Energy Star Appliances and beyond; a critical component of zero energy houses

Jeff Christian, ORNL
Rich Karney, DOE

Energy Star Appliance Partners
Meeting 2
Oct 4, 2004
Drop-In Residential Heat Pump Water Heater, R&D 100 award winner
FRIDGE OF THE FUTURE

$60
$30

$Yr. TVA Electric Prices

1994 1998
4 Affordable Near Net Zero Energy Houses built and occupied near ORNL

- ZEH 1 annual measured heating cost $92, cooling $74 with an air source heat pump, and DHW $90
- 45 cents per day space heating and cooling energy
- 82 cents cost of off site total energy
Where energy is used

<table>
<thead>
<tr>
<th>Category</th>
<th>National</th>
<th>Res. Avg.</th>
<th>ZEH1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transportation</td>
<td>27%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Residential</td>
<td>20%</td>
<td></td>
<td></td>
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<tr>
<td>Commercial</td>
<td>16%</td>
<td></td>
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<tr>
<td>Industry</td>
<td>37%</td>
<td></td>
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<tr>
<td>Space Heating</td>
<td>33%</td>
<td>10%</td>
<td>14%</td>
</tr>
<tr>
<td>Space Cooling</td>
<td>10%</td>
<td>15%</td>
<td>11%</td>
</tr>
<tr>
<td>Water Heating</td>
<td>15%</td>
<td>14%</td>
<td>14%</td>
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<tr>
<td>Other</td>
<td>42%</td>
<td></td>
<td>61%</td>
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</tbody>
</table>

Sources:
ZEH1 Features

• Integrated HPWH

• Heat recovery shower

• Energy Star Appliances
  • Air-tight floor, wall and ceiling SIPS
  • All ducts inside conditioned space
  • Mechanical supply ventilation- Air-cycler
  • 14 SEER - 1.5 ton HP
  • Windows .34 U-value, .36 SHGF
  • Reflective hidden metal seam roof (light grey)
  • Grid-connected 2 kWp PV
  • CFL
Integrated HPWH
During the summer heat comes from behind the fridge
During the heating season the HPWH pulls heat from the earth tempered crawl space
Habitat for Humanity builds experimental home

It may be the group’s most energy-efficient, all-electric home ever.

By Duncan Mansfield

LENOIR CITY, Tenn. — Kinandjar’s bungalow is the only house in the Hilltop Heights subdivision — for the 48 solar panels on the roof and an R2-D2-like heater in a closet.

“I know it is an experimental house, but it doesn’t bother me all,” said the 33-year-old woman, who moved in last month with her husband and two children.

The 1,057-square-foot house, designed by the Department of Energy’s Oak Ridge National Laboratory, is the most energy efficient, all-electric home ever built by the group Habitat for Humanity.

So-called “green building” is a growing trend, according to Jeff Christian, the director of the building technology center at the Oak Ridge National Laboratory.

“More than 13,000 parable houses across the street,” said Christian, who met the association’s slightly above conventional construction prices in the area.
Domestic Hot Water

- 72% of DHW used for showers and baths in ZEH 1
- 40 gal/day average daily usage; 43% less than found in national HWHP field study in ZEH 1
- 3.8 kWhr/day average energy; that is 28% less than found in national HWHP field study
- Measured COP 1.62 (monthly range 1.52 – 1.88 from Aug 03 to Feb 1) compared to National Field Study of 2.0
ZEH 2 - $0.78/day

- HPWH hard duct linked with crawl and fridge on outside wall, COPs of 2.0, pulling from the crawl space.
- Occupancy sensor for energy control
- R-15.5 walls, R-23 ceiling, SIPs 1.8 lb/ft$^3$ EPS R-4/in and R-23 floor
- 2 ton HP two speed compressor, variable speed ECM indoor fan
- 6/12 pitch, grid-tie 2kWp Sharp 165W Solar PV, 15% efficiency
- Insulated-unvented crawlspace
- Airtight taped joints with supply mechanical ventilation, preconditioned fresh air.

Sept. 03, 2003
ZEH 2 Integrated Heat Pump Water Heater

- Located on outside wall
- Ducts
  - Much shorter
  - No flex
- HPWH using 2.7 kWh/day (36gal/day)
- Fridge using 1.23 kWh/day
HPWH weekly COPs

Weekly COP

0.00 0.50 1.00 1.50 2.00 2.50

Week

12/30/03-01/04/04 01/05/04-01/11/04 01/12/04-01/18/04 02/02/04-02/08/04 03/01/04-03/07/04 03/08/04-03/14/04 03/15/04-03/21/04 04/01/04-04/07/04 04/08/04-04/14/04 04/15/04-04/21/04 04/22/04-04/28/04 05/09/04-05/15/04 05/16/04-05/22/04 05/23/04-05/29/04 06/09/04-06/15/04 06/16/04-06/22/04 06/23/04-06/29/04 07/07/04-07/13/04 07/14/04-07/20/04 07/21/04-07/27/04 08/07/04-08/13/04 08/14/04-08/20/04
CO$_2$ Sensor could help reduce Appliance energy loads
Near ZEH for less than $100k and $0.68/day for off site energy
ZEH4- 2-story bundled kitchen, bath and laundry location in floor plan
ZEH4 PV on average helps meet summer early PM peaks from July 23-August 31, 2004
RH in Summer Months show a key appliance integration opportunity
ZEH 5

• Under design
• Solar Hot water?

• More aggressive energy efficient appliance integration
  – Dehumidifier
  – Washer
  – Drier
  – Dishwasher
  – Oven/range
Appliances Research finds Bern and Boston condominium horizontal-axis washer machine saves 60% energy and 40% water
The Water Heating Dehumidifier

**HPWH mode**
- Ambient air
- Cool exhaust air

**Dehumidifier mode**
- Ambient air
- Warm, dry exhaust air
Drivers for R&D

• Buildings
  – Becoming tighter
  – Fresh air ventilation needed
  – Humidity control issue

Water-heating Dehumidifier
Water-Heating Dehumidifier (WHD)

- Combined appliance: Water-heating dehumidifier
  - Dual (or duplex) condenser technology needed
  - Retrofit-ready
  - Designed to meet dehumidifier EnergyStar rating
  - New product; cuts WH energy consumption by 50%

- Cooperative project with Western Carolina Research Consortium
Condenser Options for Water Heating under Study

- Air Vents
- EXP. Valve
- Ref. line
- Evap
- Fan
- Fan
- Cond-1
- Air
- Comp
- Resistance Heaters
- Hot Water
- Condenser-1 Options
- Finish Product
In-Tank Condenser Option
Bottom Condenser Option

Mastic Bottom

Plate Bottom

support
Little Solar Houses for You and Me

Working to develop the Volkswagen of solar homes

by Amanda Griscom
07 Oct 2003

Just off I-75 in Tennessee, halfway between Knoxville and Chattanooga, past a Home Depot, a Ford dealership, a Krispy Kreme, and a Piggly Wiggly supermarket, there is a newly developed tract of low-income homes built by volunteers of Habitat for Humanity.

At first glance, nothing about the development seems out of the ordinary. The houses are pleasant one-story colonials with porches, shutters, and carefully trimmed lawns strewn with bicycles and kick balls. But upon closer inspection, the development turns out to be more than just another housing project in sprawling Middle America. It is a testing ground for the affordable, zero-energy homes of the future.

The most obvious clue to the larger picture -- a two-kilowatt BP Millenia thin-film solar system -- can be seen glinting on the roof of the home of Adam Indrajaya and Linda Kinandjar, a landscape worker and pastry decorator, respectively, who moved to Tennessee from Malaysia six years ago. The solar panels were provided by the Tennessee Valley Authority (the public electricity supplier throughout the seven-state region of the Southeast) and the U.S. Department of Energy's Oak Ridge National Laboratory (located just miles away in Oak Ridge, Tenn.), which teamed up with Habitat for Humanity to build this experimental settlement.

Even more impressive than the rooftop installation is the Oak Ridge-designed technology beneath it: special insulated walls, windows, and floors; energy-efficient lighting, appliances, and ducting; and state-of-the-art systems for heating, air conditioning, and hot water. The laboratory also added more exotic efficiency measures, such as a system that captures the heat from shower water after it goes down the drain, and even one that captures the warmth that comes off the coils behind the fridge.
Recent and Upcoming Media Interest

- This Old House, National broadcasted TV Series, Nov. 04
- Cover of the Mother Earth News, Dec. 2004
- Two Environmental Film Documentaries, PBS
- Business Week
- ASHRE Journal, Jan. 05
- Forbes
- Popular Science
- Energy Design Update
- Federal Reserve Bank, Partners
Key technologies for future integration into these near zero energy houses

- Integrated appliances; refrigerator, dishwasher, oven, washer, dryer, dehumidifier and water heater
House Kit

1. 50% energy savings from base code complainant housing
2. On site renewable power “ready” to meet 50% of remaining total energy load
3. Potential to meet 50% market penetration into low to medium income new single family site built construction by 2010
4. The building method of choice for affordable, innovative, healthy, productive, durable, energy efficient near net zero energy houses under 2200 ft².
5. The kit must be designed to be prefabricated, optimized, and packaged for very fast site assembly
6. The first models are to contain commercially available components
7. Be manufactured in volume to reduce costs and deliver optimal value.
Industry Partners

- Andersen Windows
- SIPA / Insulspan / FischerSIPs) / Winter Panel
- Habitat for Humanity
- TVA
- Dow
- Metal Roofing Alliance/ATAS
- BASF
- Dupont
- NOVA Chemicals
- Sharp
- Nextech Power/EPRI (DC power)
- Lennox
- Design Basics
- EMI heat pump water heater
- American Geothermal
Energy Star Appliance Partners
National Benefits

• “Mass Buy” of a house kit will have appeal to potential home buyers which eventually will display evidence of profitable market for lead production builders

• Provides a vehicle to accelerate introduction of innovative components as they approach market ready stage

• Creates unique manufacturer partnerships across multiple technologies with aggregated buyers of near zero energy house kits.
Jeff Christian

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