

INNOVATIONS IN BUILDINGS

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Dramatically Reducing Risk Using Entire “Test Buildings”

Evaluating preproduction prototypes of new energy-efficiency products in realistic test beds is an essential step before market introduction. Environmental chambers and other lab apparatus cannot reliably impose every operating condition encountered in a real building, while occupied buildings (the living lab approach) is intrusive, risky for industry, and expensive.

ORNL has developed a risk-reducing approach to realistic residential test beds through innovative partnerships. Utility and private partners provide the land, building materials, and labor cost-share to build research houses that are leased to ORNL for research purposes over extended periods. ORNL has access to seven research houses: three from the Tennessee Valley Authority and four from Schaad Companies. Each supports research on one envelope strategy and several generations of equipment, appliances, and controls before the house is sold. Competitively-awarded American Recovery and Reinvestment Act funds were used to establish realistic light commercial building test beds at ORNL.

Technology Achievements

- In the residential and light commercial building test beds, in addition to natural exposure to weather, an average occupant effect on energy use is imposed using process control, so realistic loads, operating conditions, and interactive effects are provided for technology evaluation and physical validation of models.
- The fleet of research houses has been used to demonstrate multiple strategies for achieving deep energy savings. According to the Home Energy Rating System (HERS), a home built to code has a rating of 100 and a net zero energy home has a rating of 0. The ZEBRAAlliance research houses (www.zebralliance.com) have HERS ratings ranging from 45 to 50, indicating 50 to 55% energy savings compared to a code built home. In addition, these homes could be net zero energy with solar systems on the roof.



ORNL research houses serve as realistic residential test beds

Key Accomplishments

- ORNL's seven research houses have supported the launch of the General Electric GeoSpring™ heat pump water heater and ClimateMaster Trilogy™ 40 Q-Mode™ geothermal (ground-source) integrated heat pump.
- The first test buildings will be installed on the new light commercial building flexible research platforms by the end of 2012. More than a dozen industry partners are cost-sharing the first cycle of research that is scheduled to begin in 2013.
- ORNL is currently developing an automated building energy model tuning (to measured data) methodology called Autotune, which enables more cost-effective determination of energy-saving opportunities and ongoing verification of operational efficiency.



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- Using novel technologies employed by the latest supercomputers, machine learning algorithms, and multi-terabyte databases, the Autotune project has demonstrated methodologies using ZEBRAAlliance House #1 sensor data, which will allow an EnergyPlus model of a residence to be tuned to modest data from that residence using a desktop computer. Next these capabilities will be demonstrated for light commercial buildings using data from test buildings on the flexible research platforms.
- The greatest barrier preventing wider use of geothermal (ground-source) heat pumps is high initial cost. Two 3,700 ft² ZEBRAAlliance research houses with walkout basements were used to demonstrate that 50 to 60% of the ground heat exchanger required for a highly energy-efficient home can be installed in construction excavations needed to build the home, significantly reducing system installed cost. Modeling studies indicate that this cost reducing approach would be feasible for new construction in half the USA.
- Heat pump water heaters (HPWHs) located in the conditioned space have the potential to increase space heating loads, which would reduce their net energy savings. ZEBRAAlliance House #4 was used to demonstrate that HPWH energy savings (5.9 kWh/day) is about 13 times greater than the additional space conditioning load take-back effect (0.4 – 0.5 kWh/day) for an energy-efficient home in a mixed humid climate.
- A large and diverse array of energy conservation measures has been tested in the fleet of research houses. Analysis is under way to associate energy savings with individual measures and determine savings of bundles of measures, in order to recommend cost-effective approaches for meeting or exceeding energy codes in new construction, and achieving deep energy savings in retrofits.