True Zero Energy Homes

Avoiding the Hype and Getting to the Physics

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Earth Bound Homes
Various Disparate Definitions

- Net Zero Cost
- Zero Net Energy Emissions
- Net Zero Source Energy
- Net-Zero Energy Buildings (NZEBs) ASHRAE Definition Or Zero Site Energy Buildings
Net Zero Cost

- Cost of purchasing energy is balanced by income from sales of electricity to the grid
- Depends on how a utility credits net electricity generation and the utility rate structure
- \( 100 \text{ kWh} \times 0.33 - 300 \text{ kWh} \times 0.11 = 0 \)
Net Zero Source Energy

- Uses no more energy than it produces, INCLUDING the energy used for transport as well as associated losses.
- Must significantly overproduce
- Difficult to calculate
- Current monitoring systems not capable of recording appropriate information
- Multiplier
  - Electricity – 3.4
  - Gas – 1.2
Site Net Zero Energy Buildings

- Means a building uses only as much energy as it produces on site.
- Often used synonymously with Zero-Net Energy Building (ASHRAE definition) which means throughout a year a building produces as much energy as it uses.
- Often, erroneously, references only electricity usage.
- Does not include the building or repair of the home.
- True Zero Energy would be a cave or a cardboard refrigerator box, no heating, cooling, electricity, gas, plumbing, hot water,
Net Zero Carbon Emissions

- Also known as a zero carbon building or zero emissions building
- Carbon emissions generated from on-site or off-site fossil fuel use are balanced by the amount of on-site renewable energy production or Carbon Credits
- Problem:
  - Carbon Dioxide Production (Carbon Release) is a one way equation
True Zero Carbon Homes

- Means that no carbon is consumed (natural gas, propane, fuel oil, coal, wood) or released (CO\textsubscript{2} and CO) from the use of the home.

- Does not include building or repair of the home.

- Often, erroneously, ignores wood burning heating sources.

- Much harder to achieve than Zero Energy.
Zero Energy $\neq$ Green Homes

- Conservation of fuel or power is only one aspect of green building.

- Green building refers to resource conservation (energy, land, pristine environments, sustainable building materials, reducing materials usage, durability) and indoor air quality.
Zero Energy ≠ Energy Efficiency

- Greater usage can be offset by larger renewable energy systems, but at a significant cost
- Energy efficiency only reduces the cost of attaining Zero Energy status
All new homes built after 2020 and all new commercial buildings after 2030 shall be Zero Energy.

Inside a ‘zero-energy’ home
A San Francisco company is planning to build multifamily townhomes, lofts and apartments that create as much energy as they use. Here is a look at some of the net zero energy methods and materials.

- Solar panels
  Convert energy from the sun into electricity

- Heat recovery ventilator (HRV)
  Provides controlled and natural ventilation for airtight building envelope

- Energy Star appliances
- Wastewater heat recovery system
  Preheats shower water

- High-efficiency heat pump
  Uses indoor heat to warm incoming air

- High thermal performance windows
  Four times more efficient than coated double-pane windows

- Natural day-lighting
  Solar orientation

- Insulation
  Walls, floors, roof, and basement

- Automated controlling and monitoring system
  Manages heating, cooling, ventilation and thermal storage

- Thermal storage basement
  High flyash concrete stores daytime heat and provides nighttime cooling

Note: Diagram represents an example of one type of net zero energy building.

Source: Zeta Communities
What are the Advantages of Going Zero Energy

- Significant Money Savings (>\$1,000s/year)
- Greater comfort
- Better quality of life, more free time, more money
- Less use, Less maintenance
- Longer lasting heating and cooling equipment
At What Cost?

- **Passive House**
  - Very High levels of insulation
  - Very Low air leakage (<0.6 ACH @ 50 pa.)
  - **Heating** Energy Use - ≤ 15 kWh/m²/year (4.75 kBtu/sf/year) ($30.00/month/2000sq.ft.)
  - **Total** Energy Use - ≤ 120 kWh/m²/year (38.1 kBtu/sf/year) ($250.00/month/2000sq.ft.)
  - High Vol./Surface Area Ratio
  - Everything else “Green”
Where We Can Be

- Built 2005
- Cost $335/sq. ft.
- 3100 sq. ft.
- ~90 heating/0 cooling days
- Home to two adults, 3 kids (8-11 years old)
- No net electricity used (CA ave. per person - 7,032 x 5 = 35,160kwh.)
- Without PV – 11 kwh/day = 4,016kwh/year
- $159 gas bill/year (156 therms, CA ave. per person – 422 therms)
- Gas + Electric = 10,000 kWh/year (22% of Passive House allowance)
- 74 g/d winter water use
- Heavy Metal Free Artificial turf
- Grey water system
- Rain Water cistern
- Photovoltaic system
- Solar Hot water
- 93% Salvaged Deconstruction
- Highly Durable ext. and int. finishes
The Perfect Green Material
The Solution – A Holistic Approach

- Everything in the house must be looked at that consumes, holds, absorbs, keeps out or is otherwise effected by or affects any type of energy.

- Each thing is important and essential to the success of the entire product – A Zero Energy Home.

- Think of it like TdF riders “The Tour cannot be won today, but it can be lost today.”
Home Energy Use

- Energy is used to do something in the home (hopefully)
- To make it Zero Energy, you have to know what you need to offset AND the most effective ways to do so

![Pie chart showing energy use in a typical home](image)
Architectural Design and Site Planning

- Passive solar heating and cooling
- Taking advantage of prevailing winds, shade and light
- Understanding of the laws of physics
- Making use of what is free and using it to offset what is not (energy consuming equipment)
## MICROPAS7 ENERGY USE SUMMARY

<table>
<thead>
<tr>
<th>Energy Use</th>
<th>Standard</th>
<th>Proposed</th>
<th>Compliance</th>
</tr>
</thead>
<tbody>
<tr>
<td>(kTDV/sf-yr)</td>
<td>Design</td>
<td>Design</td>
<td>Margin</td>
</tr>
<tr>
<td>Space Heating</td>
<td>16.54</td>
<td>5.61</td>
<td>10.93</td>
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<tr>
<td>Space Cooling</td>
<td>7.44</td>
<td>4.21</td>
<td>3.23</td>
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<tr>
<td>Water Heating</td>
<td>8.05</td>
<td>2.54</td>
<td>5.51</td>
</tr>
<tr>
<td>Total</td>
<td>32.03</td>
<td>12.36</td>
<td>19.67</td>
</tr>
</tbody>
</table>

*** Building complies with Computer Performance ***

*** HERS Verification Required for Compliance ***
Heat Pumps

- Does not create heat from electricity or burning fuel but instead concentrates heat from one source for use in another area.
- Air to air (Forced Air)
- Water to water (solar thermal or geothermal to radiant)
- Water to air (hydronic air handler)
- Air to Water
- Limited by temp differential, total heat available
Geothermal Heating and Cooling

- Extracts or deposits heat into the earth's crust
- Heat energy is held in crust
- Uses large network of pipes with large surface area in ground
- Either vertical or horizontal fields
- Usually PEX plumbing lines embeded in high thermal mass concrete slurry
- Limited by conduction and heat capacity of earth, size of field and cost
Insulation Types

- Fiberglass
  - R3.1-3.4/inch
  - Very had to install correctly as batts
  - Easier and much more effective when blown in (Cocoon)

- Cellulose
  - Similar to fiberglass in most respects
  - Treated with flame retardants, mildewcides
  - Blown in only

- Cotton (recycled content, no itch, no stapling)
  - Heavy
  - No plastic wrapping, No vapor barrier
  - Only avail in 3.5” and 5.5”
  - Can’t get wet
  - Cut with Saw

- Closed-Cell Polyurethane (R6.8/in., Integral air/vapor barrier, seals rims, attics, crawl)
  - Expensive ($3/sq. ft. for 3”)
  - Must be sub-ed out ($100K setup)
  - Open cell different but cheaper
OVE - Optimum Value Engineering

- Stick Framing
- Minimize lumber, maximize insulation

Framing
- 24” oc studs walls
- Insulated Headers
- Ladder blocking
- 2 stud corners
- Drywall clips
- Energy Heels on Trusses

- Structurally Insulated Panels (SIPs)
- Insulated Concrete Forms
Structurally Insulated Panels (SIPs)

- Energy efficiency (R13.7 vs. R21.7 = Δ58%) DOE
- Speed of Installation
- Quality of Installation
- Consistency of materials
- Quality of finished product (sound, energy, finish (in and out))
- Strength of structure
- Material conservation
- No HFCs, CFCs or HCFCs
Energy Efficiency

- Items that use energy in the house
  - Furnace (50%)
  - Water Heating (17%)
  - Air Conditioner (6%)
  - Refrigerator (5%)
  - Lights and Appliances (24%)
    - Lights
    - Cooktop or Range
    - Washing Machine
    - Dishwasher
    - Clothes Dryer
  - Shower, sinks, toilets, tubs
  - Irrigation
  - Vacuum cleaners
PhotoVoltaic

- A penny saved is a penny earned
- Cost Between $5-6/kw
- Typical system
- 1 kwh =
  - 1.7 miles driven
  - 1.42 lbs of green house gasses
  - 0.003 mature trees (10.8/year)
- 11kwh/day (US ave. = 52)
  - 7.3 barrels of oil/year
  - 6120 miles in a car
  - 5112 lbs green house gasses
Is PV Really the Answer?

- Peak production vs. Peak usage
- Storage Very expensive

![Figure 11. Average Peak Demand for July, 2005](image)
Solar Hot Water Heating

- 2-3x’s more efficient than PV
- About 1/5\textsuperscript{th} the cost of PV
- Typical System/typical Day - 90g/day @ 70°F (70 °F + 55 °F = 125 °F)
- Small recirc. pumps can run off small solar PV
- If combined in serial with Tankless water heater for backup, must change to compliant model
- Tax Credit up to $2,000 from Fed. www.energytaxincentives.org/con sumers
Tankless Water Heaters

- $800-$1200.
- Gas only tankless water heaters (T24)
- Efficiencies around 70%-95% (40-50% tanks)
- No stand by losses
- Tax credits (~$300)
  - [www.energytaxincentives.org](http://www.energytaxincentives.org)
  - [www.pge.com/res/rebates](http://www.pge.com/res/rebates)
- Exterior mounted
  - best (no summer heat gain)
  - Cheapest (no venting and not floor space)
  - Healthiest (no CO leaks)
- Insulate both hot and cold water lines
- Most cannot handle preheating from solar water heating or recirculation loops
What Zero Energy Does and Does NOT Address

- Zero Energy is purely dedicated to the result of a calculation:

\[ \text{Energy Produced/year} - \text{Energy Used/year} > 0 \]
Zero Energy Calculus

- Size Matters but is not all that matters
- Usage patterns ie.- who is living in the home, how many and how old they are
- Efficiency matters, but can be offset with lots of money
- Environment(weather and climate) matter to the bottom line
- Design can help dramatically reduce bottom line usage across the board
Location, Location, Location
Efficiency: Energy and Water

- **Water Mass** -
  - 1g/cm.³
  - 8.34 lbs/gallon
  - 62.4 lbs/ft.³
  - 2.8x10⁶ lbs/1 acre ft. (acf) (333,333 gallons)

- Water pumped to LA requires min. 2,200 kwh/aft. (3 months elec. use)
- 6.5% of CA energy to pump and treat
- Currently we use 42.6 x10⁶ aft. while 37 x10⁶ aft. remain in rivers and waterways for environmental uses (33.8 Ag/8.8 urban)
Wood Burning for Heat
Is Anybody Home?

- The occupants of a EE home can have just as much to do with it being zero energy as the home is.
- Who is living in the home – Family with stay at home mom, work from home father and home schooled kids or DINKs
- How many people live in the home
- How old are they – Kids, teenagers, old people
The Prius Effect

- If you give people feedback on usage, they will use less
  - Especially when it’s something that costs $s (fuel/power)
Simple Energy Monitoring
Plug Load

- **Kill A Watt**
  - Plugs directly to appliance
  - Very simple to use

- **Very Inexpensive**
  - ~$25-$30

- **No automated operation**
Other Plug Load Monitors

- Green PowerLink
- PowerSave IAM
- Watts Up Pro
- Brultech ECM 1220
Whole House Energy Monitoring

- TED
  - The Energy Detective
- Integrated
  - Whole house use
  - Can monitor production
- Diagnostics
- Hard to isolate
- Still low cost
  - $119-$450

www.theenergydetective.com
Integrated Energy Monitoring

- Connects to circuit breaker panel with clamp sensors
- Sends information via modem; hosted service
- $689 + ~$10/month after 2 years
- http://www.powerhousedynamics.com
Integrated Energy Monitoring

- Agilewaves
  - Menlo Park based
- More advanced integrated system
  - Also includes water & gas
  - Calculates carbon footprint
- Tracks performance of PV, solar water, geothermal
- More robust analytics
- Expensive $$$$
Google PowerMeter

- Free online energy mgt tool
- Info provided by smart meter or energy monitoring devices
  - Florida and San Diego Utilities
  - Compatible with TED and Current Cost Systems
Other Whole House Energy Monitors

- Blueline PowerCost ($99)
- Cent-A-Meter
- Meter Reader
- Green Energy Options (UK only)
- Current Cost (Google)
Energy Efficiency

- Items that use energy in the house
  - Refrigerator
  - Lights
  - Cooktop or Range (40%-90%)
  - Washing Machine (11gal/$11)
  - Dishwasher (3x, booster, full loads)
  - Clothes Dryer (parity)
  - Furnace (15%, 35% leakage)
  - Air Conditioner (SEER-17, 3x)
The Keys Are Motivation and Accessibility

- Without a will, there is no way

- If not given the opportunity, there is no chance of success
Federal Tax Credits

- **Builder:**
  - Energy efficient new homes* $2,000 credit

- **Homeowner:**
  - Insulation upgrades Up to $500 credit
  - High efficiency water heaters $300 credit
  - Energy-efficient windows and skylights Up to $200 credit
  - High efficiency furnaces and boilers Up to $150 credit
  - High efficiency central air conditioners $300 credit
  - High efficiency furnace and/or central air fans $50 credit
  - Ground source heat pumps $300 credit
  - Solar Water Heating Systems Up to $2,000 credit
  - Solar Photovoltaic Systems (PV) Up to 30% credit
Where You Can Get Some Help

- **PG&E**
  - Duct Sealing - $400 ($740)
  - Furnace - $300 ($50) ($1600)
  - Whole House Fan - $100 (10% AC)
  - Swimming Pool Pumps - $100 ($477)
  - Clothes Washer - $75 ($569)
  - Dishwasher - $50 ($277)
  - Tank Water Heaters - $30 ($159) (30-50 gal)
  - Cool Roof - $200/1000 sq ft.
  - Attic and Wall Insulation - $150/1000 sq ft.
  - P.V. - $1.90/watt (3.2 kW = $6080)
Resources

- www.cee1.org
- www.pge.com
- www.builditgreen.org
- www.energystar.com
- www.buildinggreen.com
- www.usgbc.org
- www.greenhomeguide.com
- www.pathnet.org
- www.eere.energy.gov/buildings/building_america/

Dynamic Pricing

- Missing the Point
  - Energy Use ≠ Energy Cost