Welcome to the Lab Homes...

Goal is to demonstrate an intelligent, responsive, energy efficient, and grid responsive home retrofit over a period of five to seven years which achieves 50% whole house energy savings.
Lab Homes Partners

► Initial Partners
  ■ DOE/BT/Building America-ARRA
  ■ DOE/BT/Windows and Envelope R&D
  ■ Bonneville Power Administration
  ■ DOE/OE
  ■ PNNL Facilities
  ■ Tri Cities Research District
  ■ City of Richland
  ■ Northwest Energy Works
  ■ WSU-Extension Energy Program
  ■ Battelle Memorial Institute (made land available)

► Funding from Building America, DOE Windows and Envelope R&D and BPA secured for FY12 to investigate highly insulating (R5) windows performance.
Sited Within the Tri-Cities Research District
Lab Homes Characteristics

- Specified to represent existing manufactured and stick-built housing
  - 3 BR/2BA 1493 ft$^2$ double-wide factory-built to HUD code
  - All-electric with 13 SEER/7.7 HSPF heat pump central HVAC + alternate Cadet fan wall heaters throughout
  - R-22 floors, R-11 walls & R-22 ceiling with composition roof
  - 195.7 ft$^2$ (13% of floor) window area
  - Wood (Smartpanel) siding
  - Incandescent lighting
  - Bath, kitchen, whole house exhaust fans
  - Carpet + vinyl flooring
  - Refrigerator/range
  - All electric

- Modifications include extensive metering and EV charging station
Metering and Monitoring Characteristics

- **Energy metering**
  - 42 individually monitored breakers with ½ controllable and whole house
  - Itron smart billing meter

- **Temperature and relative humidity**
  - 15 room temperature thermocouples
  - 22 interior and exterior glass surface temperature thermocouples
  - 2 room relative humidity sensors
  - 2 mean radiant temperature sensors

- **Water and Environment**
  - Controllable water flows at fixtures
  - Solar insolation (pyronometer) inside home
  - Weather station (Lab Home B only)

- **Data collection via Campbell Scientific data loggers**
  - 1 minute, 15 minute, and hourly
Simulation in accordance with Building America House Simulation Protocol (Hendron and Engebrecth, 2010)

Lab Homes Hourly Simulated Electricity Use
Connect Watts per hour

60W light simulating adult occupant
Null Testing

Building construction comparison

- Homes’ air leakage (CFM air flow @50Pa) was within 6.2%
- Homes’ duct leakage (CFM air flow @50Pa) was within 2%, similar distribution performance
- Heat pumps’ performance similar ΔT across coil and air handler flow within 6%
- Ventilation fans’ flows within 2.5%
- Thermal conductivity with IR camera shows settling of R-11 batt insulation in 2x6 wall cavity in both homes.

<table>
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<tr>
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<th>Baseline Home</th>
<th>Experimental Home</th>
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<tr>
<td></td>
<td>Average Value</td>
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*n = 21.5, based on single story home in zone 3, minimal shielding
Null Testing

Whole House energy consumption comparison

Lab Homes Null Testing: 1-22-12

\[ y = 0.994x \]

\[ R^2 = 0.9993 \]
Current Experiment

- Energy consumption and thermal comfort impact of highly insulating (R-5) windows
  - Jeld Wen triple pane, argon/krypton filled, vinyl frame, triple Low-e 366 coating on two inside panes
  - Compared to “typical” double pane, aluminum frame clear glass windows
  - No window treatments in either home

<table>
<thead>
<tr>
<th></th>
<th>Baseline Windows</th>
<th>Home Windows</th>
<th>Highly Insulating Windows</th>
<th>Patio Doors</th>
<th>Windows</th>
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Heating Season Results

Overall 7.6% +/- 1.9% heating season whole house savings

- Strong dependence on weather

Daily Whole House Energy Savings

- 11.0% +/- 1.9% on cloudy days
- 4.6% +/- 1.4% on sunny days
Sunny vs. Cloudy

Graph showing the comparison between Sunny and Cloudy conditions.

- **Whole House Energy Consumption (Watts)**
- **Indoor Temperature (F)**
- **Time**
- **Lab Home A (Watt-hrs)**
- **Lab Home B (Watt-hrs)**
Impact on thermal comfort

Also examined window condensation potential and peak load impacts.

Results show significant energy savings and thermal comfort improvement.

- Also suggest R-5 windows will be very beneficial in summer cooling season due to low SHGC.

- Heating season report to be finalized in June.
Initial study is focused on thermal performance of highly insulating (R5) windows (FY11/12).

Future planned research will evaluate grid-smart appliances & smart electric vehicle charging stations.

Future potential research may include ducted heat pump water heater, low-e storm windows, efficient enclosures, innovative HVAC technologies, non-intrusive load monitoring, and solar-thermal/PV.
For more info….

➤ Visit our website (under development):
  ▪ http://labhomes.pnnl.gov/

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