Zero-Energy Housing (ZEH) Technologies

The NDCEE is helping the DoD through its public-private partnership with Actus Lend Lease to design and build cost-effective, energy-efficient housing.

Problem Statement

The DoD provides more than 300,000 homes for soldiers and their families; these homes use 11 trillion British thermal units (BTUs) per year of electrical power. The goal is to provide military families with housing that maximizes occupant comfort and wellbeing while minimizing costs and energy requirements. In support of this goal, the NDCEE is validating zero-energy housing (ZEH) technologies that can be incorporated into military housing by installing them in homes located at Aliamanu Military Reservation, HI, and Fort Campbell, KY.

Technology Description

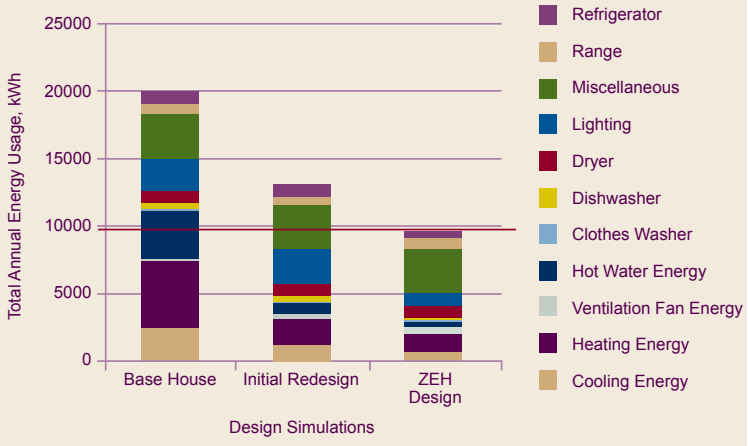
A zero-energy house produces as much energy as it consumes when averaged on an annual basis. To achieve this goal, housing energy needs are reduced through innovative design, energy-efficient technologies, and construction techniques. Houses can then be powered using renewable energy sources, such as solar and wind.

The NDCEE uses three primary tools to assist with the design of energy-efficient and zero-energy housing: integrated design, energy modeling, and lifecycle cost analysis. Integrated design replaces the traditional sequential design process by integrating multiple disciplines early in the process to help identify and optimize systems, resulting in a reduction of overall energy usage and costs. Energy modeling uses computer simulation to estimate the energy performance impact of building elements and systems. Lifecycle cost analysis is used in conjunction with energy modeling to evaluate both first costs and life-time building operation costs.

For the Hawaii houses, energy modeling and lifecycle cost analysis were used to rank ZEH concepts by performance and cost. Based on findings, the demonstration featured solar attic fans for ventilation, house coatings that contain reflective additives to reduce solar absorption, and radiant barriers that reflect heat rather than absorb it like other insulation materials (fiberglass, foam, etc.). At Fort Campbell, all three tools are being used to create an optimal technology portfolio that will allow the design of a ZEH to be achieved.

Environmental, Safety, and Occupational Health (ESOH) and Cost Benefits

ZEH technologies will reduce energy consumption; however, as with all technology investments, implementation costs should be balanced against operating and maintenance costs. Energy modeling can assist with selecting the technologies that will optimize both costs and energy performance. An example of results from modeling candidate ZEH technologies for Army Hawaii family houses is on the right.



Model simulations show the results of proposed changes throughout the design process. The amount of energy to be provided by photovoltaics is shown by the red line.

National Defense Center for Energy and Environment

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Technology Benefits and Advantages

- Reduces energy consumption and therefore energy costs
- Maximizes occupant comfort and wellbeing
- Reduces reliance on off-site utility providers, improving energy security
- Reduces utility-generated pollution

Rear view of original duplex design

Technology Limitations

- Technology selection must take into account end-user preferences, building design, climatic conditions, and other factors.
- Some ZEH technologies must be installed during the construction phase of the building.
- Some ZEH technologies have a long payback period.

Accomplishments

- Conducted energy modeling in which 15 ZEH technologies were modeled for potential use in Hawaii family housing. Technologies included insulation techniques, shading, lighting alternatives, radiant barriers for walls and roofs, and reflective house paints.
- Conducted energy modeling on single family home for Ft. Campbell, KY; final design is expected to reduce energy usage by 51%.
- Installed three ZEH technologies in July 2008 in select houses at Aliamanu Military Reservation and collected three months of energy consumption data. Technologies installed included radiant barriers in walls, low absorptance house coating, and solar attic fans for increased ventilation. “Smart” energy meters were installed as well to collect energy data from a regular “control” house where no ZEH technologies were installed and from houses where ZEH technologies were installed. Data from the energy monitoring has not yet been analyzed, but results are expected to show that ZEH technologies enhance the quality of life for soldiers and their families; support design and construction of sustainable, high-performing buildings; reduce operating costs; and reduce energy consumption and air emissions.
- Held a performance goal workshop and design charrette at Fort Campbell on August 25-26, 2008.

Roof redesign on rear of house to provide additional space for photovoltaics

The computer generated house graphics are courtesy of Luckett & Farley.

Technology Transition Opportunities

ZEH technologies can be installed in commercial and residential buildings. They can aid installations in meeting a DoD mandate that all new buildings be certified to at least a Silver level under the Leadership in Energy and Environmental Design (LEED™) green building rating system.

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