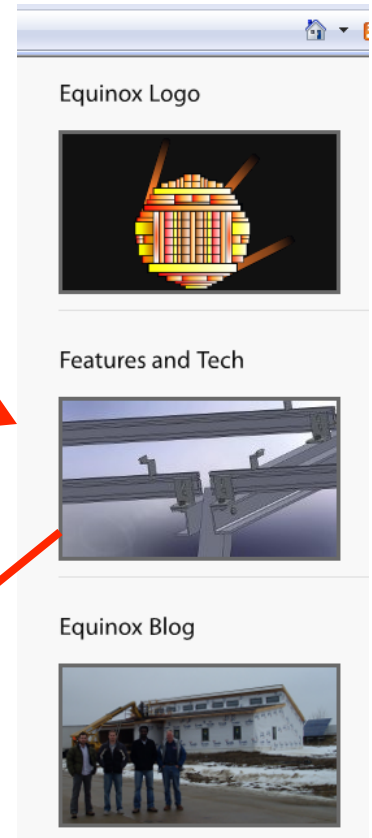


# VISIT [newellinstruments.com/equinox](http://newellinstruments.com/equinox)



Resources and background material

Many "features" of Equinox House described



ASHRAE Journal 12 month article series on design, performance and cost



# Newell Background

- Renewable Energy
- Energy Conservation
- Energy Efficiency
- Resource Conservation



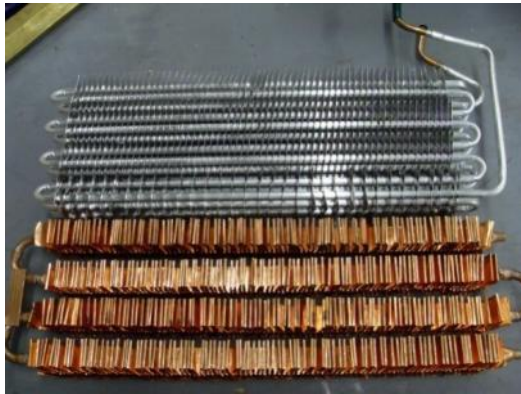
Grad school 1970' s



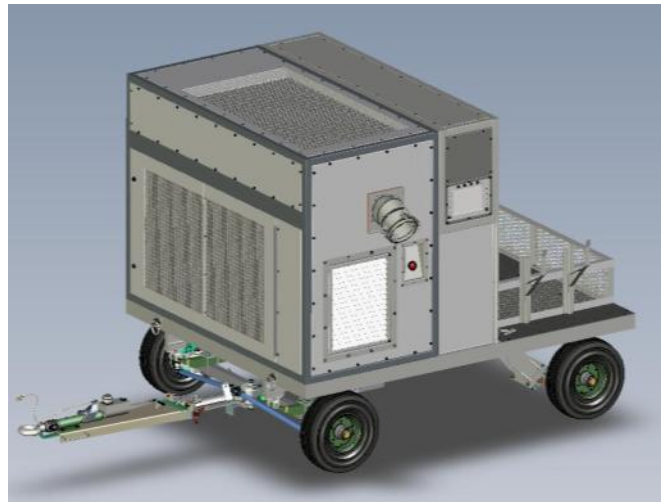
Univ of Illinois Solar Lab  
1980' s



# Newell Instruments



appliances



military cooling systems



automotive



NI Laboratory is  
solar powered  
**We believe in solar!**



# Equinox Project Motivation and Objectives

- Newell Instruments: Combine our knowledge of building sciences and air conditioning/heating to create products for meeting the energy needs of super efficient homes

- Residential fresh air system



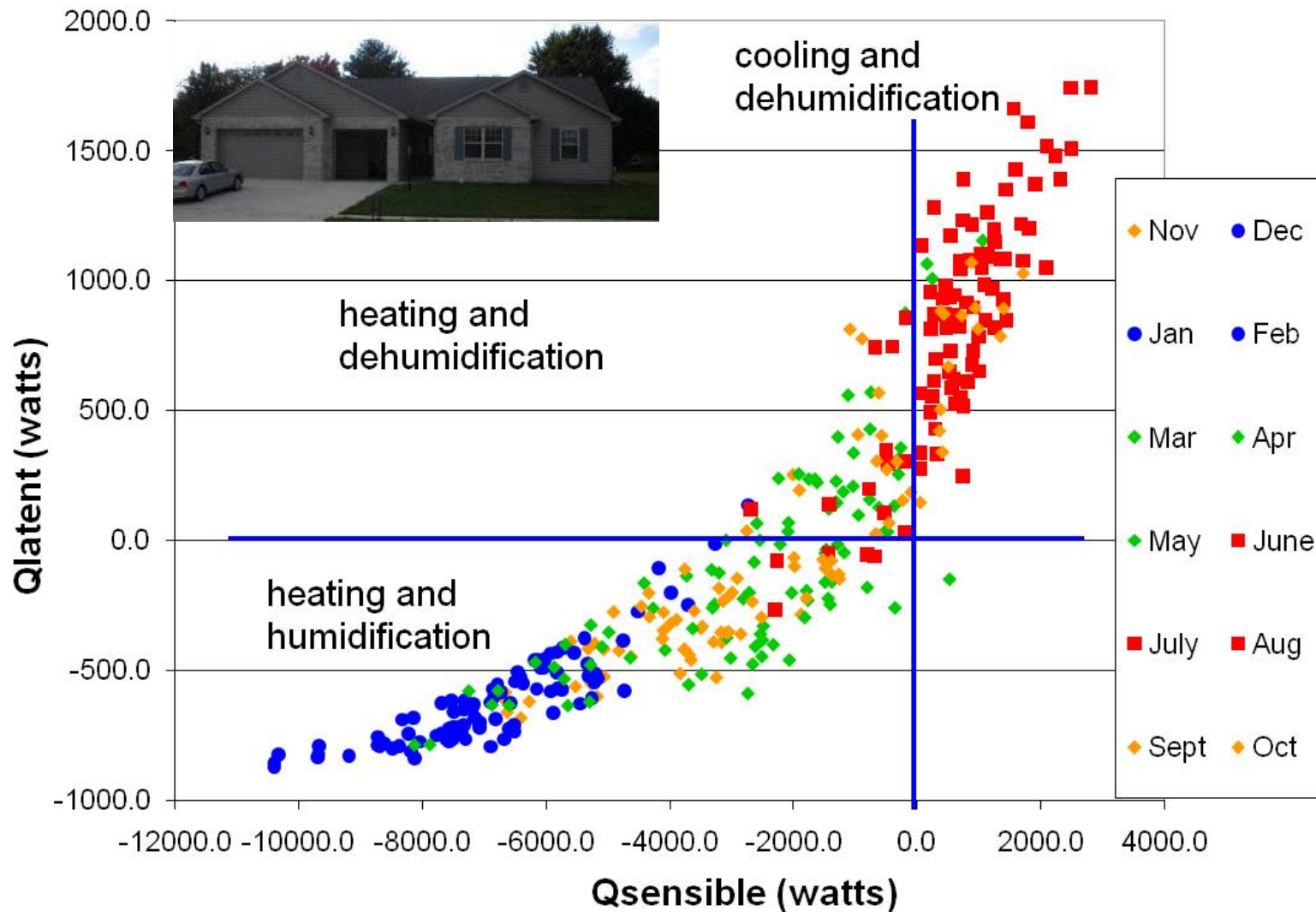
- Demonstrate that an energy efficient home can be fully powered (house and transportation) by solar energy in a cost effective manner ... even in central Illinois

- Learn home construction costs and processes firsthand

- File **lots** of permit applications
- Fill out **lots** of lien waivers
- Schedule **lots** of inspections
- Write lots & **lots** of checks!

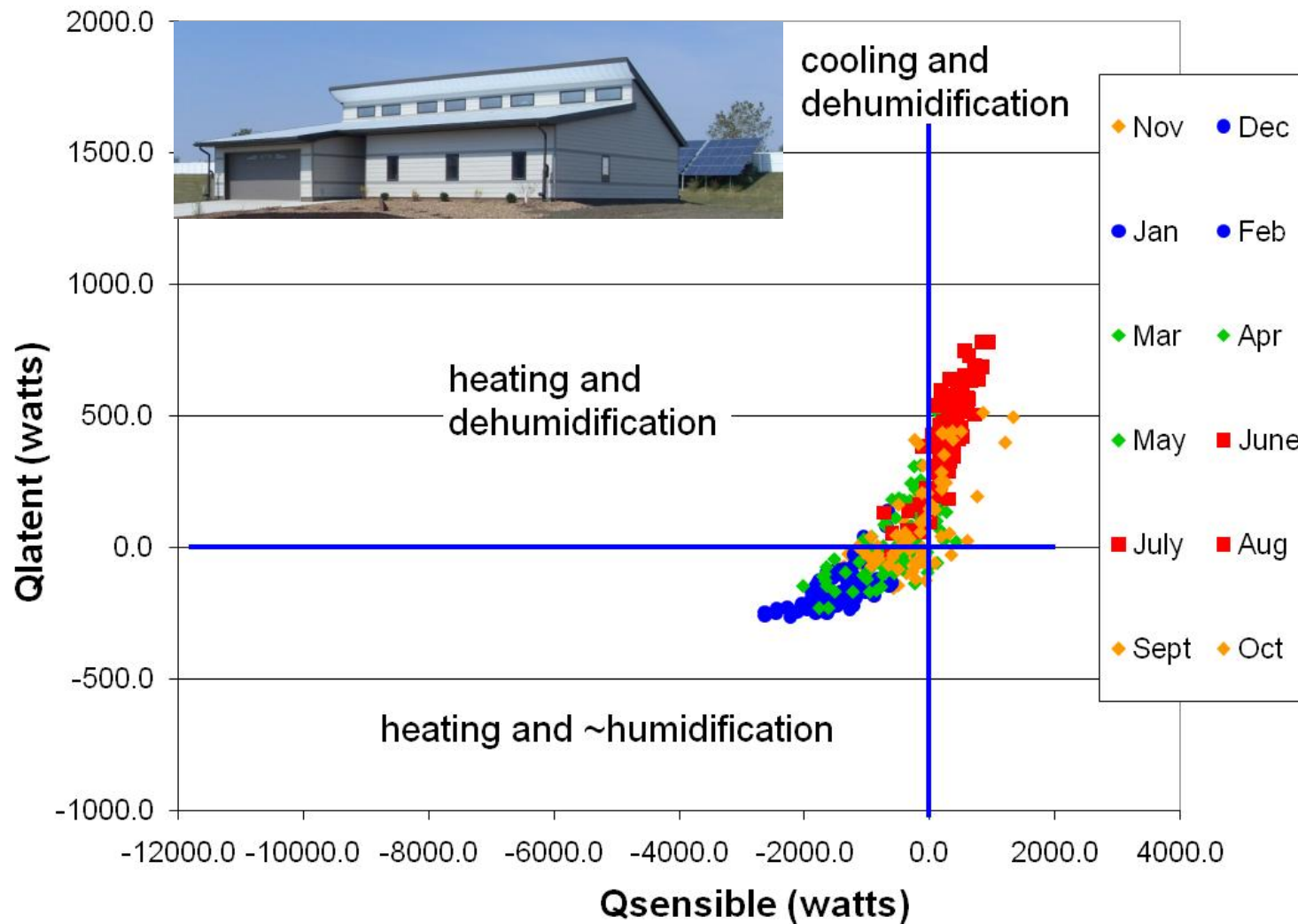


# “Conventional” House 2100sqft Climate Dominated Energy

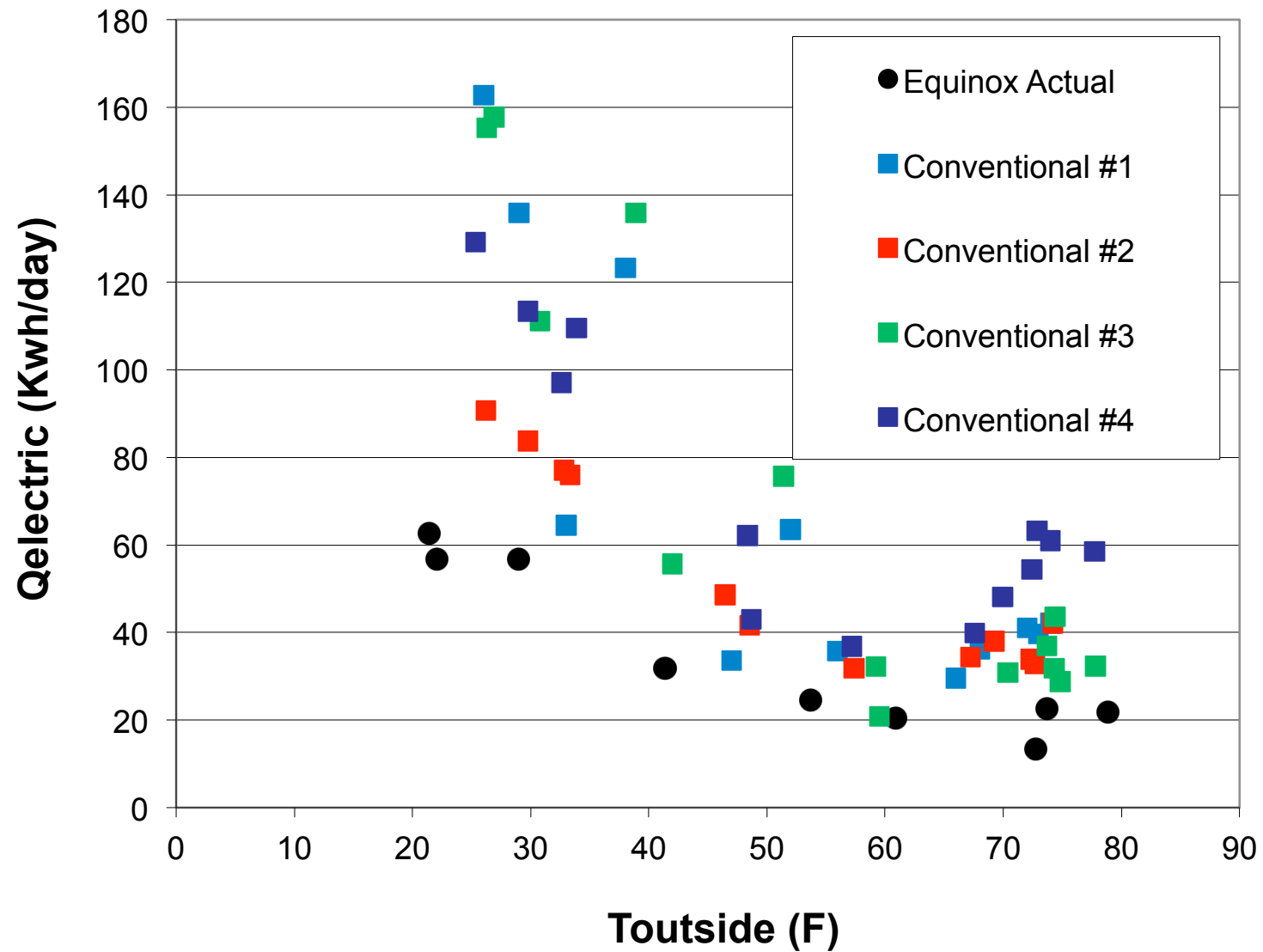


# Equinox House 2100 sqft

## People & Appliance Dominated Energy

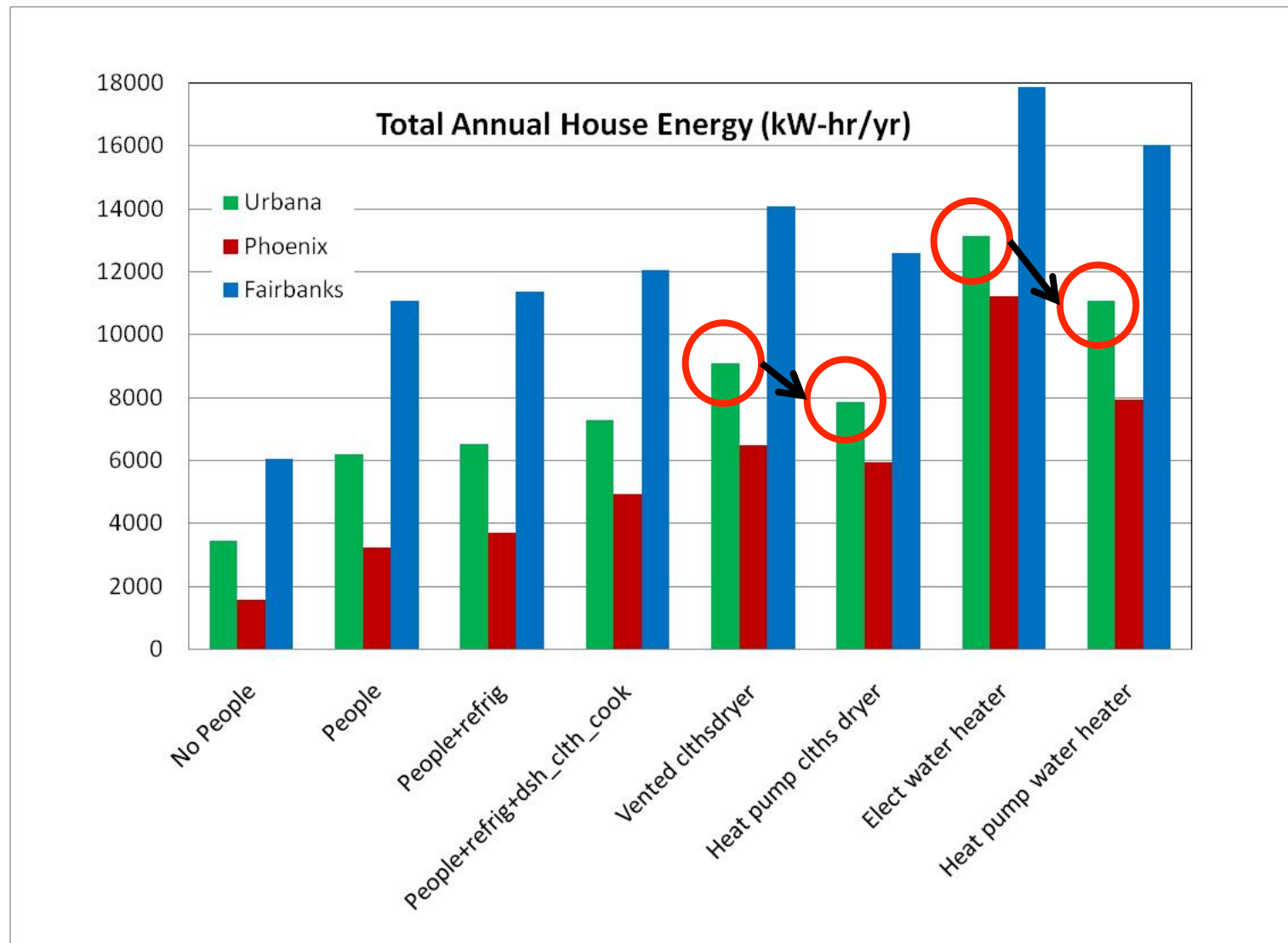


# Comparison of Energy vs Temperature





# People – 2/3 House Energy



# Solar Powered Dwelling

- Lots of insulation ....R40 to R50 (12 inch thick walls and roof)
- Adequate windows for light and view
  - Triple to quadruple glazed, low e
- Supersealed with filtered fresh air, controlled ventilation
- “Flexible” conditioning system (large variation of sensible to latent ratios)
- **Details are extremely important!** Construction must be monitored closely with performance/quality test validation



# Do High Performance Homes HAVE to Look Different?

Newell Instruments super performance  
designed home for a Minneapolis area developer



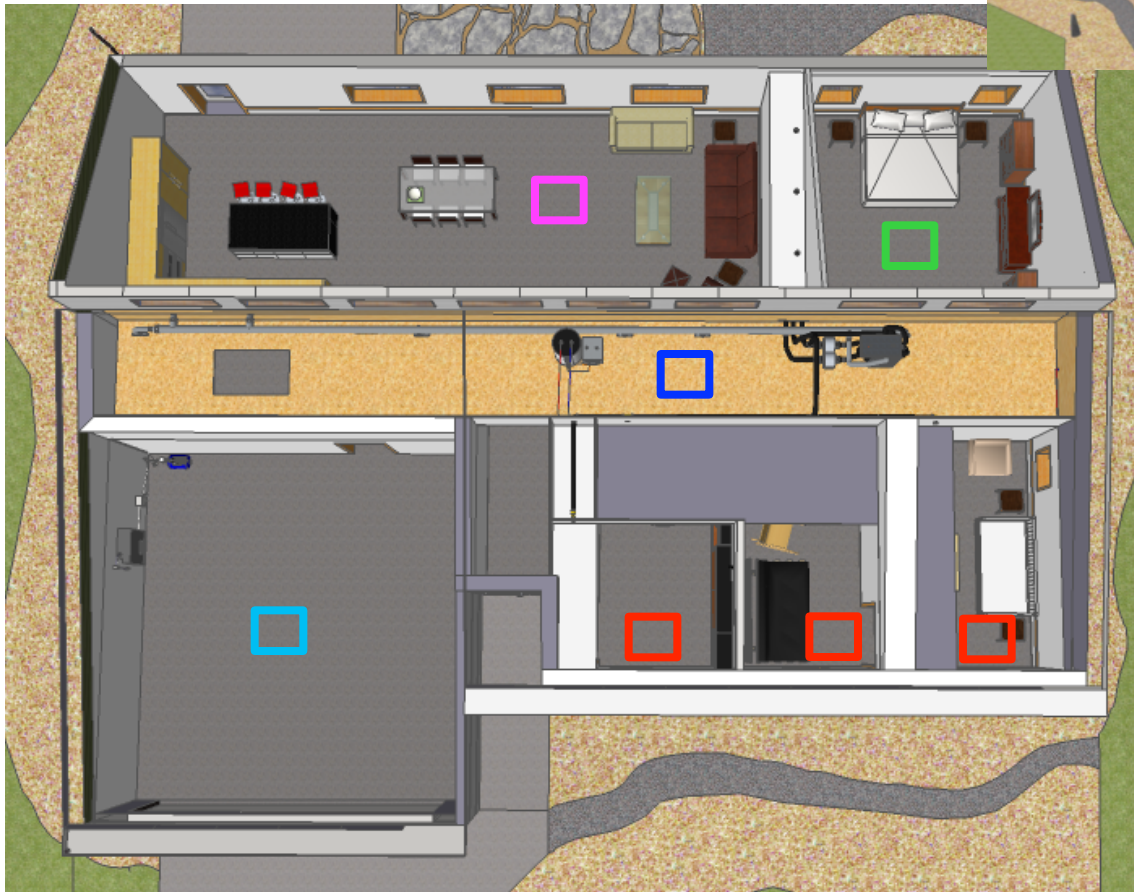
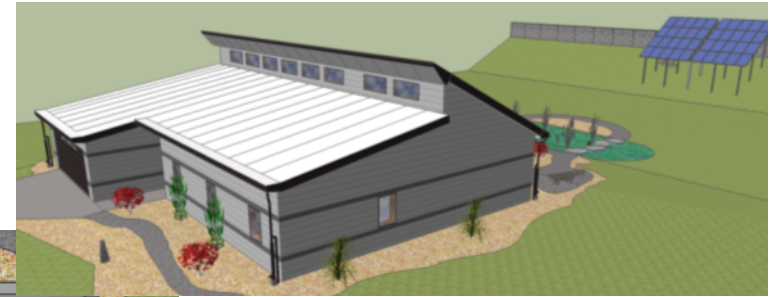
Location: Minneapolis  
Annual Energy = 8000 kWh



2000 sq ft, 3 Bd, 2 1/2 Bath



# Equinox House Floor Plan



- Open Living
- Master Bedroom
- 3 Bedrooms
- Utility corridor  
(bathrooms,  
laundry, pantry)
- Garage



# Single Story, Slab Floor Construction

~2100 sqft Living ~500 sqft Garage



- Easy-to-maintain design (accessible electric, plumbing, ductwork)
- 4 bedrooms (master and 3 small bedrooms)
- 2 ½ baths (modest size)
- Open living space floor plan



# SIPs

## Structural Insulated Panel



- 1<sup>st</sup> panel installed
- Walls and roof 12 in thick, ~R44
- Follow the numbers, ~80 panels (walls and roof total)
- Heaviest panel (8ft by 24ft) weighs ~400lb
- Minimal waste, whole house up in 1 week

# Shell Completion



Roof Paper



House wrap

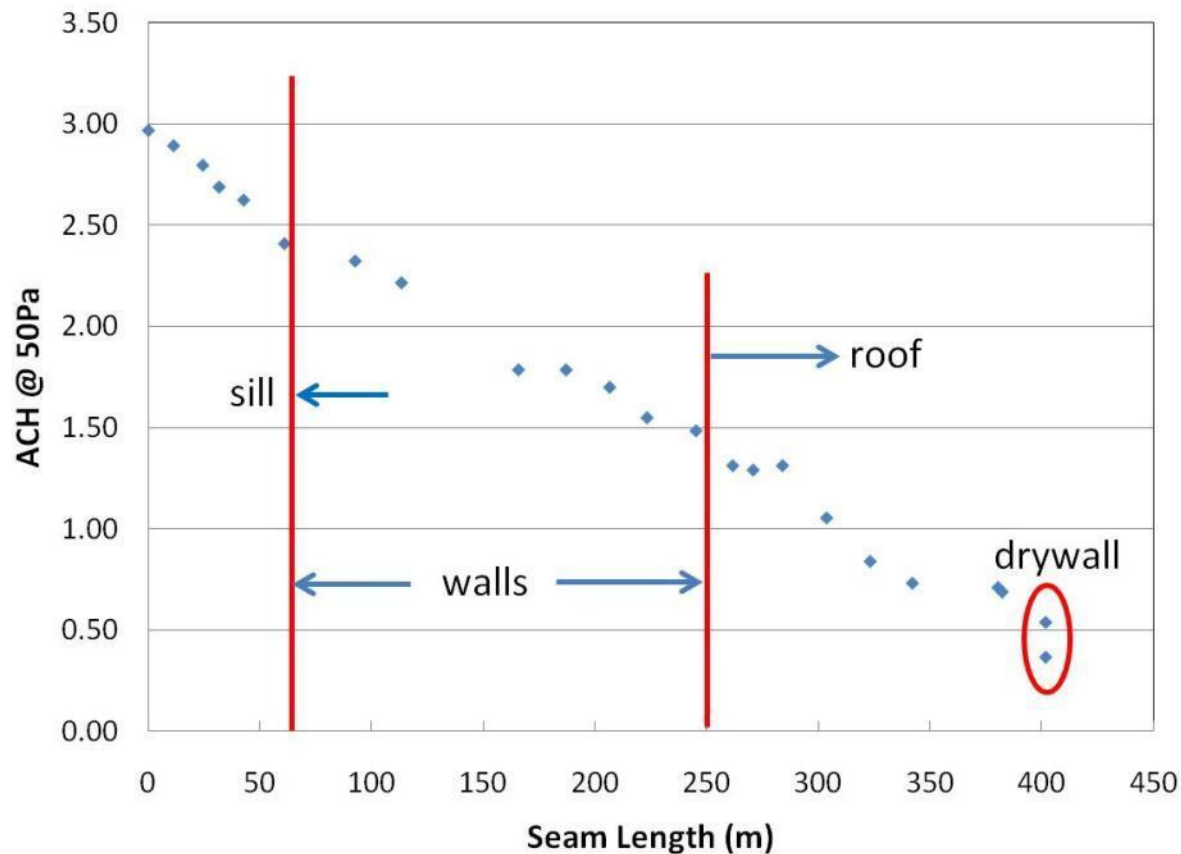


Windows



# Supersealing and Infiltration Testing

The best design will not perform as desired unless built with quality **that is verified**





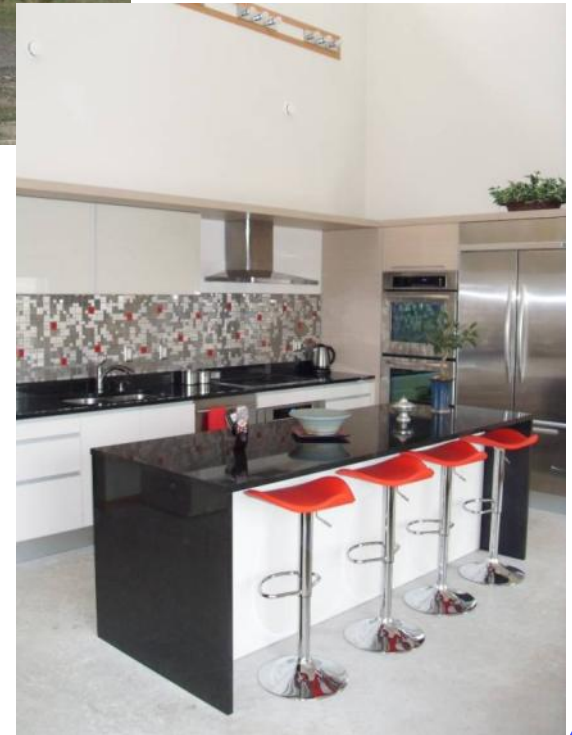
# House Completed and Inspected Nov 19



Main construction completed July 2010

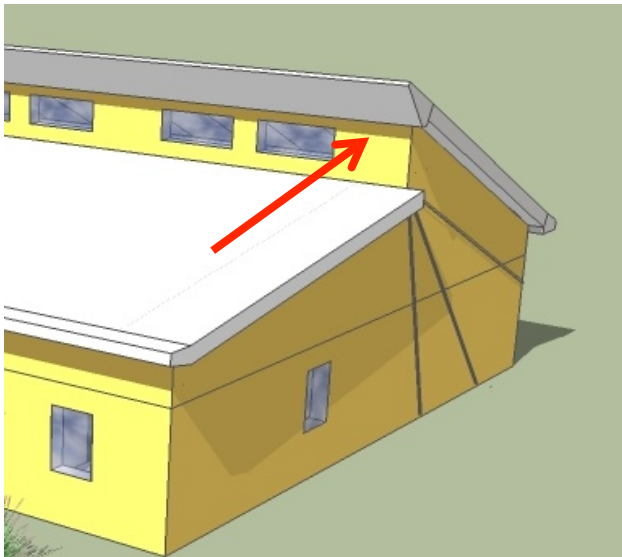
....but, custom Italian cabinets delayed  
until November (“eco modern”  
Demode by Valcucine)

Luxury and Sustainability are not  
mutually exclusive

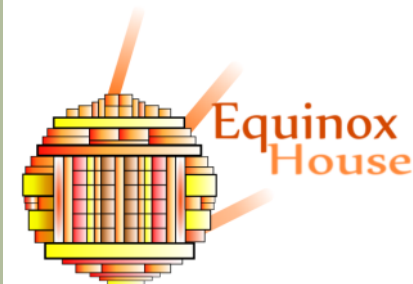


# Outdoor Shading

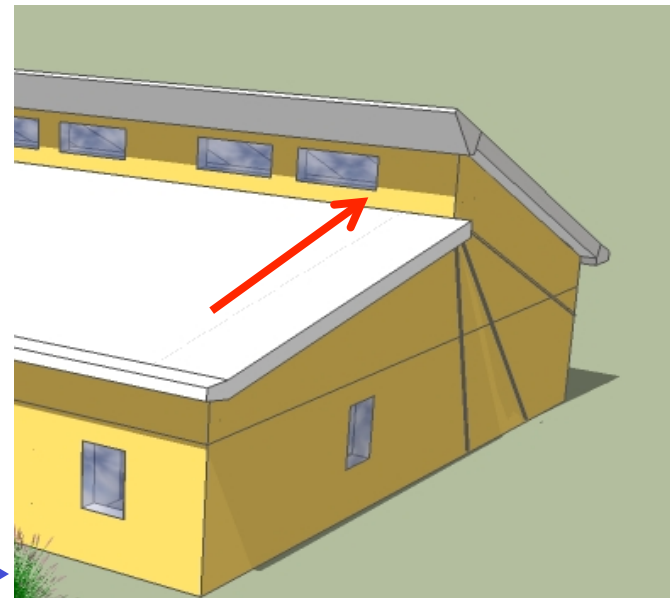
For Illinois, equinox is a good time to shade & unshade



Clerestory shading on March 21  
and September 22



Clerestory shading on April 14  
and September 1



# Indoor Daylighting



**Winter Solstice** pattern  
(Dec 21) near sunset

**Fall Equinox** pattern  
(September 22)  
Direct Sunlight enters  
for first time since  
spring



# Lighting



All lighting are mercury free  
LED bulbs

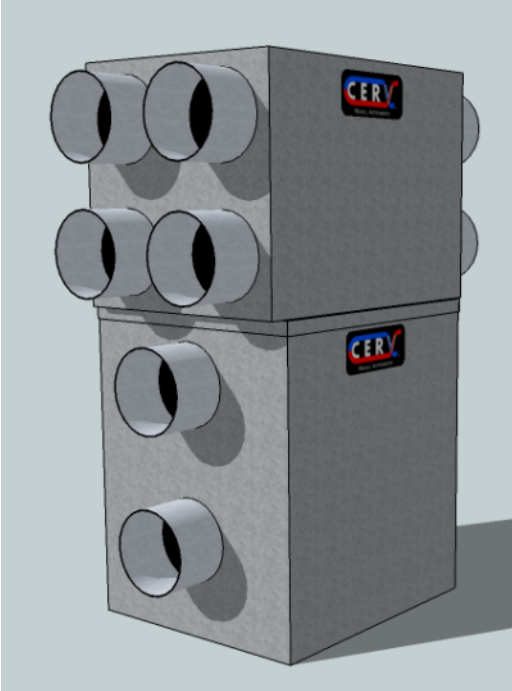


Wireless switches eliminate electrician's holes through walls





# Comfort Conditioning Systems



The next generation of building conditioning systems designed for the next generation of buildings

- CERV to serve (Conditioning Energy Recovery Ventilator)
- Multi-functioned fresh air/heat pump/air conditioner/energy recovery
- More “appliance” than house air conditioner
- “Smart” algorithms; demand ventilation, “free” conditioning, energy efficient defrost



# Comfort

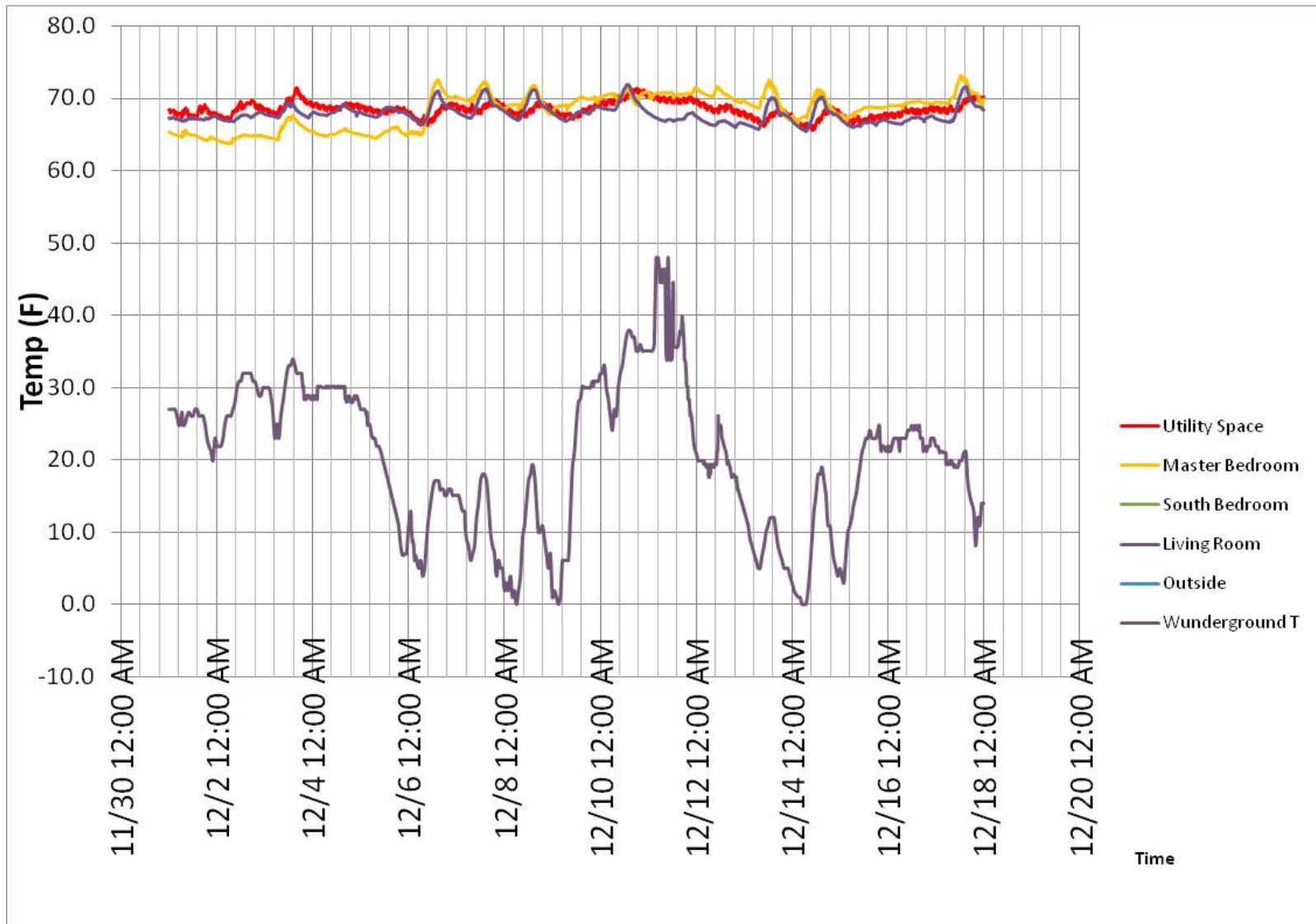


Superinsulating and supersealing creates very uniform interior temperatures and comfort

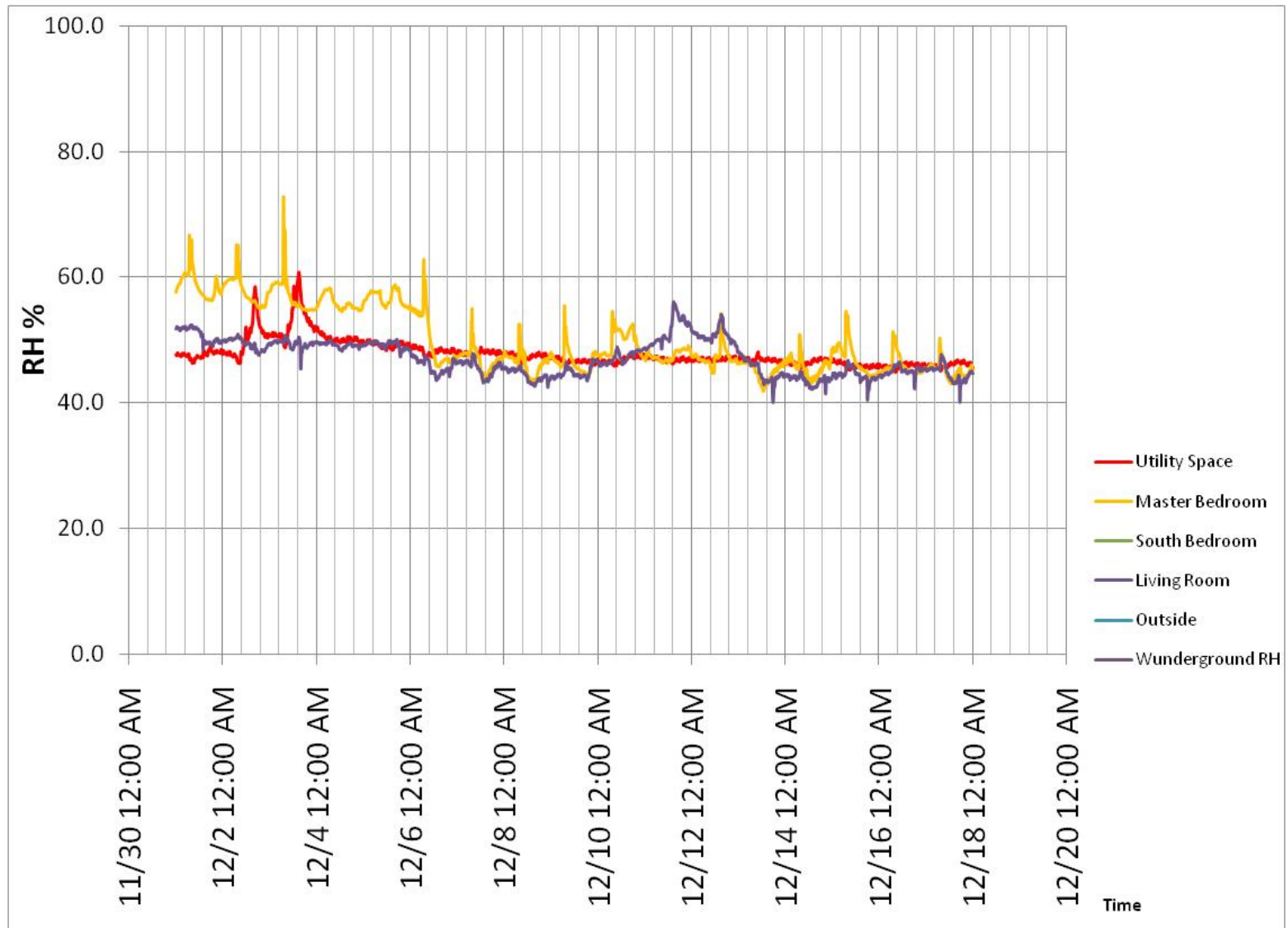
- 20 ft ceiling and concrete floor within 2-3F all year with no ceiling fans!



# Interior Temperatures



# Interior Humidity





# Clean, Filtered Fresh Air

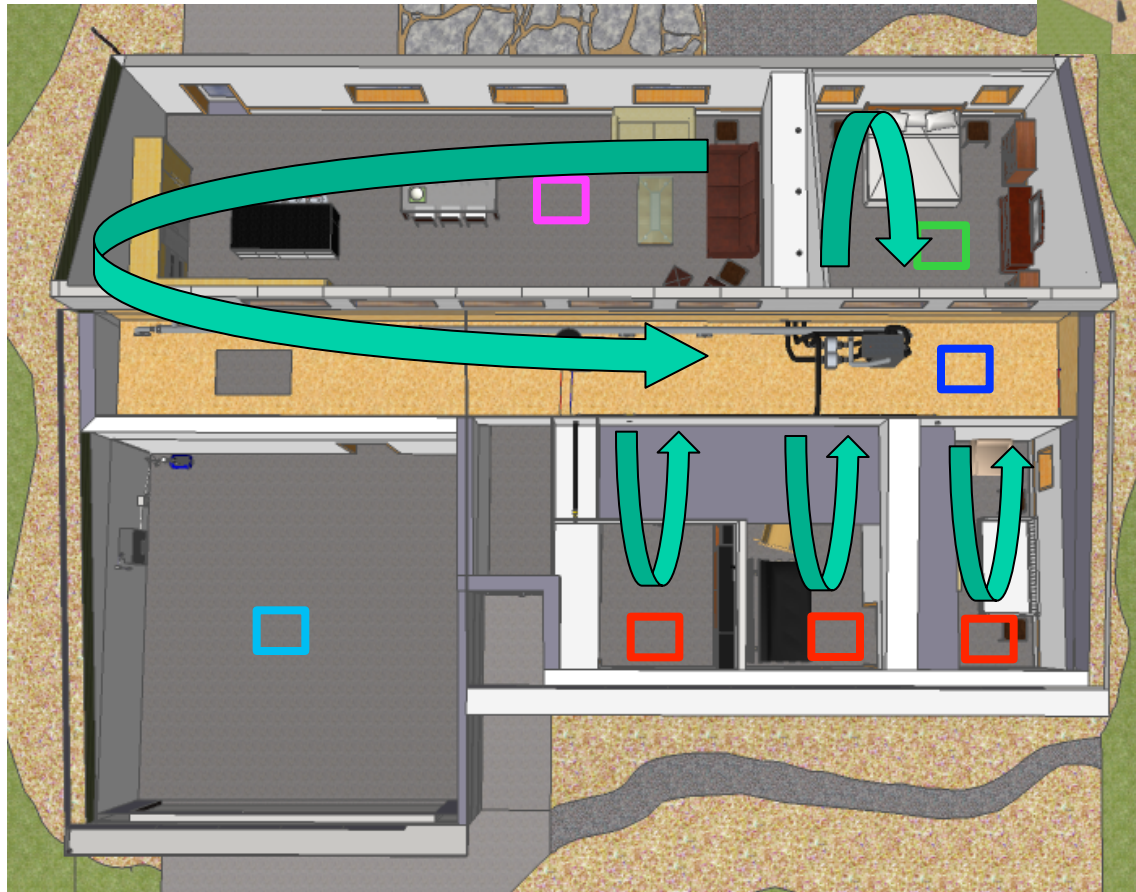


- Continuous fresh air and exhausted stale air
- All fresh air is filtered
- Maintain low levels of CO<sub>2</sub>, VOCs and radon
- Use “free” conditioning when outside is nice

# Fresh Air “Purges” House

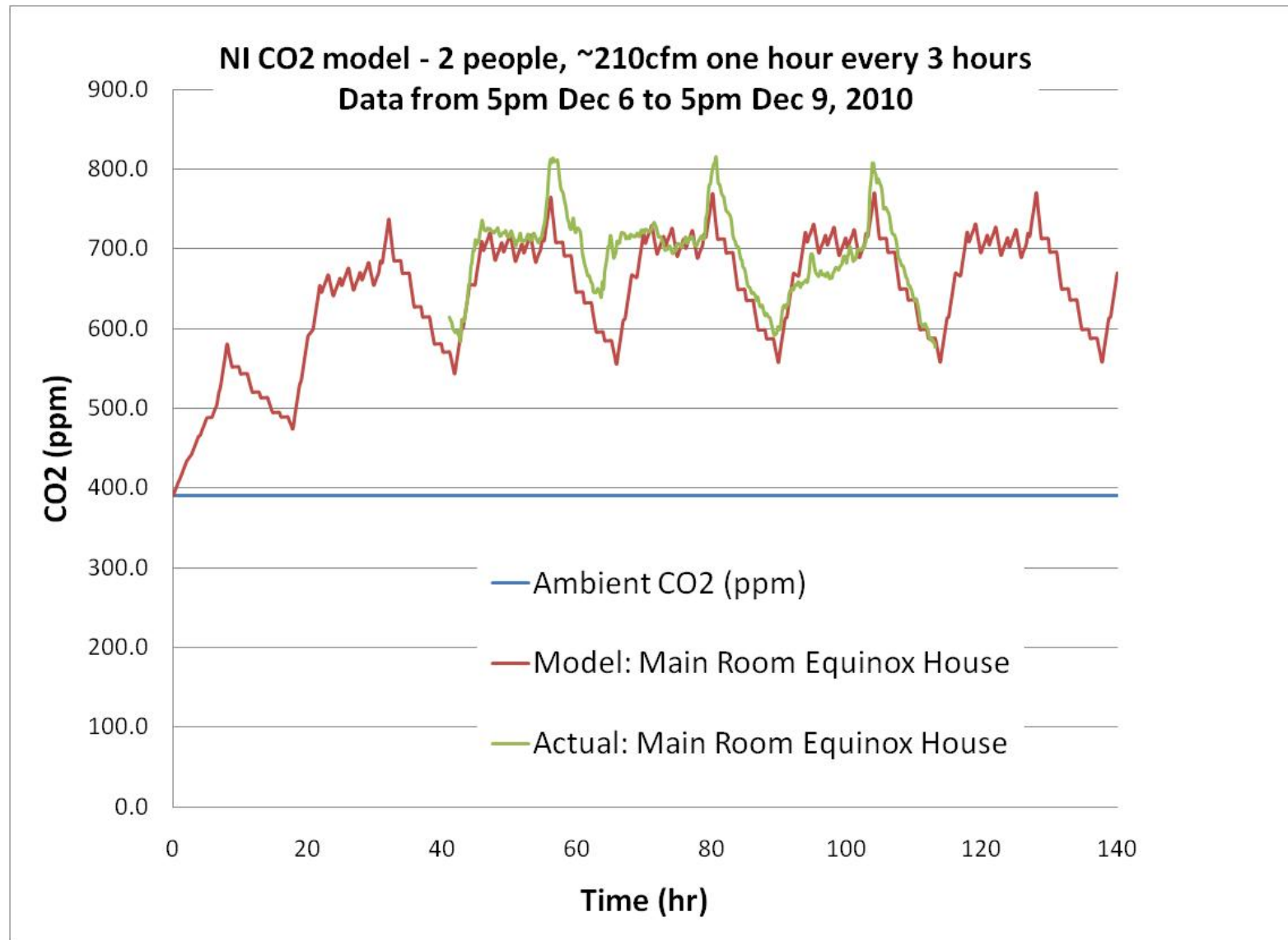
Supply fresh air to living and bedroom areas

Exhaust from kitchen, laundry and bathrooms

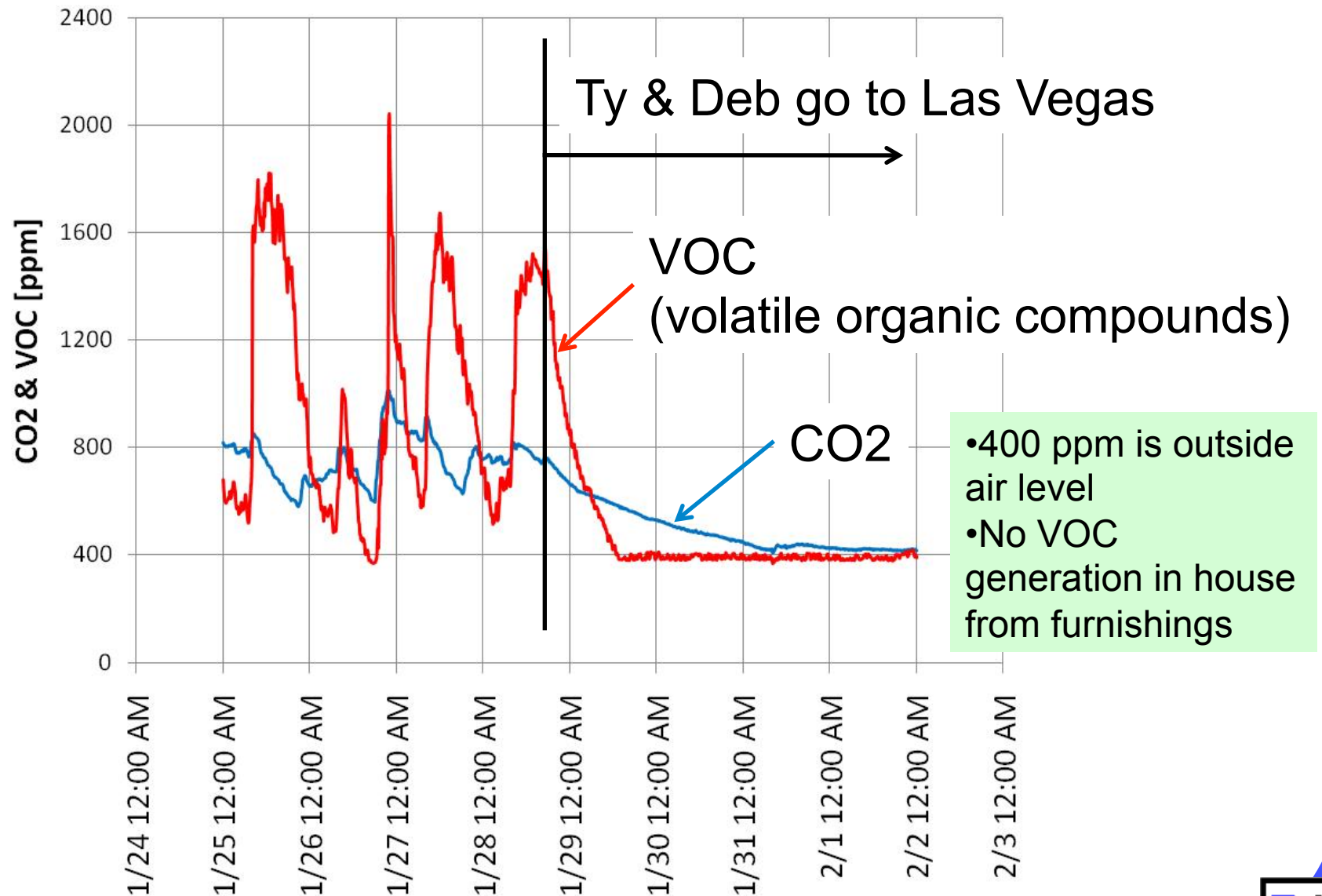


- Open Living
- Master Bedroom
- 3 Bedrooms
- Utility corridor  
(bathrooms,  
laundry, pantry)
- Garage

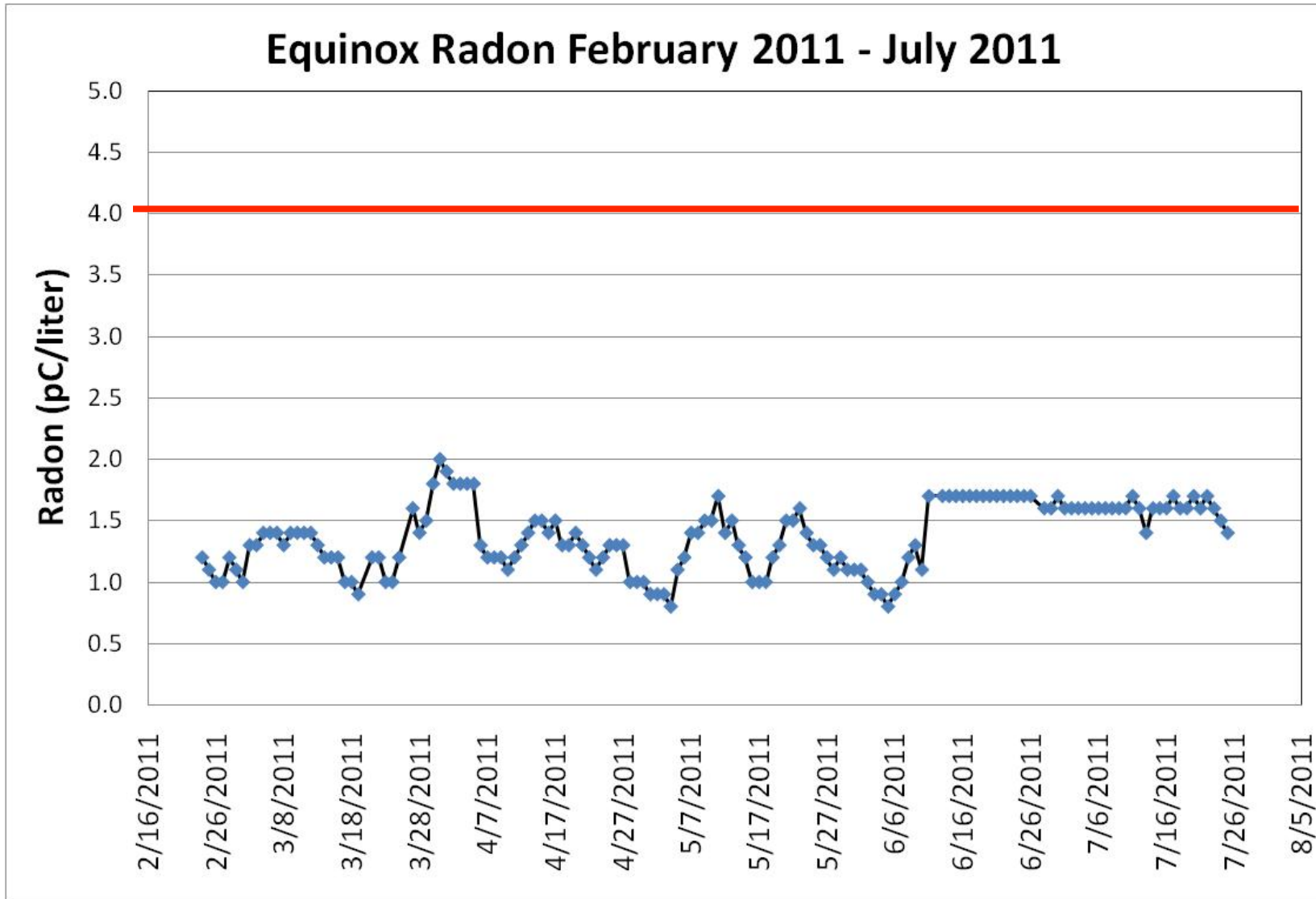
# Fresh Air- Carbon Dioxide



# Fresh Air – VOCs



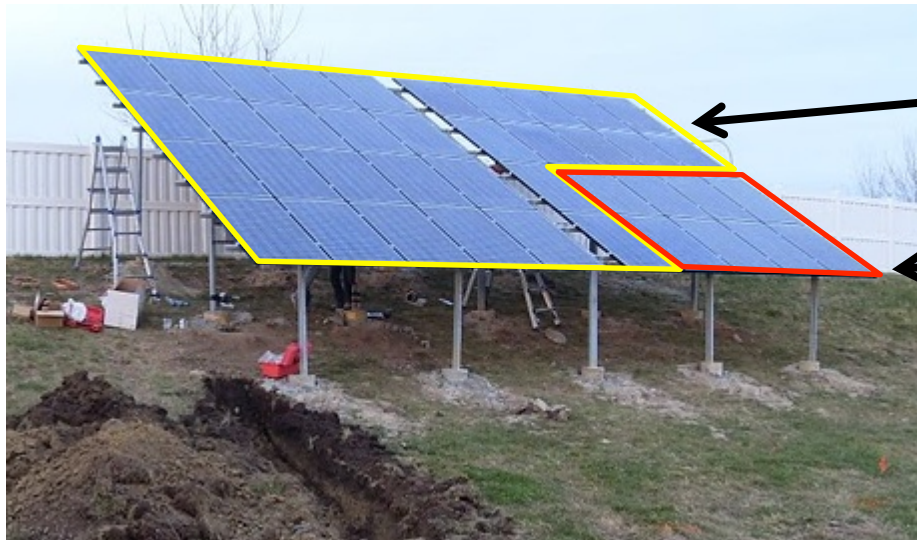
# Fresh Air- Radon





# Solar System Installation

8.2kW nominal system size  
~4 days to install rack and panels  
~600 to 750 sqft  
~10,000kWh per year  
8000kWh for house  
2000kWh for electric car



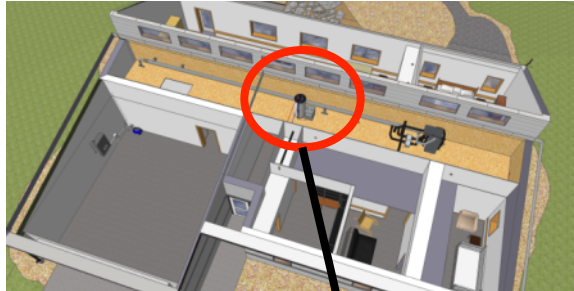
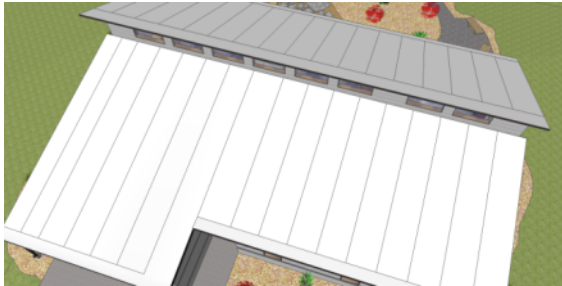
House panel area

Car panel area (8000  
miles per year)

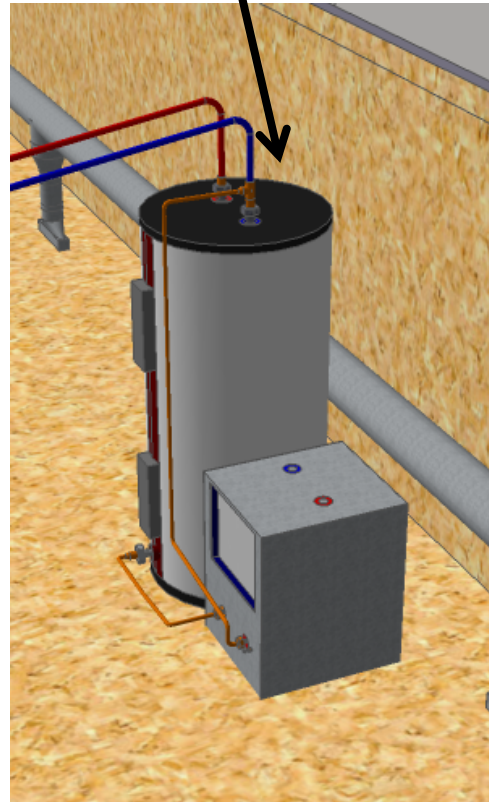
SOLAR ENERGY  
built Equinox House



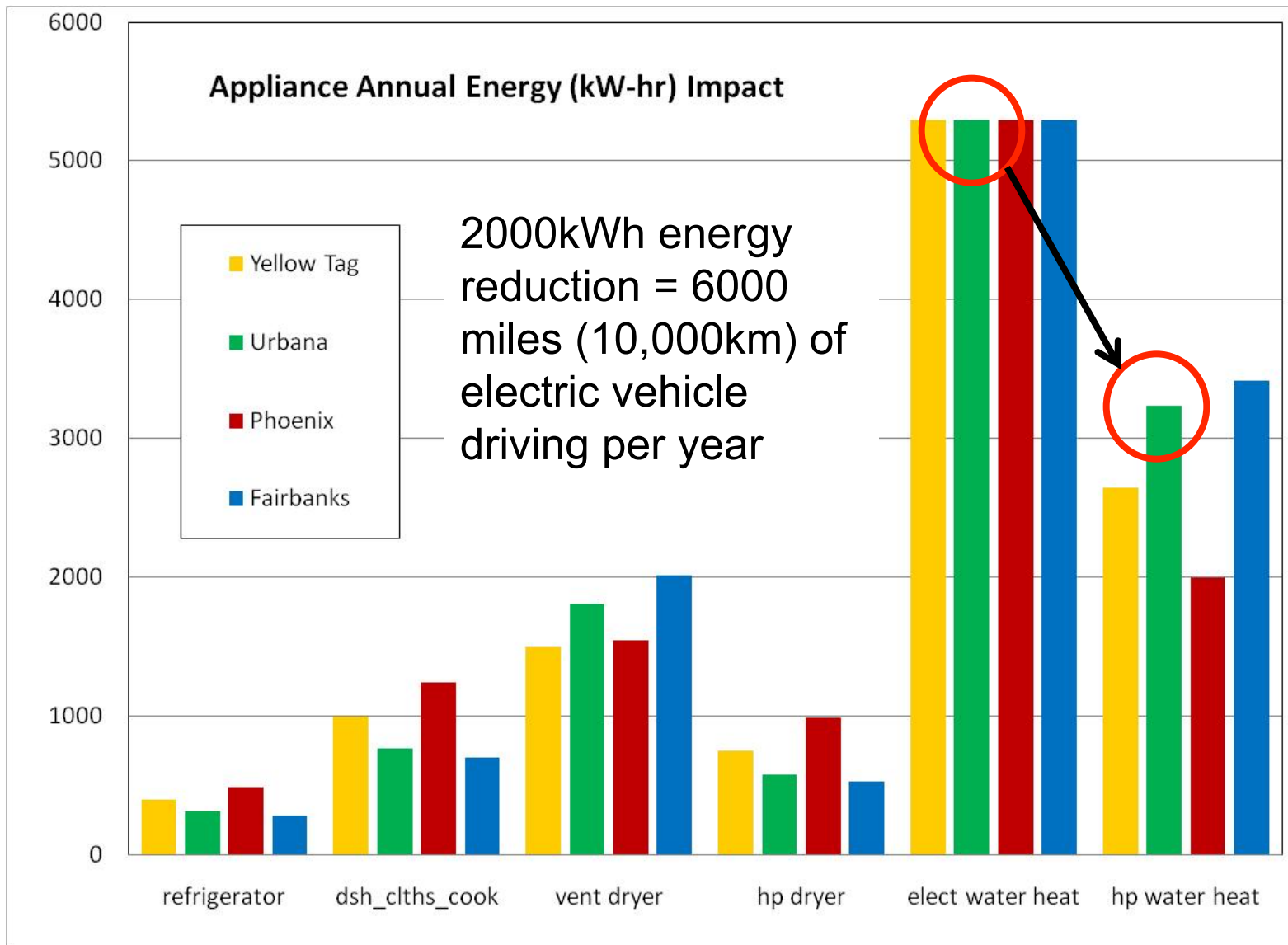
# “Solar” Water Heating with Heat Pump



- Water heating important!
- COP range from 2 to 5 depending on temperatures and design
- Cooling/dehum of space added benefit... even in winter

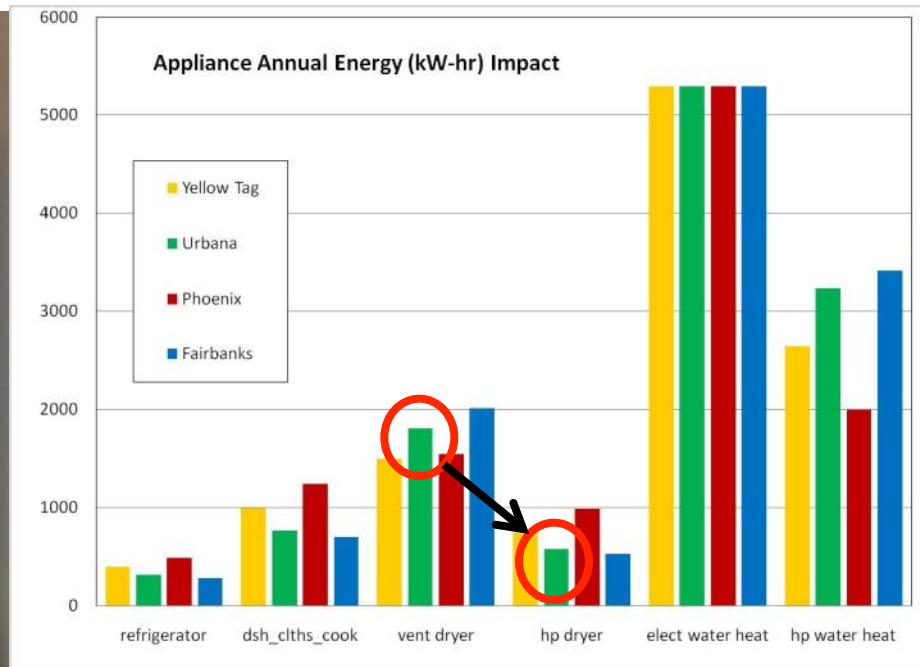


# Electric Water Heating vs HPWH





# High Performance Appliances are Essential



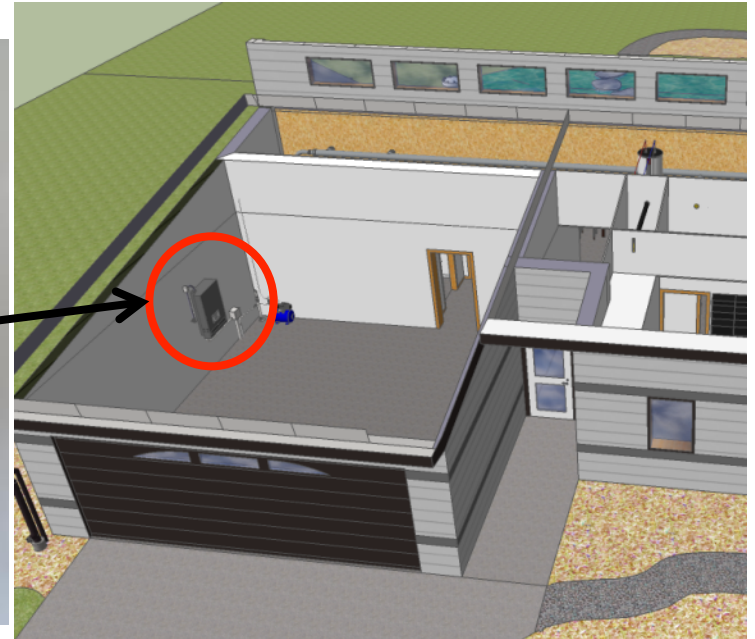
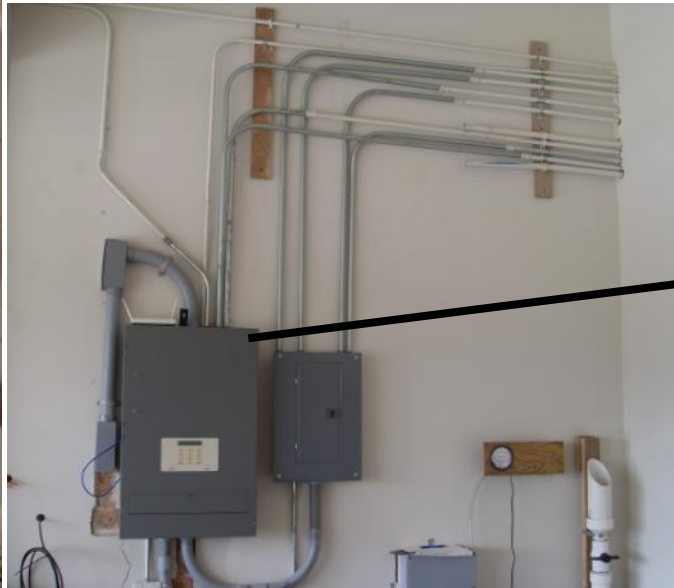
- Ventless, heat pump dryer
- High spin speed washer



- Heat pump dryer savings  
~1000kWh or more per year
- Savings on installation cost  
and house losses due to vents

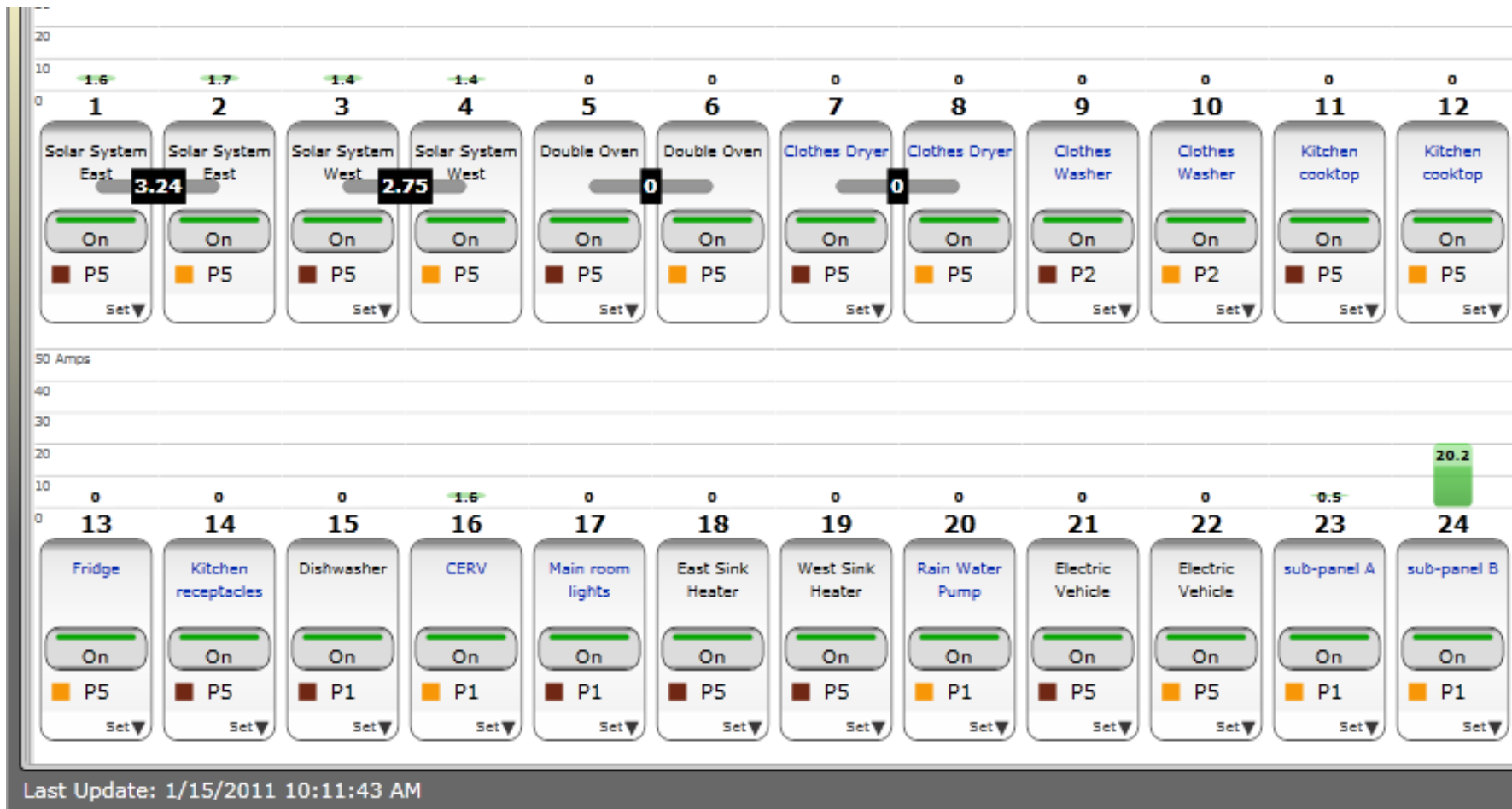


# “Smart” Electrical System Monitoring and Control



- Monitor activity anytime from anywhere
- Control circuits based on time-of-day
- Control circuits based on cost
- Monitor “health” of house, health of people

# Equinox House Power Management



Homeowners can manage loads

Homeowners can compare homes and appliances



## Last, But Not LEAST Ease-of-Living, Accessibility

In the US, our population is getting “old”

- People need to be in control of technology
- Equinox has 36 inch wide doorways and no steps, stairs or barriers throughout its living area, including the shower area
- We need simplified, robust house designs that allow our elderly to live independently longer

The biggest cost savings of Equinox House may be deferred elder care and minimizing accidents



“our tools are better than we are, and grow better faster than we do. They suffice to crack the atom, to command the tides. But they do not suffice for the oldest task in human history: to live on a piece of land without spoiling it.”

Professor Aldo Leopold; 1938  
University of Wisconsin  
Engineering and Conservation speech

