



DoD Executive Agent

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(Installations and
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Designing and Evaluation Zero Energy Housing for Military Installations

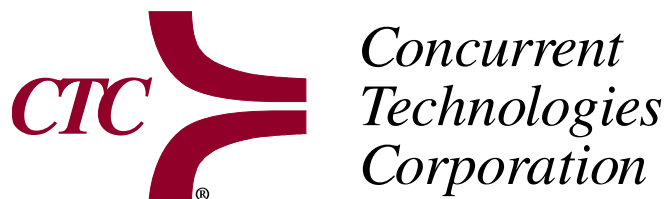
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Technology Transition – Supporting DoD Readiness, Sustainability, and the Warfighter

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Partners and Performers



Project Overview

- Use integrated design and energy modeling to demonstrate zero energy housing
- Validate the potential to provide cost effective zero energy housing
- Transfer project knowledge DoD-wide and beyond

Project Phase

- Design – completed fall 2009
- Construction – began January 2010
- Monitoring – design complete, installation expected in Summer 2010
- Analysis – 12 month monitoring period
- Technology Transfer – in process throughout project

Design Approach and Methods

- Held design team teleconferences to:
 - identify constraints/baseline conditions
 - set performance goals
 - identify specific technologies, tools, and strategies.
- Held two-day design charrette with multi-discipline, multi-organizational team
- Tools used:
 - Integrated Design: Replaces the traditional sequential design process by integrating multiple disciplines early in the process to help identify and optimize systems and reduce overall costs
 - Energy modeling and analysis
 - Life-cycle cost analysis

Constraints

- Street exterior to be unaltered
- Baseline and ZEH to be placed in existing development plan
- Occupants historically not responsible for utilities
- Work within existing floor plan



Baseline Design

- Duplex
- Four-bedroom
- Two-story dwelling
- 1,985 square feet of conditioned space per unit
- 2.5 baths
- Energy Star Rating



Photo courtesy of Lockett & Farley; Architect of Record.

ZEH Strategies

Reduce heat transfer through the envelope

Reduce solar heat gain

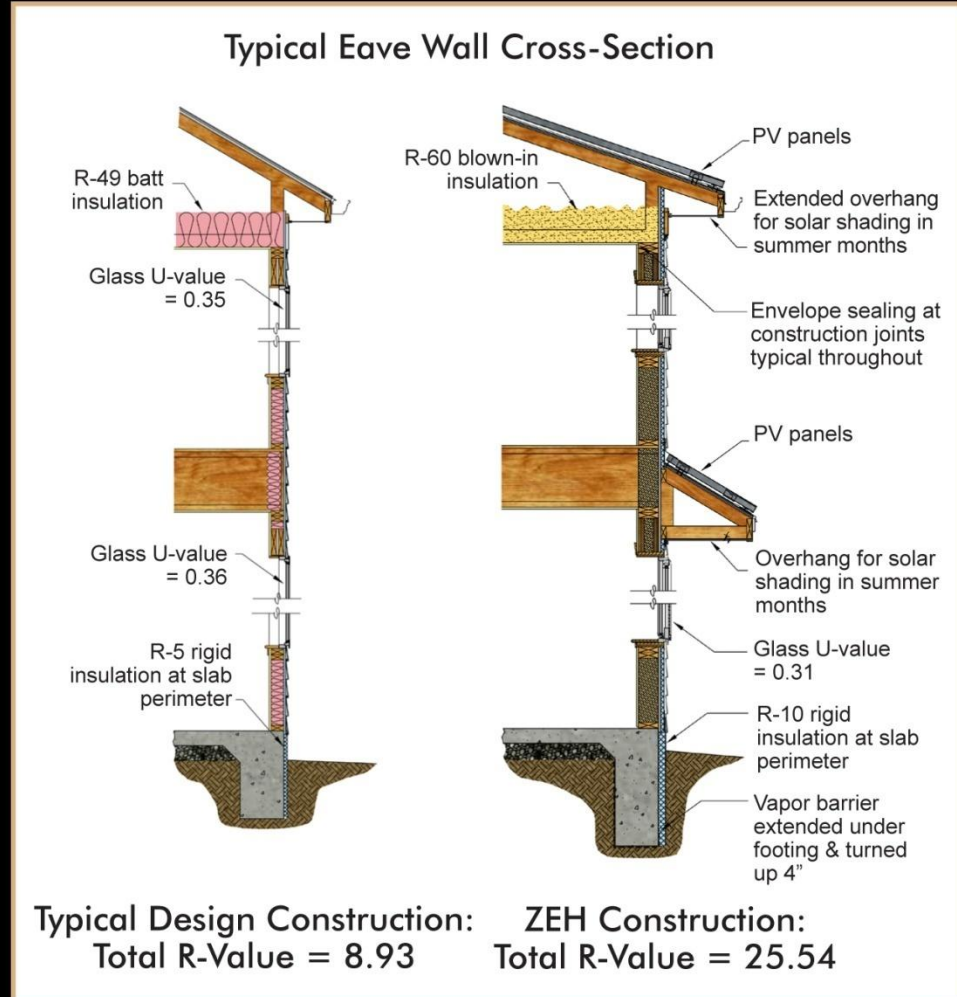
Reduce demand

Reduce consumption/miscellaneous loads

Provide on-site renewable energy source

Reduce heat
transfer
through the
envelope

Reduce solar
heat gain



R-Value indicates the insulative value (resistance to heat flow) of the exterior walls

Reduce Systems Demand

Increase efficiency of HVAC

GSHP with De-superheater

High SEER air-to-air system

Ductwork sealed and in conditioned space

Solar water pre-heat system

Flat Plate solar thermal water heating

120 Gallon high R value storage tank

On demand hot water backup

Central location for storage tank

All hot water plumbing insulated

Water distribution manifold plumbing

Energy efficient lighting/appliances

Internal CFL's

External CFL's

Energy Efficient Appliances

Reduce Consumption/Miscellaneous Loads

- Resident behavior / habits
- Timers on bath fans
- Control power strips
- Ability to view real-time usage

Optimize Solar Power

Baseline Home



Net Zero Energy Home



On-site Renewable Energy System

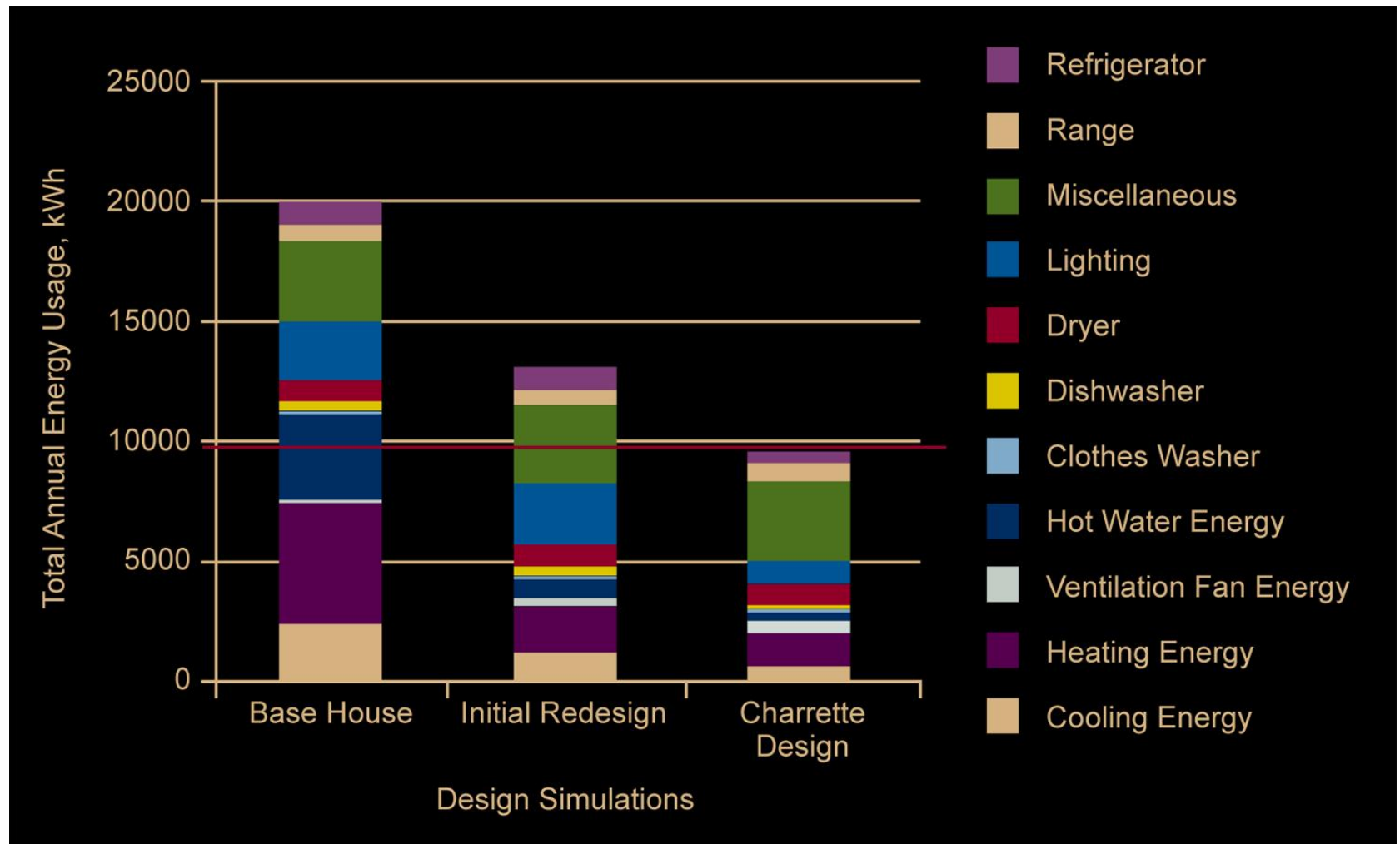
Photovoltaic Modules

- 6 Strings of 11 panels in series 33 – 225 W panels per unit
- 7,425 W per unit

Solar Production

- Clarksville, TN - 4.5 Sun Hours
- Production 9,447 kWh annually

Design Progression - Modeling Results





Construction Progress Photos
Fort Campbell ZEH - January 2010



Construction Progress Photos
Fort Campbell ZEH - February 2010



Construction Progress Photos
Fort Campbell ZEH - March 2010



Construction Progress Photos
Fort Campbell ZEH - March 2010



Construction Progress Photos
Fort Campbell ZEH - March 2010



Construction Progress Photos
Fort Campbell ZEH - March 2010

Whole Building Performance Measurement

- Comparing typically designed duplexes with net zero energy duplexes
 - Matched Pairs analysis
- Comparing ZEH with average performance of Ft. Campbell residences
- Comparing ZEH with National Standards
 - Residential Energy Consumption Survey (RECS)
 - Center for the Built Environment (CBE) occupant satisfaction survey

ZEH Performance Objectives

- 14 different Performance Objectives addressing design and performance measurement
- Design Objectives include:
 - Reduce *modeled* energy use
 - On-site energy generation is equal to or greater than modeled energy use
 - Reduce *modeled* potable water demand
- Performance Measurement Objectives include:
 - Reduce *measured* energy use
 - On-site energy generation is equal to or greater than *measured* energy use
 - Reduce end-use energy use

Monitoring Equipment in the ZEH design

- Monitoring needs included in design specifications
- Metering points include:
 - Electricity meters
 - End use meters
 - Water meters
 - Indoor and outdoor temperature and humidity
 - Solar hot water
 - Photovoltaic panels
- In-home, user-friendly displays being selected



Example of monitoring equipment in the ZEH design specification

- **Veris Industries E30 Branch Circuit Power Monitoring (BCPM) device**
 - Installed in the home electrical panel
 - Capable of monitoring 42 circuits
 - Connects directly to data acquisition device via MODBUS (RS-485) cables (provided by electrical contractor)
 - Monitors all sub-level electricity loads

Identify and Train Occupants

- **Occupant Identification Criteria**
 - Willingness to participate
 - Number and age of family members
 - Expected typical occupancy hours
 - Monthly energy use for past year for each family
 - Electronic equipment typically used by each family

Identify and Train Occupants

- **Occupant Training Strategy**
 - Develop and distribute occupant recruitment pamphlet
 - Discuss study goals and occupant expectations with potential occupants
 - Walk-through home with occupants to offer training on how to minimize energy use in the ZEH
 - Provide home operations guide
 - Communicate regularly (monthly) with occupants regarding energy use

Ongoing Interaction with Occupants

- Monthly:
 - Provide written feedback on energy and water
 - Discuss over the phone
- Six months:
 - Meet in person and discuss usage patterns in depth
 - Provide refresher training as needed
- **GOAL: to help both the occupants and the research team understand energy use patterns**

Next Steps

- Complete monitoring
- Summarize and report results
- Present results at energy and construction industry conferences
- Produce case study
- Develop ESTCP reports
- Incorporate lessons learned into over 40,000 military housing units that Actus Lend Lease is building nationwide



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