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:

Green Objective:

Reduce environmental footprint!
Low impact homes

Don’t have to look like this!
They come in any style:
Social Transformation
Total CO2 emissions:

- **China**
- **United States**
- **Russia**
- **India**
- **Japan**
- **Germany**
- **Canada**
- **United Kingdom**
- **South Korea**
- **Iran**
- **Saudi Arabia**
- **Italy**
- **South Africa**
- **Mexico**
- **Australia**
- **Indonesia**
- **Brazil**
- **France**
- **Spain**
- **Ukraine**

**Total 2008 CO2 Emissions**

**2008 CO2 Emissions per Capita**
US Greenhouse emissions

Based on annual consumption

40% from buildings!

http://www.nahb.org/generic.aspx?genericContentID=75563
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
Better suitable for commercial building homes

Approved by ANSI
# NAHB Green

## Green Building Categories

<table>
<thead>
<tr>
<th>Green Building Categories</th>
<th>Performance Point Levels (1) (2)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>BRONZE</td>
</tr>
<tr>
<td>1. Chapter 5 Lot Design, Preparation, and Development</td>
<td>39</td>
</tr>
<tr>
<td>2. Chapter 6 Resource Efficiency</td>
<td>45</td>
</tr>
<tr>
<td>3. Chapter 7 Energy Efficiency</td>
<td>30</td>
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<tr>
<td>4. Chapter 8 Water Efficiency</td>
<td>14</td>
</tr>
<tr>
<td>5. Chapter 9 Indoor Environmental Quality</td>
<td>36</td>
</tr>
<tr>
<td>6. Chapter 10 Operation, Maintenance, and Building Owner Education</td>
<td>8</td>
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<tr>
<td>7. Additional Points from any category</td>
<td>50</td>
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<tr>
<td><strong>Total Points</strong></td>
<td><strong>222</strong></td>
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</tbody>
</table>
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 Spaciness
  – 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

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

- Windows on the south side of the house are used for heating.
- Block Sun exposure when Sun latitude > 45-50 degrees
- Allow full Sun exposure when Sun latitude < 25 degrees
South window surface: 7 – 12% of the sq ft of conditioned area
Passive solar (cont)

Depth of overhangs depends on the latitude

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

\[ U = \frac{1}{R} \]

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

http://www.efficientwindows.org/energystar.cfm
d) Improve building envelope

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

Walls - R32: cellulose insulation inside + rigid foam outside

Ceiling - R50: Bat and spray foam insulation
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

Air Leakage by Year

ACH @ 50 Pa

Year Built

Pre-Retrofit Evaluation
Post-Retrofit Evaluation
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
Efficient El. Equipment:

Energy star appliances

Compact Fluorescent Lights
In 2011 CREE developed white LED (4500K) that has 231 lumens / watt!
CASE 1: warm white LED strips

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

LED strip + Remote + Controller + 12Vdc Power supply=
Multi Color LED strip
CASE 3: LED downlight

120Vac, MR16 light fixture

LED

Halogen

3 W, 270 lumens

50 W, 750 lumens
LED downlight

50 W Halogen

3 W 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, smartphone, iPod
Power consumption data:

Electricity used March 2011

Electricity used May 13–May 14

Compared to past usage

20% over expected usage for Saturday
House automation system

Criteria:

• Reliable
• Secure
• Affordable
• Scalable
• DYI
## 2 wireless systems:

<table>
<thead>
<tr>
<th>Developed by Zensys</th>
<th>IEEE 802.15.4</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>900 MHz</strong></td>
<td><strong>2.4 GHz (global)</strong></td>
</tr>
<tr>
<td>Up to 30m range</td>
<td>10 – 100m range</td>
</tr>
<tr>
<td>Lower cost</td>
<td>Control your world</td>
</tr>
</tbody>
</table>
Zwave components:

- keylock
- thermostat
- remote
- Appliance switch
- Motion/temp sensor
- router
- dimmer

2g
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 doorbell
• Receive an email with photo when camera with armed sensor detects motion
• Turn on the lights in bedroom during severe weather
Integration:

- Alarm system
- Surveillance
- Light
- TV / movies
- Tablet
- Music
- Home automation
- Irrigation

Operate everything in the house with one device.
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”
• Bigger is not better “Not So Big House”: http://www.notsobighouse.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?