Energy Efficient Design Conference Passive House/Zero Energy Home Case Study

January, 2015



Near Zero-Energy Homes (NZEH) Units

- KHIC History
 - > Founded in 1968
 - > Economic Development/Job Creation
 - > Partnerships
 - > Housing Efforts began around 2006
- Development History
 - > CDBG-R & RHED funding: 5 units
 - > TVA grid



NZEH Design

• Passive House Design

- >>75% more energy efficient than minimum building and energy codes
- > Extremely air tight (<0.6 AHC_{50} ; <90 CFM_{50})
- > Well insulated
- > Passive solar heat gain through windows
- > Changes the heating/cooling paradigm
- > 4 of 5 units received Passive House cert.
- PV and Passive House standard required particular attention to siting of homes



NZEH Design

- \circ 1284 ft²
- 3 bedrooms
- 2 bathrooms
- Includes a bathroom/laundry/kitchen pod
- Houses facing south
- Awnings for Summer shade





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Building Envelope: Foundation & Floor

- Onventional CMU Foundation
- Vented Crawlspace
- 2 x 12 floor joists 24" oc
- Fiberglass insulation in floor joists
- 1 ½" Poly-iso installed on bottom side of floor joists





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Building Envelope: Walls

- Double 2x4 walls
- High-Density fiberglass blown insulation
- OSB on 6 sides (all 4 walls, below & above)
- Taping all seams
- Sealing all penetrations
- Wrapping exterior walls with 2" Poly-iso
- Triple-pane windows (U value-0.16; SHGC-0.63)
- Triple-latch doors















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Building Envelope: Ceiling & Roof

- OSB ceiling with 3 ¹/₂" soffit below
- Mechanicals in the soffit
- High-Density fiberglass blown in soffit
- Raised Heel Trusses
- All penetrations air-sealed
- Vented attic

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 ~15" of cellulose attic insulation as prescribed by Passive House energy model











Mechanical System: HVAC

- Designed for 1 ductless minisplit heatpump, triple-pain windows & awnings; had to tweak design
- \circ 2 mini-split units
 - > A Fujitsu ductless minisplit
 - > A Mitsubishi ducted minisplit
- Baseboard heater as back-up system













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Mechanical System: Water

- Solar thermal hot water (4 of 5 units)
- GE Geo-Spring heat pump hot water heater
 - > Installation savings of approximately \$5,000
 - > Worse HERS rating by 6 points
- Dual flush toilets
- Output Compact plumbing layout, all in the bath/laundry/kitchen pod





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Equipment

Bosch washer and condensing dryer
GE Energy Star appliances
CFL light fixtures
3.76 KW PV array









NZEH Performance

87-108 CFM₅₀ across 5 houses
Best result: 0.44 ACH₅₀
HERS Ratings of 15, 10, 9, 9 & 9
PV generation ~4,000 KwH/year



Predicted Annual Energy Costs

Heating	\$43.90
Cooling	\$57.10
Hot Water	\$73.00
Lights/Appliances/Plug Loads	\$446.90
PV	(\$462.00)
Total	\$158.90



2013 Annual Cost of Electricity





PV KwH Generated



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NZEH Costs vs Appraisal

• Total Cost without land or PV: \$170,000 > \$132.40/ft² • Total Cost: \$214,897 > \$167.37 ft² • Cost of Standard house: ~\$140,000 • Appraised value: \$115,000 > No credit for PV or energy efficiency > Might have seen approximately \$9,500



Costs Compared to Standard House

Foundation & Floor	\$2,500
Walls	\$12,200
Ceiling & Roof	\$3,300
Hot Water (solar thermal)	\$6,500
Doors	\$700
Windows	\$13,500
PV	\$26,340
Appliances	\$1,130
Awnings	\$1,700
TOTAL	\$67,870



Lessons Learned: The Good

- Air sealing
- Doors
- Heat Pump Hot Water Heater
- Post-purchase counseling



Lessons Learned: The Bad

- Passive House is too ambitious to replicate at scale in our market
- Windows-excessive cost for the payback
- 2" poly-iso on exterior walls
- Double 2 x 4 walls & OSB ceilings
- Solar Thermal Hot Water



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