



BUILDING GREEN AND SMART HOME

from personal experience

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What is Green Building?

A structure and process that is **environmentally responsible** and **resource-efficient** throughout a building's life-cycle:



Design – Construction – Operation – Maintenance – Renovation – Demolition



Green Objective:



Reduce
environmental
footprint!



Low impact homes



Don't have to look like this !



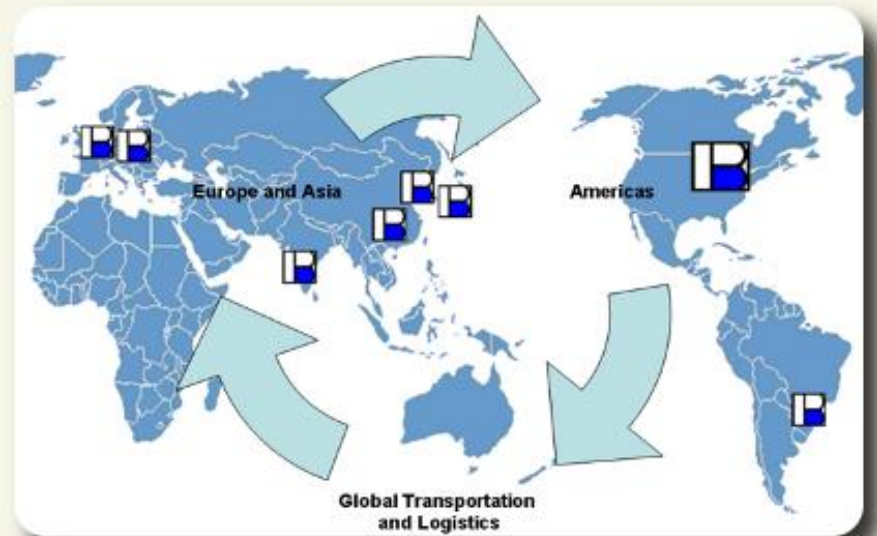
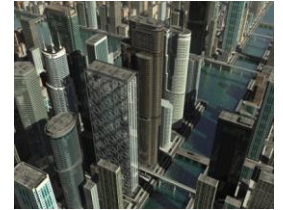
They come in any style:





Social Transformation

LOCAL



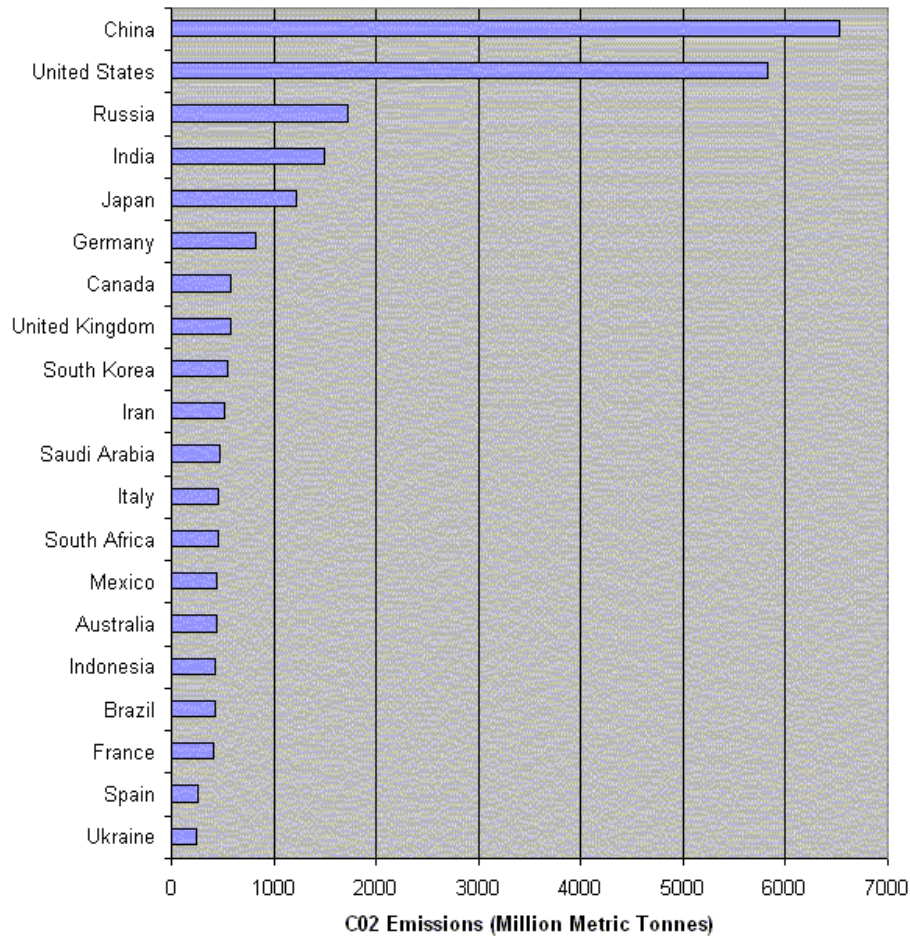
GLOBAL



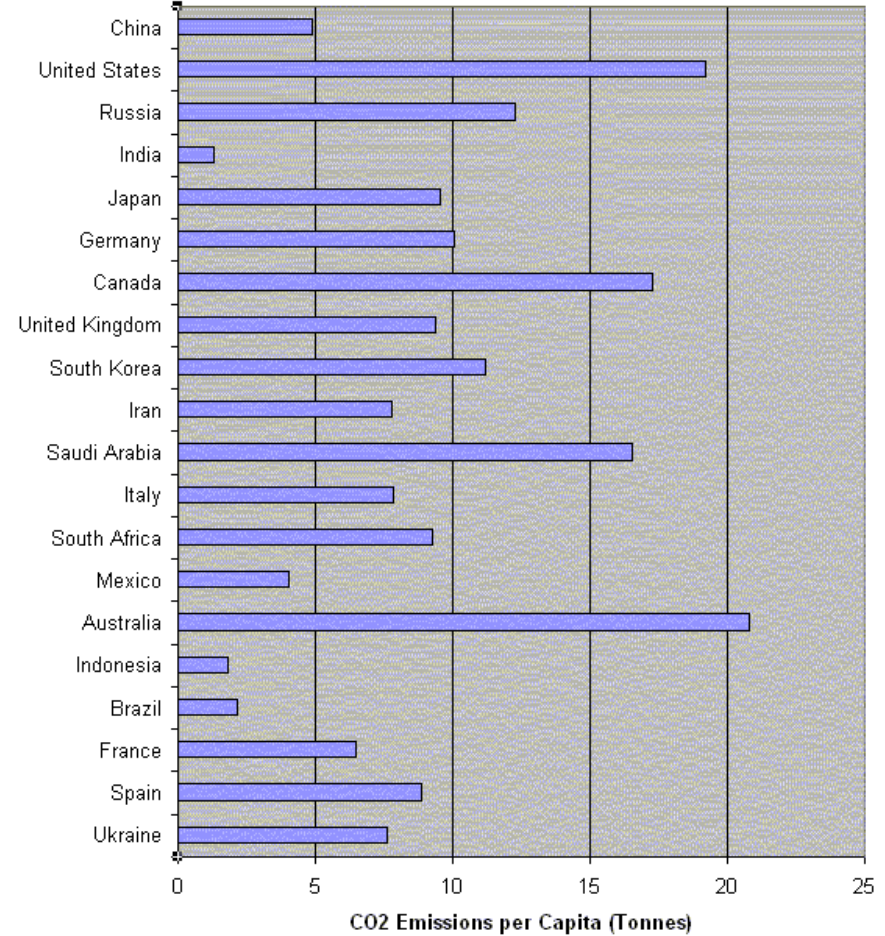


Total CO2 emissions:

Total 2008 CO2 Emissions



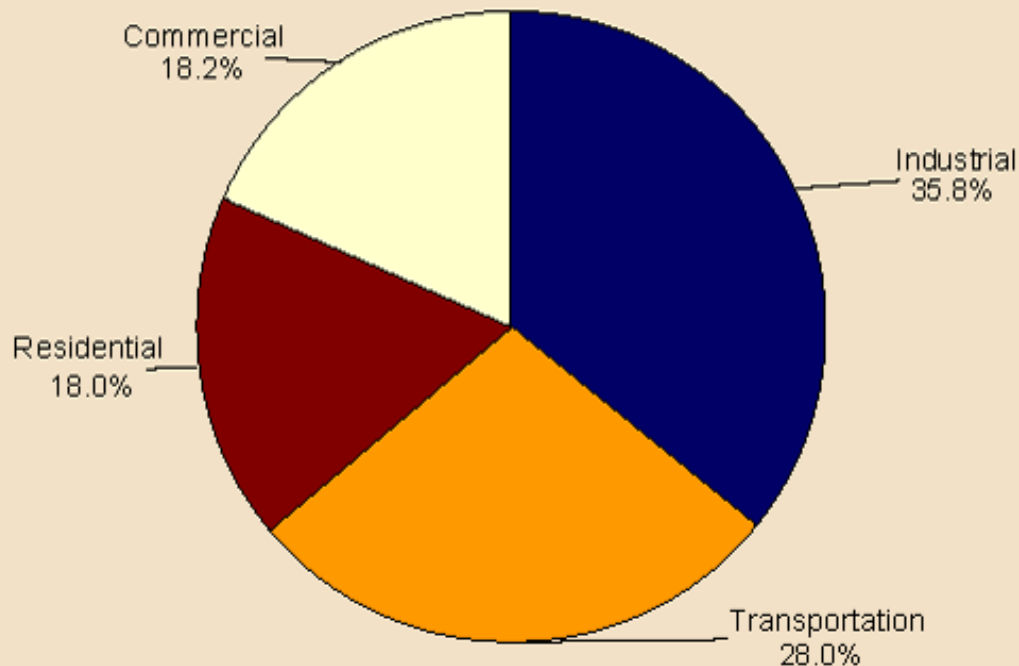
2008 CO2 Emissions per Capita





US Greenhouse emissions

Figure 1. U.S. Total Greenhouse Gas Emissions in 2005
(MMT CO₂ equivalent)



Based on
annual
consumption

**40% from
buildings!**



Bad CO₂

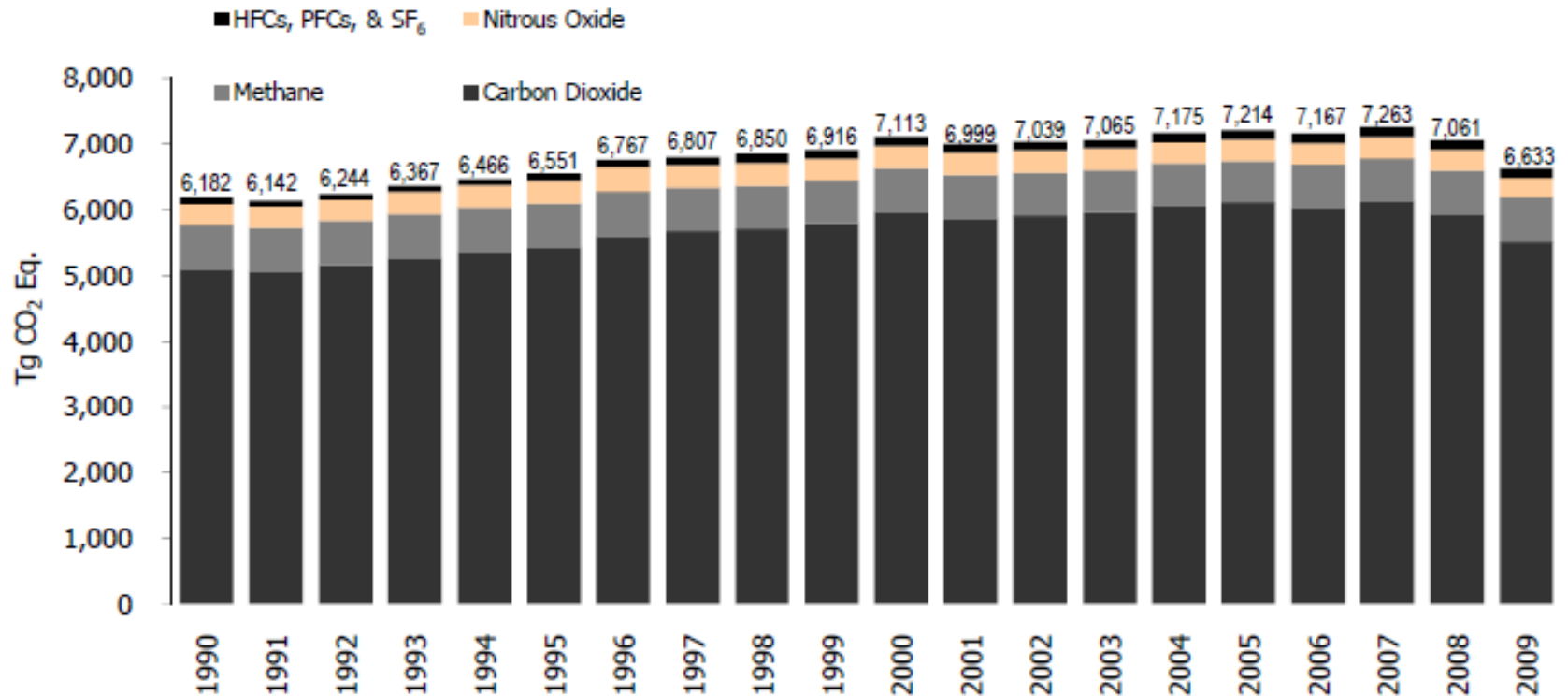


Figure ES-1: U.S. Greenhouse Gas Emissions by Gas



House lifecycle – energy usage

2,450 ft² residential home built in Ann Arbor, Michigan was analyzed to determine **total life cycle energy** consumption of materials fabrication, construction, use and demolition over a 50 year period

Lifecycle Energy distribution:

- 6.1% - construction phase
- 93.7% - use phase
- 0.2% - end of life phase



15,455 GJ

Total life cycle energy
consumption:
(2,525 barrels of crude oil)



Green Standards

2 main standards in USA:

Better suitable for
residential homes



Approved by ANSI

Better suitable for
commercial building
homes





NAHB Green

Green Building Categories			Performance Point Levels (1) (2)			
			BRONZE	SILVER	GOLD	EMERALD
1.	Chapter 5	Lot Design, Preparation, and Development	39	66	93	119
2.	Chapter 6	Resource Efficiency	45	79	113	146
3.	Chapter 7	Energy Efficiency	30	60	100	120
4.	Chapter 8	Water Efficiency	14	26	41	60
5.	Chapter 9	Indoor Environmental Quality	36	65	100	140
6.	Chapter 10	Operation, Maintenance, and Building Owner Education	8	10	11	12
7.		Additional Points from any category	50	100	100	100
Total Points			222	406	558	697



Green Home Benefits:

- Economic Benefits:
 - Reduced energy / water consumption
 - Lower maintenance cost (durable materials)
- Health Benefits:
 - Improved indoor quality (nonvolatile organic and non-toxic materials, ventilation, far fewer problems with mold or mildew)
- Environmental Benefits:
 - Reduces environmental footprint



Goals:

- Obtain GOLD level of NAHB green standard
- Consume no more energy than previously owned 1500 sq ft condo
- Guidelines:
 - Quality before Quantity
 - Functionality before Formality
 - Efficiency before Spaciousness
 - Comfort and Character



1) Resource efficiency:

- Reduce the quantity of material used and waste
 - Efficient floor plan, pre-cut joists
- Enhance durability and reduce maintenance
 - Covered entry, roof overhands, flashing details
- Use recycled content material
 - Recycled insulation, countertops, tiles...
- Use renewable materials:
 - Bamboo, FSC wood (forestry stewardship council)



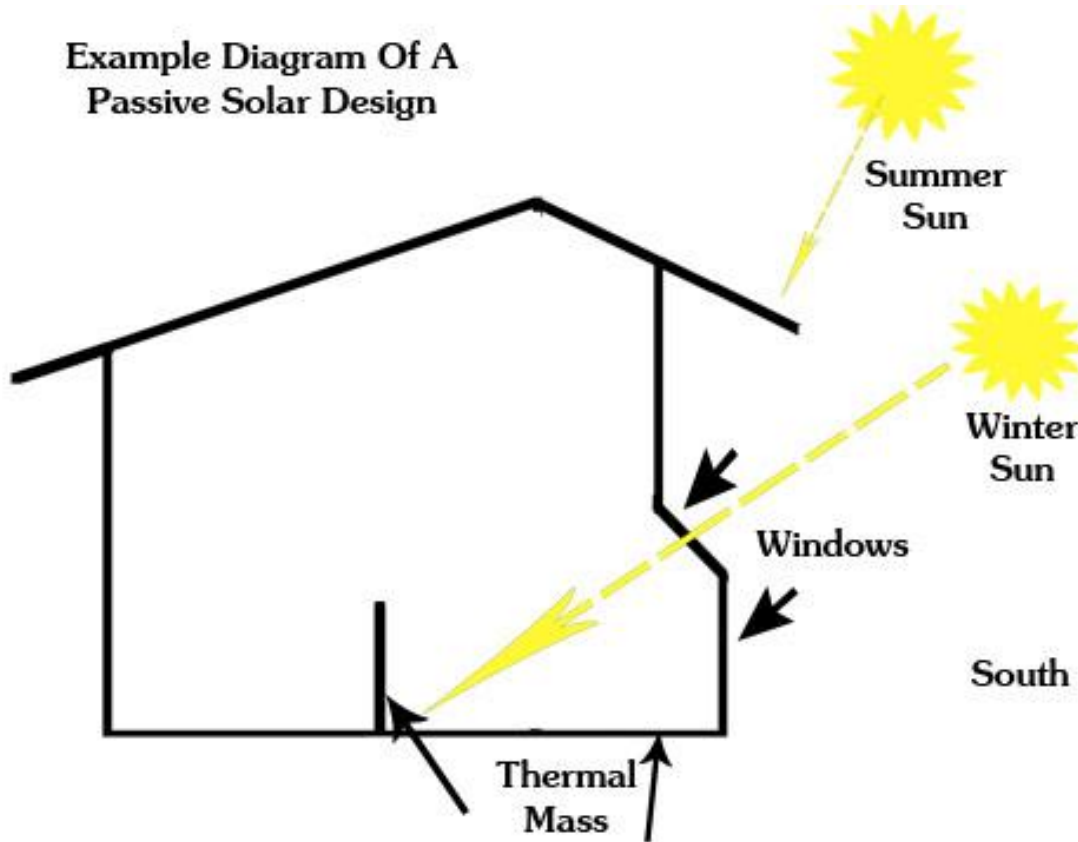
2) Energy efficiency

- a) Passive solar design
- b) Use daylight to preserve energy
- c) Use appropriate windows
- d) Insulate and airtight building envelope
- e) Use efficient HVAC design
- f) Use efficient equipment and monitor consumption
- g) Install house automation system



Passive solar design

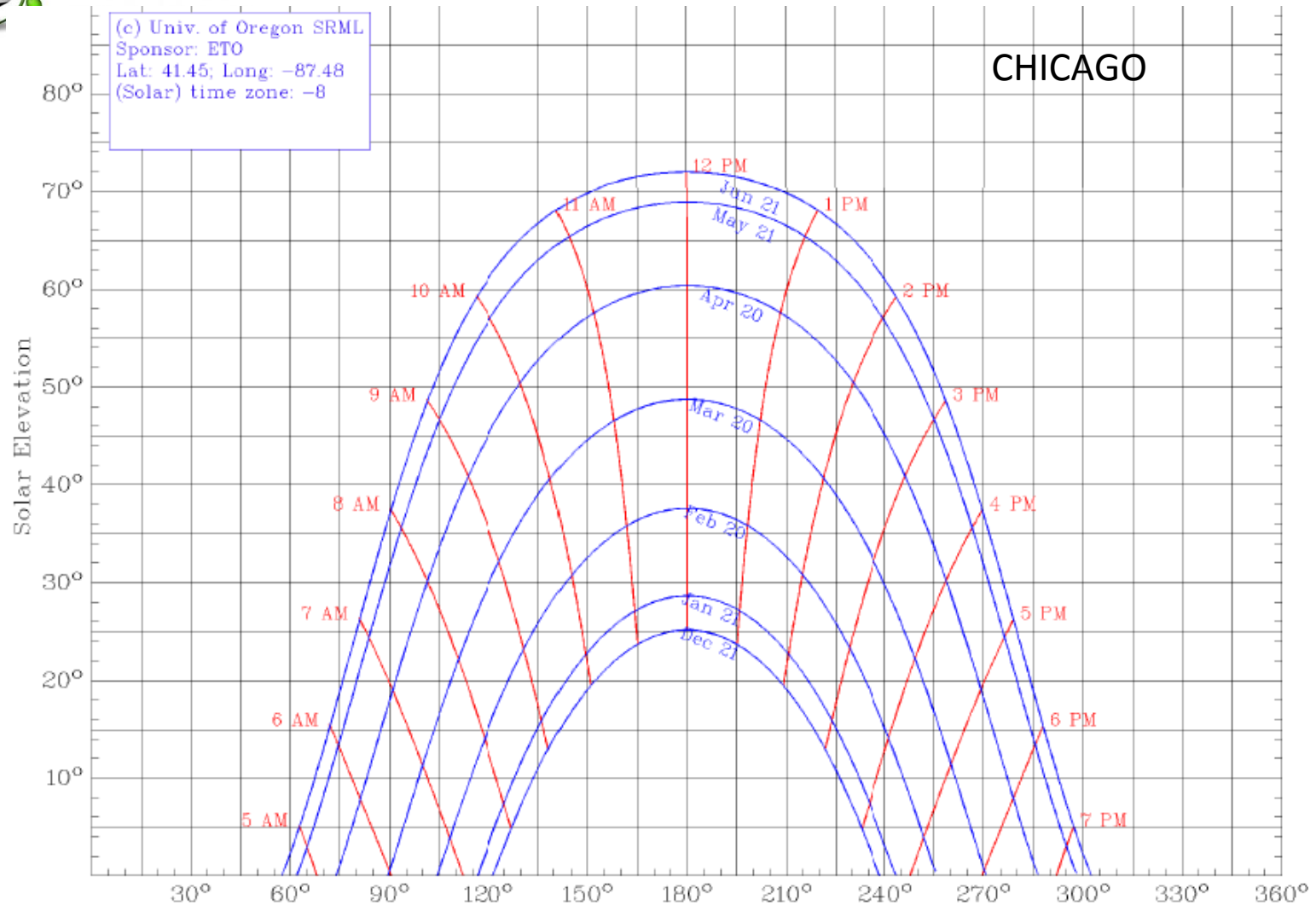
Example Diagram Of A Passive Solar Design



- Way of harnessing Sun energy
- No active components
- Concept used for centuries (Roman bathtubs)

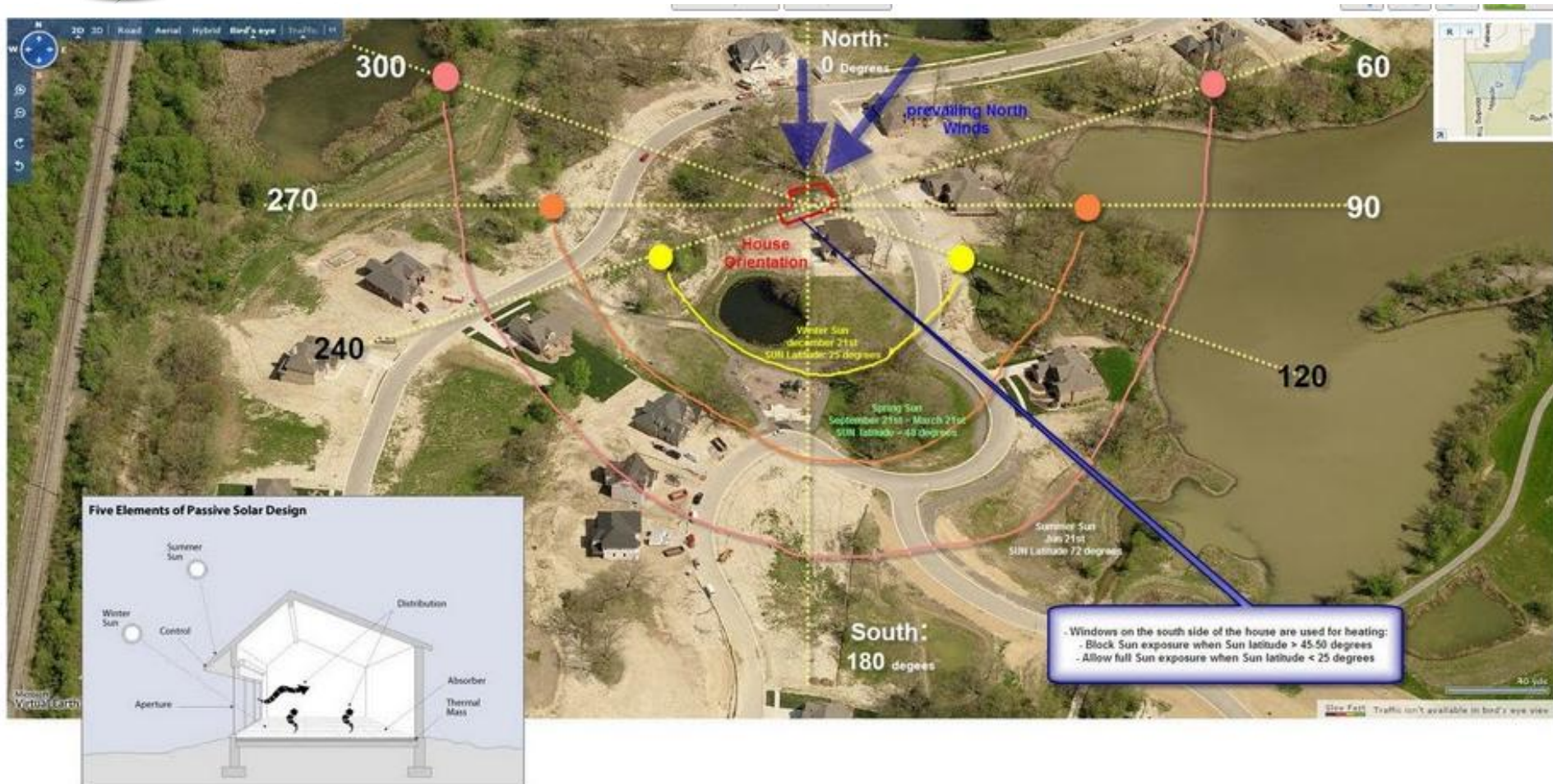


Sun Chart:



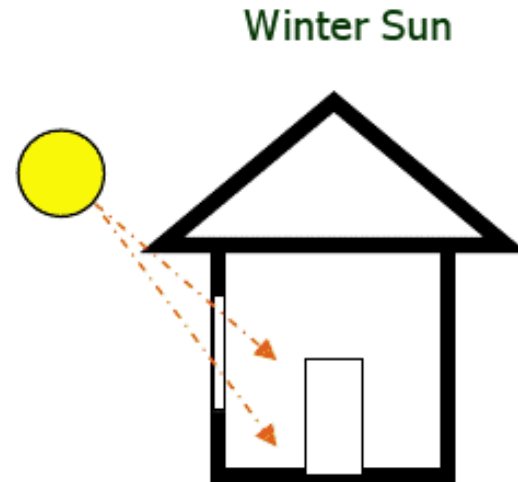
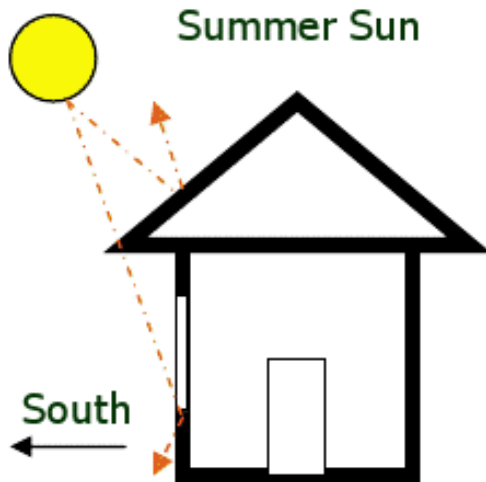


Sun chart over Site location





Passive solar (cont)



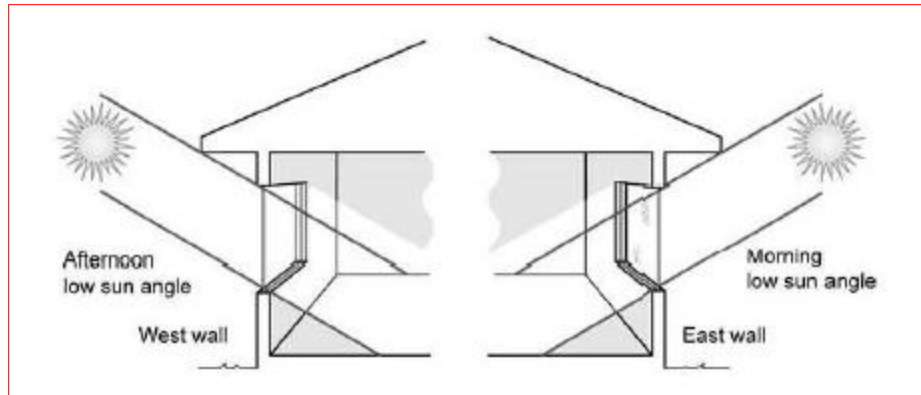
South window surface: 7 – 12% of the sq ft of conditioned area

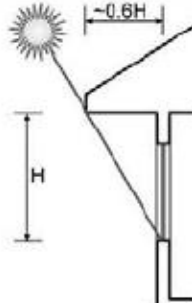
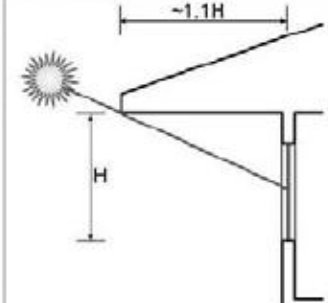
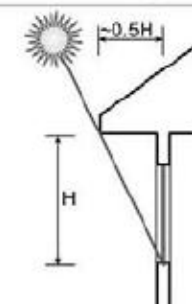
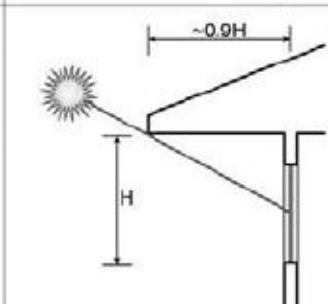
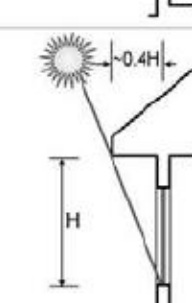
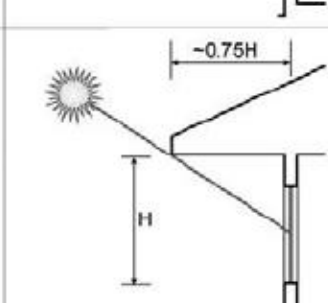


Passive solar (cont)

Depth of overhangs depends of the latitude

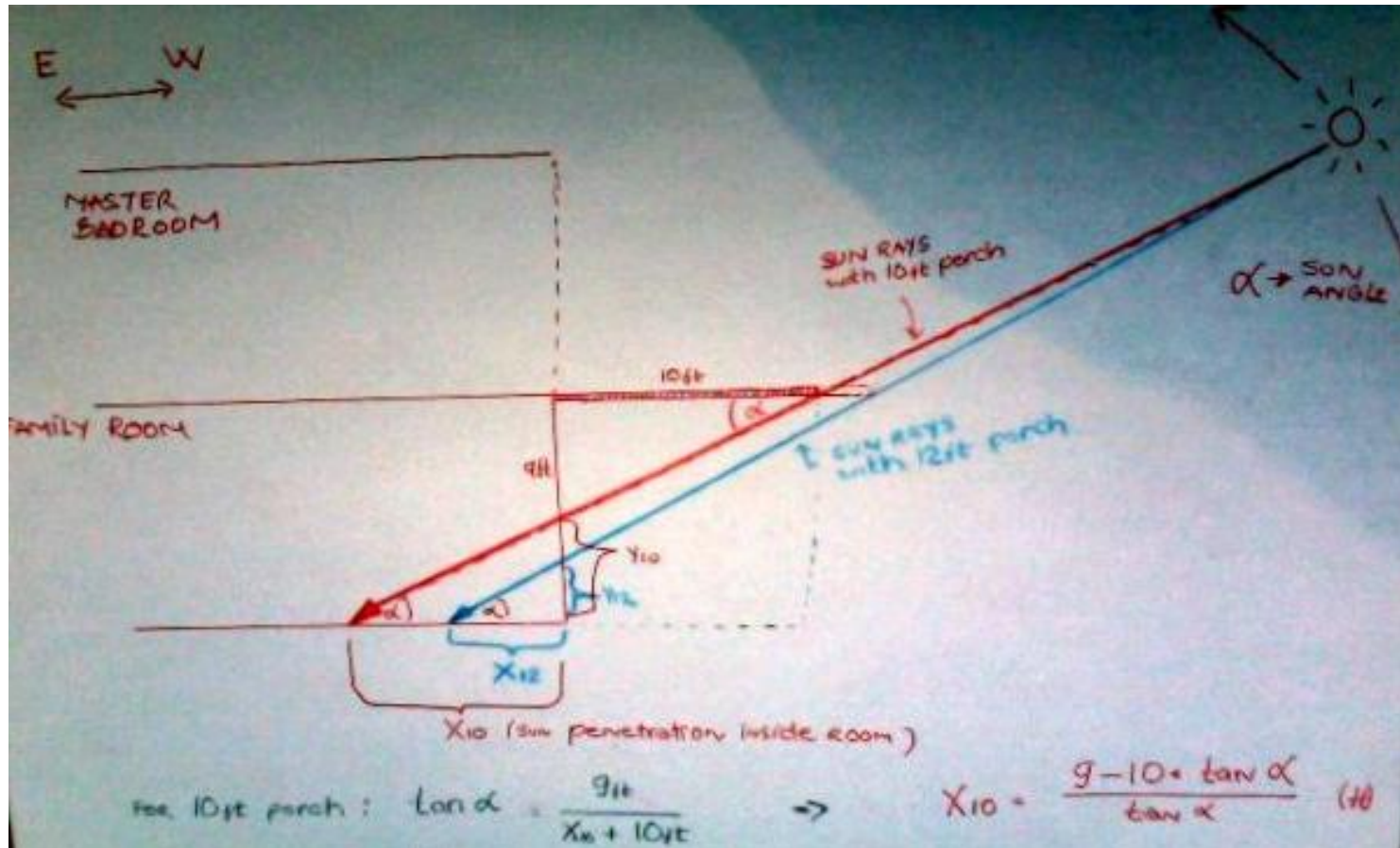
West side windows < 2% of sq ft
North + East windows < 4% of sq ft



Location/Latitude	Minimum Depth (Noon August 21st)	Maximum Depth (Noon December 21st)
Redding Lat. ~ 41°		
Fresno Lat. ~ 37°		
San Diego Lat. ~ 33°		

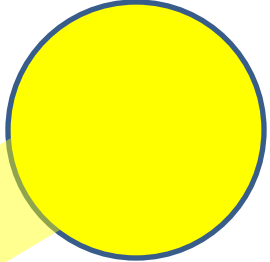


Passive solar (cont)





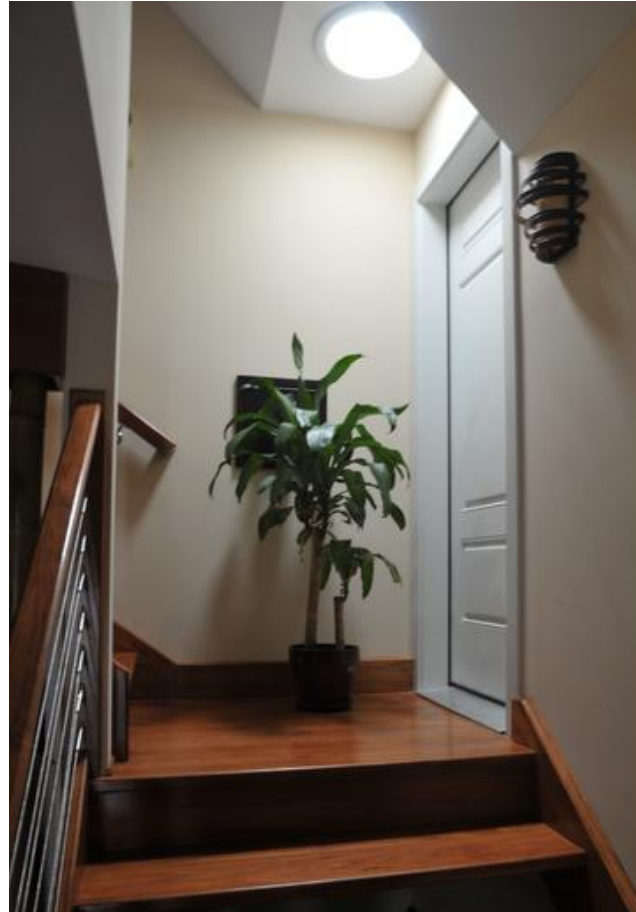
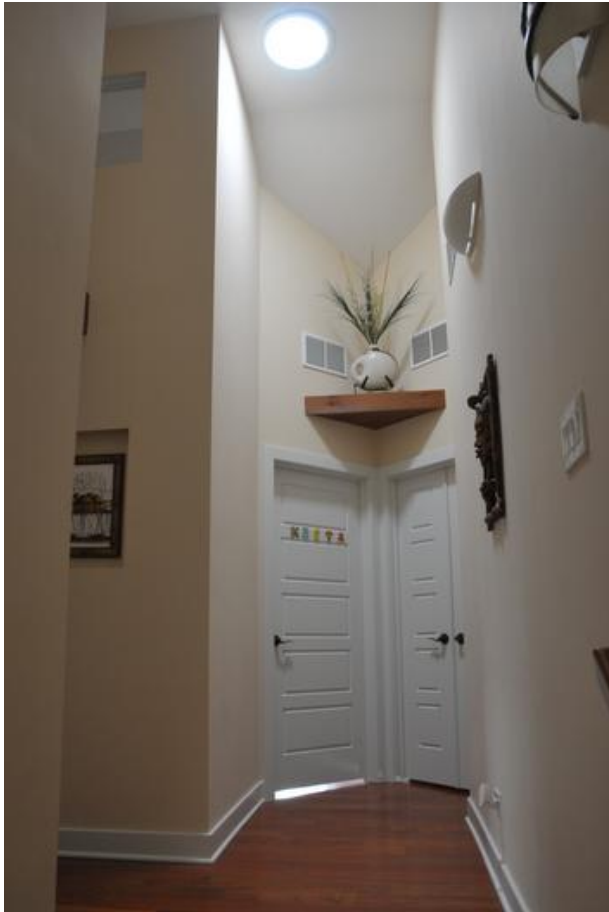
It works in Chicago Winter!



-20F outside
on the Sunny
day heating
turned off.



b) Daylight



Well insulated
light tubes
bring in light
without
compromising
insulation





b) Daylight (cont)



Enough light during an overcast day

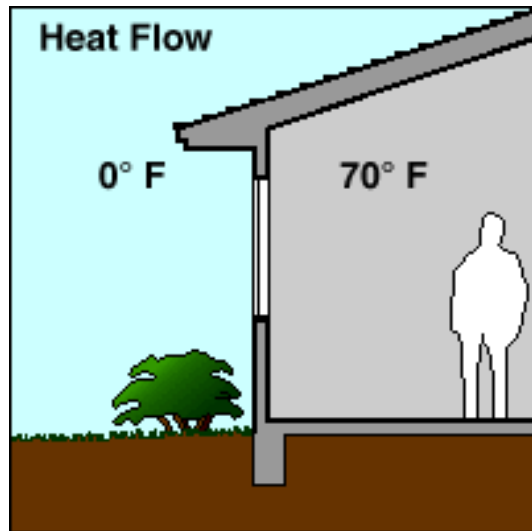


c) Use appropriate windows

U factor – rate of heat loss

$$U = 1/R$$

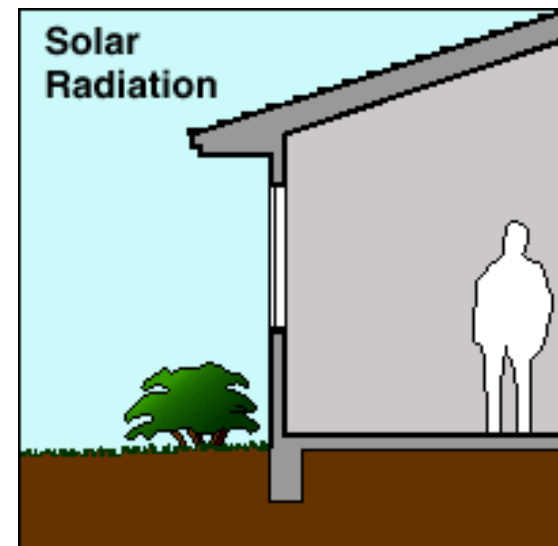
Low U (< 0.31) most important
in heating dominating areas



SHGC – solar heat gain coeff

Range (0 – 1)

Use low SHGC in south, and
high SHGC in north climates





d) Improve building envelope

- Insulate, Insulate, Insulate
- Add external insulation to prevent thermal bridging and reduce/prevent condensation in the exterior walls



Thermal bridging

Yellow areas indicate the greatest heat loss through uninsulated wood studs.

Cavity Insulation with OSB Sheathing



Blue indicates minimal heat loss.

Cavity Insulation with OSB and R-5 Insulated Sheathing



Environix -
Copyright 2010



Insulation



Ceiling - R50: Bat and spray foam insulation

Walls - R32 : cellulose insulation inside + rigid foam outside





Make house Airtight!





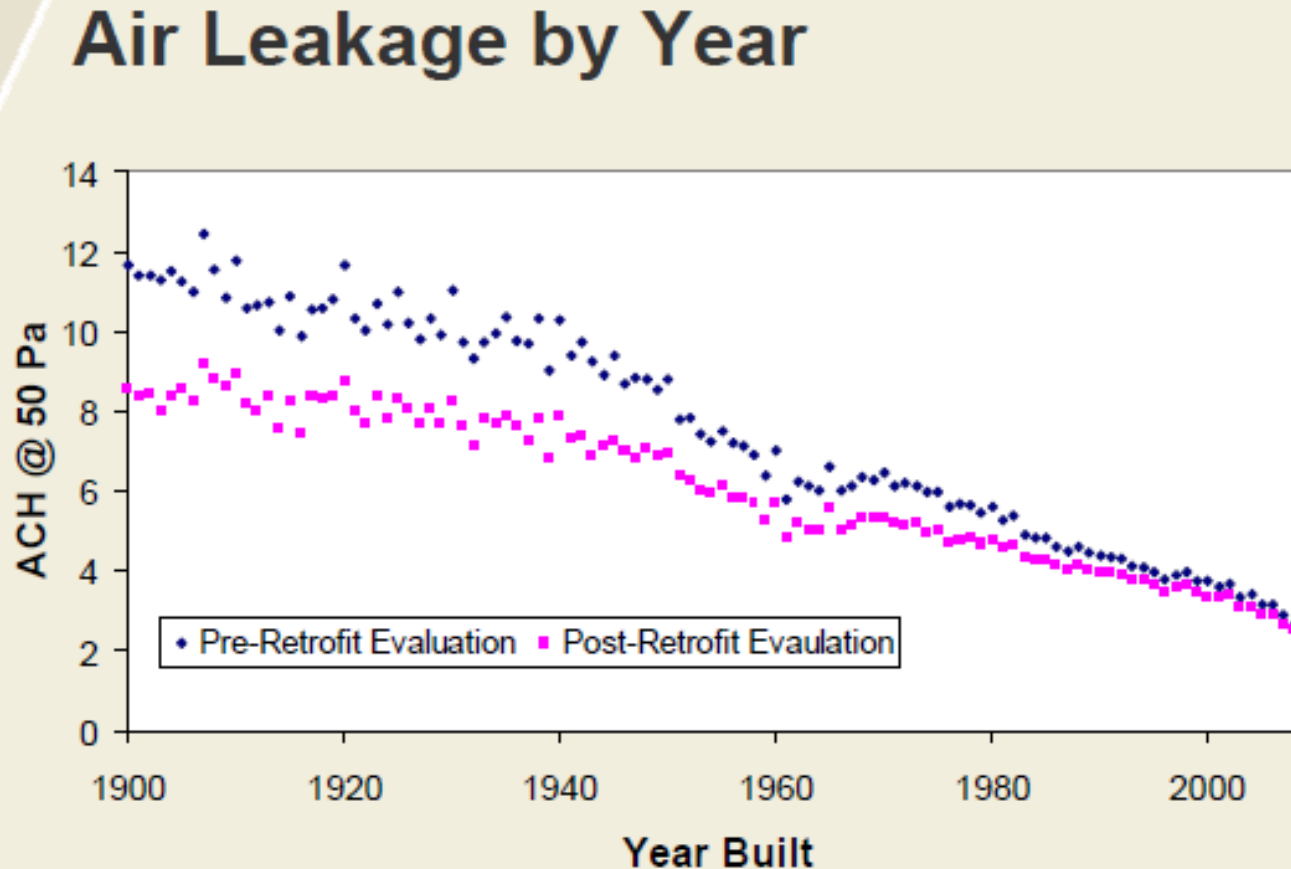
Airtight building envelope (cont)

- Old houses can lose as much heat through air leakage as through building envelope conduction.
- Moisture, condensation..
- Door blower test
- Mechanical ventilation system may be required, if ACH (air exchange per hour) < 0.35





Air leakage in Canadian homes



12



Natural Resources
Canada

Ressources naturelles
Canada

Canada



Efficient HVAC design

- Properly size the equipment (Heat loss calculation, ACCA “Manual J” for residential homes)
- Bigger is not Better. Oversized equipment leads to:
 - Higher energy bills
 - Higher initial cost
 - Uncomfortably cold/hot spots
 - Indoor humidity



SEER rating

- Higher SEER (Seasonal energy efficiency ration) means better efficiency

SEER	1 Ton	1.5 Ton	2 Ton	2.5 Ton	3 Ton	3.5 Ton	4 Ton	5 Ton
8	\$ 270	\$ 405	\$ 540	\$ 675	\$ 810	\$ 945	\$ 1,080	\$ 1,350
9	\$ 240	\$ 360	\$ 480	\$ 600	\$ 720	\$ 840	\$ 960	\$ 1,200
10	\$ 216	\$ 324	\$ 432	\$ 540	\$ 648	\$ 756	\$ 864	\$ 1,080
11	\$ 196	\$ 295	\$ 393	\$ 491	\$ 589	\$ 687	\$ 785	\$ 982
12	\$ 180	\$ 270	\$ 360	\$ 450	\$ 540	\$ 630	\$ 720	\$ 900
13	\$ 166	\$ 249	\$ 332	\$ 415	\$ 498	\$ 582	\$ 665	\$ 831
14	\$ 154	\$ 231	\$ 309	\$ 386	\$ 463	\$ 540	\$ 617	\$ 771
15	\$ 144	\$ 216	\$ 288	\$ 360	\$ 432	\$ 504	\$ 576	\$ 720
16	\$ 135	\$ 203	\$ 270	\$ 338	\$ 405	\$ 473	\$ 540	\$ 675
17	\$ 127	\$ 191	\$ 254	\$ 318	\$ 381	\$ 445	\$ 508	\$ 635
18	\$ 120	\$ 180	\$ 240	\$ 300	\$ 360	\$ 420	\$ 480	\$ 600
19	\$ 114	\$ 171	\$ 227	\$ 284	\$ 341	\$ 398	\$ 455	\$ 568
20	\$ 108	\$ 162	\$ 216	\$ 270	\$ 324	\$ 378	\$ 432	\$ 540
21	\$ 103	\$ 154	\$ 206	\$ 257	\$ 309	\$ 360	\$ 411	\$ 514
22	\$ 98	\$ 147	\$ 196	\$ 245	\$ 295	\$ 344	\$ 393	\$ 491
23	\$ 94	\$ 141	\$ 188	\$ 235	\$ 282	\$ 329	\$ 376	\$ 470
24	\$ 90	\$ 135	\$ 180	\$ 225	\$ 270	\$ 315	\$ 360	\$ 450
25	\$ 86	\$ 130	\$ 173	\$ 216	\$ 259	\$ 302	\$ 346	\$ 432
26	\$ 83	\$ 125	\$ 166	\$ 208	\$ 249	\$ 291	\$ 332	\$ 415

Base on 9 cent a KW and 2000 cooling hours





Efficient El. Equipment:



Energy star appliances

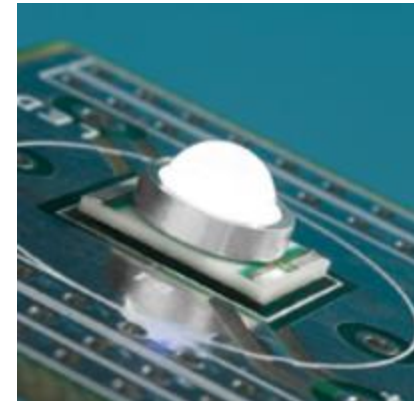
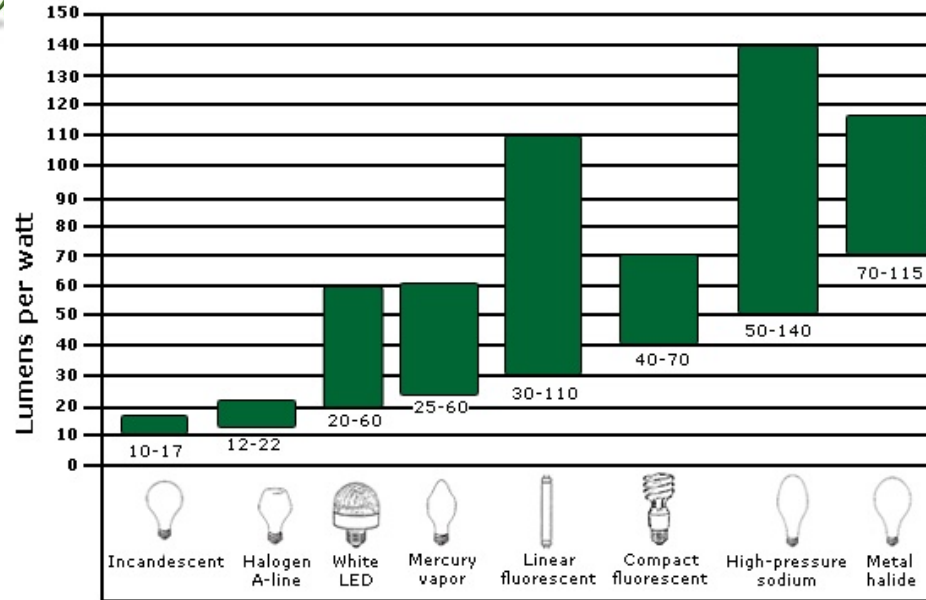


Compact Fluorescent Lights





Lumens per Watt



In 2011 CREE developed white LED (4500K) that has 231 lumens / watt !



CASE 1: warm white LED strips



5M 500CM Warm White 3528 SMD LED Strip Lights 300 leds



On Ebay:

300 LEDs, 15ft, 12Vdc, 0.4A,
250 lumens

Use with 12Vdc power supply



Warm white LED strips



20ft = 7W



6ft = 2W

Can cut every
2 inches



Warm white LED strips



Cove light
(30ft = 10W)

Under cabinet light –
using 2 strips
mounted parallel

Kick toe light



CASE 2: multi color LED strip



New 5M 5050 RGB LED Strip 44key Controller Power Supply

LED strip + Remote + Controller +
12Vdc Power supply=



Multi Color LED strip

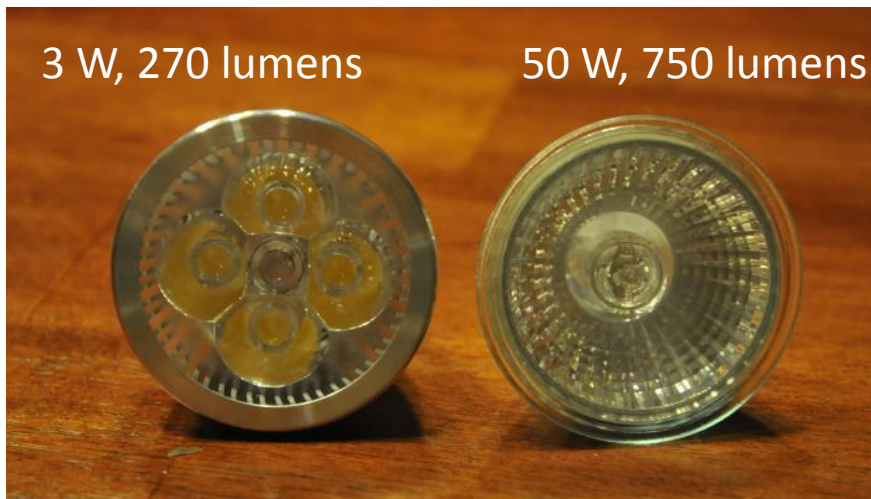




CASE 3: LED downlight



120Vac, MR16
light fixture





LED downlight



Halogen

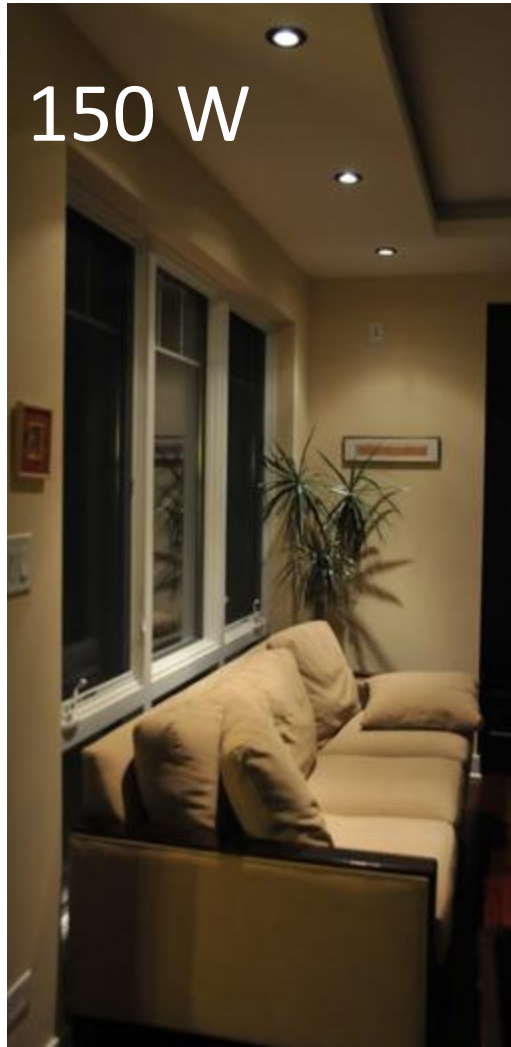


LED



LED downlight

150 W



3 Halogen lights

9 W



3 LED lights



Monitor Power Consumption



- TED 5000 energy detective
- Real time monitor power consumption
- Record data in GOOGLE power module
- See it on computer, smart phone, Ipad



Power consumption data:

Nenad: TED5000

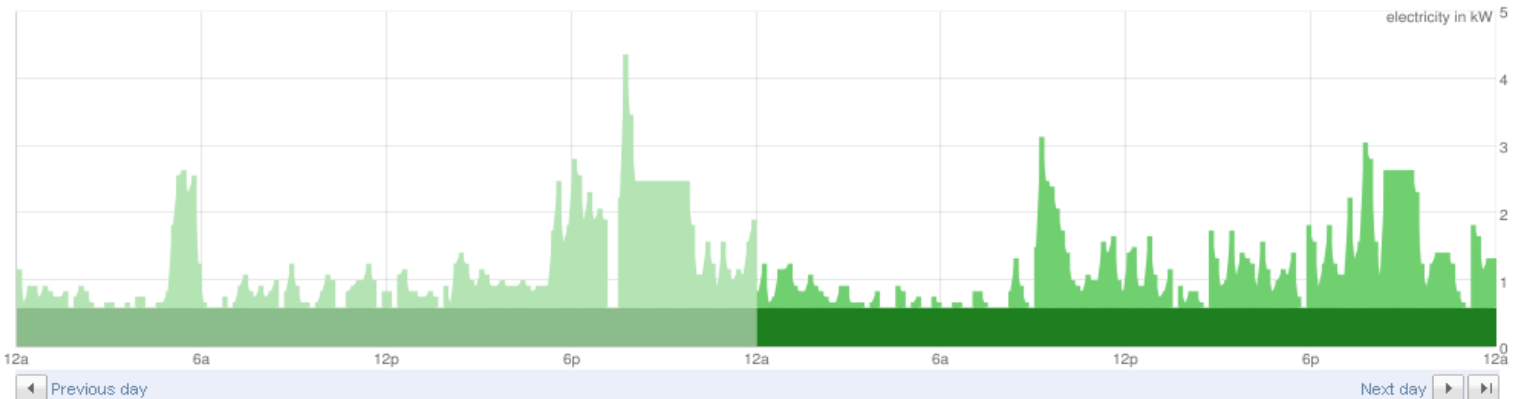
Electricity used March 2011

[Day](#) [Week](#) [Month](#)



Electricity used May 13-May 14

☒ Energy ☐ Approx. cost: \$ /kW-h



Friday May 13
28 kW-h used
Approx. \$1220/year [?](#)
■ Always on: 13 kW-h used

Saturday May 14
28 kW-h used
Approx. \$1218/year [?](#)
■ Always on: 14 kW-h used

Compared to past usage

20% over expected usage for Saturday [?](#)





House automation system

Criteria:

- Reliable
- Secure
- Affordable
- Scalable
- DIY





2 wireless systems:



ZigBee®

Control your world

Developed by Zensys

IEEE 802.15.4

900 MHz

2.4 GHz (global)

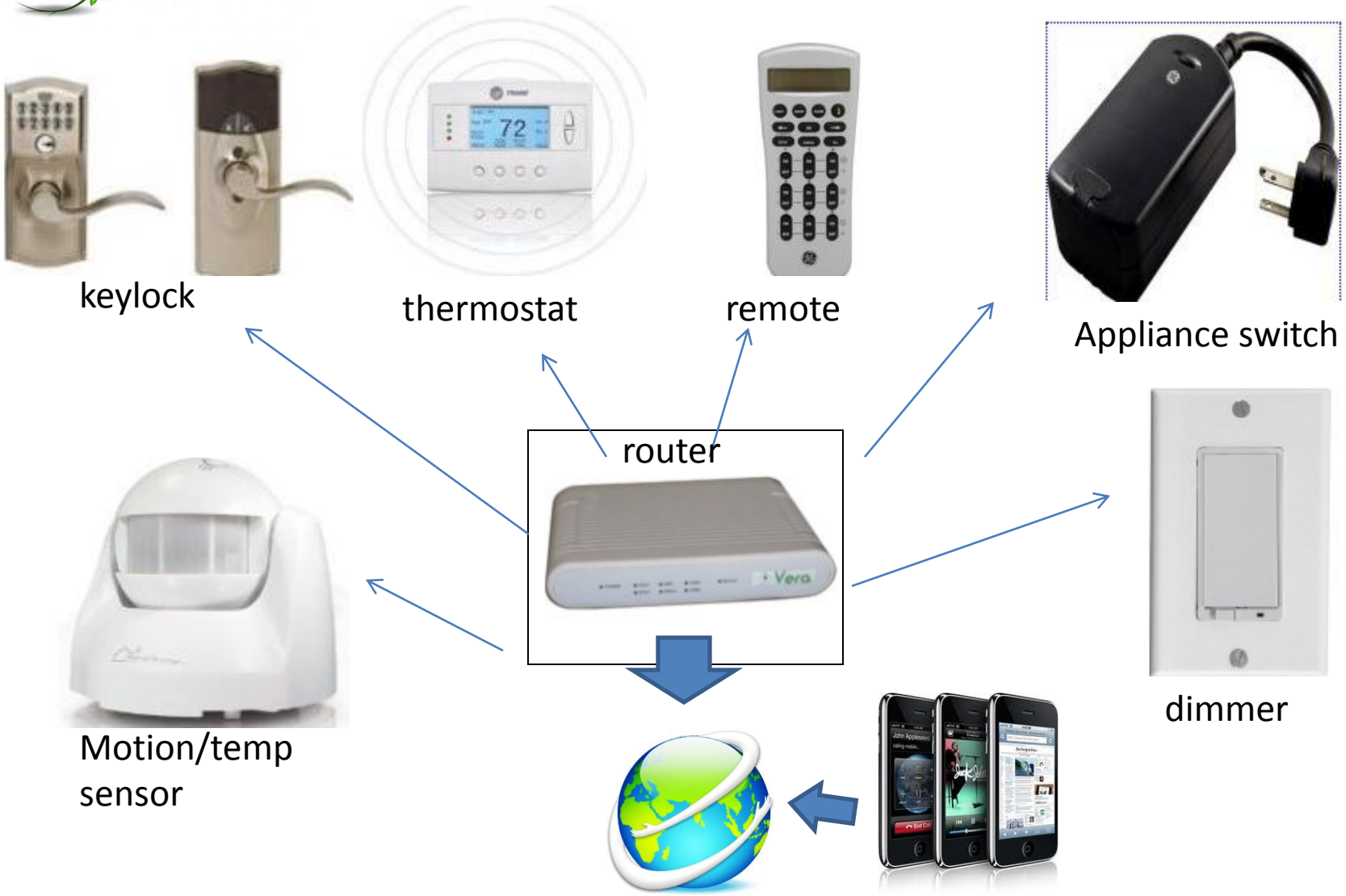
Up to 30m range

10 – 100m range

Lower cost

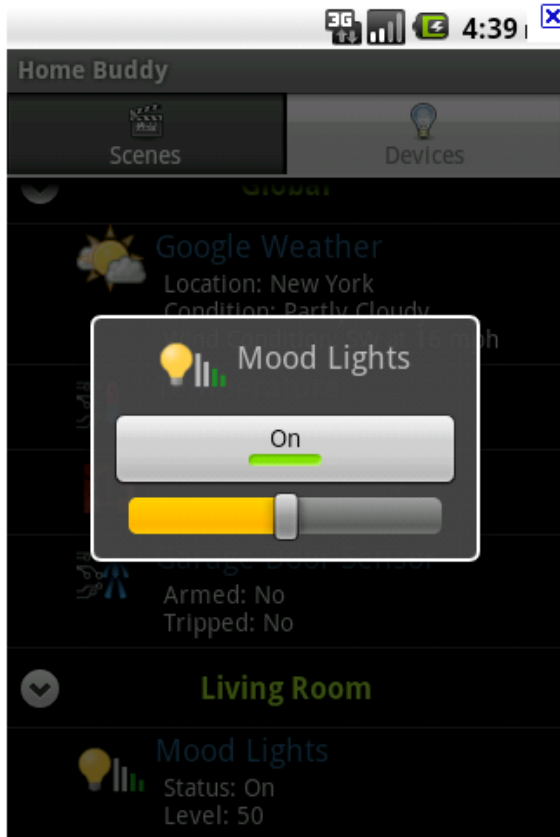


Zwave components:





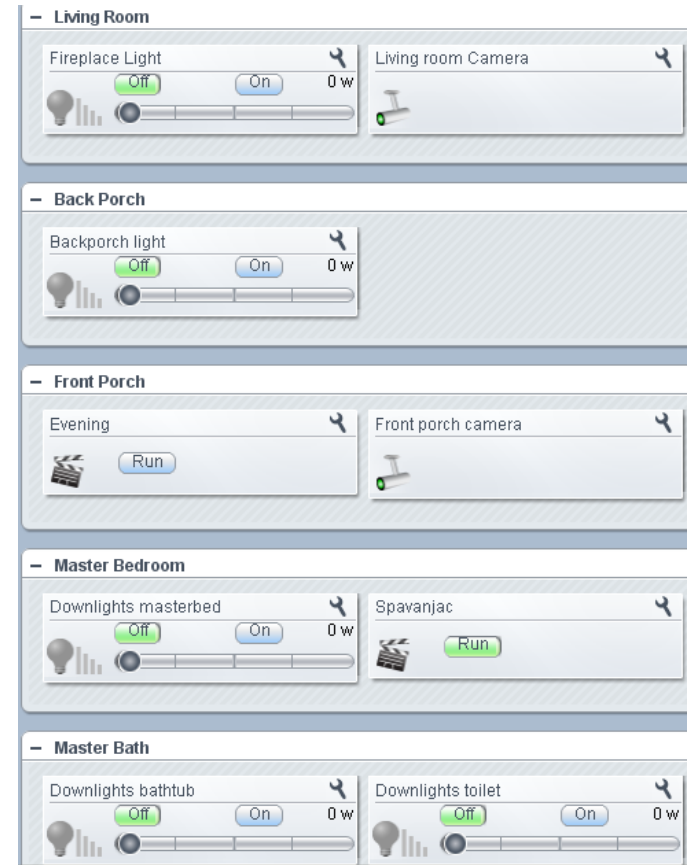
Remote/local access:



Android phone



Iphone



PC/MAC browser



Applications:

- Automatically turn on/off lights when on vacation
- Turn off all loads when leaving the house
- Adjust thermostat from the bed, or away from home
- Automatically turn off selected lights during Sunny day
- Receive a text message when someone rings the door bell
- Receive an email with photo when camera with armed sensor detects motion
- Turn on the lights in bedroom during severe weather



Integration:





Water Efficiency



Touch faucet



Low flow rate shower



Drip irrigation system



Indoor air quality

- No Carpets
- Low VOC paint / stain
- Direct vent fireplace
- Tightly sealed doors to garage
- MERV9 filter
- Whole house ventilation system



Lesson learned:

- Installing 5 occupancy sensors = 20 points
- Passive solar feature of the house = 10 points
- Carbon reduction is not proportional to number of points.
- Go for QUALITY, NOT QUANTITY (smaller, more functional, more durable, less cleaning, less maintenance)
- Use standard as a guideline, not Bible.
- MINIMIZE ENERGY consumption.
- Don't forget to have FUN in the process!



References:

- Passive solar design: “The sun inspired house”
<http://www.sunplans.com/store/book>
- Bigger is not better “Not So Big House”: <http://www.ntsobighouse.com/>
- Sun Charts: <http://solardat.uoregon.edu/cgi-bin/SunChart.cgi>
- Misc solar tools: <http://www.builditsolar.com/References/SunChartRS.htm>
- Overhang design: <http://www.susdesign.com/overhang/>
- Building science: http://www.buildingscience.com/index_html
- Perfect Wall design: <http://www.buildingscience.com/documents/insights/bsi-001-the-perfect-wall>
- Supported ZWAVE devices:
http://wiki.micasaverde.com/index.php/Supported_Hardware
- NAHB Green standard: <http://store.builderbooks.com/cgi-bin/builderbooks/874>



QUESTIONS?

