Dramatically Reducing Risk Using Whole Research Buildings

Evaluating preproduction prototypes of new energy-efficiency products in a realistic environment 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 technology validation through use of whole research houses. ORNL currently has access to four research houses: three from the Tennessee Valley Authority (TVA) and one acquired by ORNL. As part of its contribution to a research collaboration with ORNL, TVA is covering through leases the full carrying charges for land, building materials, and labor required for its three research houses. Generally, each house supports research on one envelope strategy and several generations of equipment, appliances, and controls before being sold. Also, competitively awarded American Recovery and Reinvestment Act funds were used to establish two, realistic whole light commercial research buildings on the flexible research platforms (FRPs) at ORNL.

Technology Achievements

- In the residential and light commercial building technology validation facilities, 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.
- Schaad Companies provided ORNL access to four ZEBRAlliance research houses for a 3-year period ending in 2013 to validate 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

ORNL's unoccupied research house in Yarnell Station subdivision serves as realistic residential research facility.

Key Accomplishments

- ORNL's 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 research buildings were installed on the new light commercial building flexible research platforms. More than a dozen industry partners are cost-sharing the first cycle of research that is ongoing.
- 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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has a rating of 0. The ZEBRAlliance research houses (www.zebralliance.com) achieved 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.

- By employing the latest supercomputers, machine learning algorithms, and multi-terabyte databases, the Autotune project has developed and demonstrated an automated calibration methodology using ZEBRAlliance and TVA house sensor data, which allows 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 research buildings on the FRPs.

- The greatest barrier preventing wider use of geothermal (ground-source) heat pumps is high initial cost. Two 3,700 ft^2 ZEBRAlliance research houses with walkout basements were used to demonstrate that 50 to 60% of the ground heat exchanger (GHX) 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 use of all basement walls and below the basement floor would have enabled 100% of the GHX used in construction excavations. The models also suggest that this cost reducing approach would be feasible for new construction in half of 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. ZEBRAlliance 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 evaluated 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.

- The first experiments using the FRPs have recently begun.

Light Commercial Building Flexible Research Platforms

Flexible research platforms include 1-story 40x60 ft (2400 gsf) and 2-story 40x40 (3200 gsf) units, each consisting of foundation slabs, structural frames, and utility and IT infrastructure to support a variety of whole building research configurations.