U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Whole-House Solutions for Existing Homes

Building America Case Study

Community-Scale Energy Modeling

Southeastern United States

PROJECT INFORMATION

Construction: Existing home

Type: Single-family

Builder: Not available

Size: 1,100 ft^2 to 1,400 ft^2

Number of Homes: 1,166

Price Range: Not available

Date completed: 1970s, 2000s

Climate Zone: 3A, Hot-humid

PERFORMANCE DATA

Annual Energy Consumption:
Average: 15,459 kWh
Median: 15,252 kWh

Standard Deviation: 4,163 kWh

2.5th Percentile: 7,469 kWh

97.5th Percentile: 24,001 kWh

Community-scale energy modeling and testing are useful for determining energy conservation measures that will effectively reduce energy use. To that end, the U.S. Department of Energy Building America team IBACOS analyzed pre-retrofit daily utility data from 1,166 houses in two military communities in the southeastern United States. The team used Building Energy Optimization (BEopt™) software with calibrated simulations to sort the homes by energy consumption and to produce high-quality baseline energy models for verifying savings post-retrofit or for projecting savings. The team used a combination of inverse modeling and hourly simulations to understand how the homes were performing individually and as a group.

Utility bills can be inverse modeled to evaluate the “actual” energy savings associated with home energy retrofits and disaggregate utility bills into relative usages for heating, cooling, and base load. The Building Performance Institute ANSI/BPI-2400-S-2012 standard requires practitioners to quantify energy-savings estimates with utility data to increase confidence in predictions.

Energy-use simulations can be calibrated to utility data and then used to estimate energy savings from various energy conservation measures. The team used a screening process to understand the degrees of uncertainty in the utility data and to produce trustworthy modeled predictions. The team also compiled differences in results between monthly and daily resolution input data.

This research emphasized the importance of understanding how occupancy may have changed during an analysis period and proposed automatic methods to select the best time intervals for input. This was necessary because occupants’ move-in/move-out dates were unknown, and manually selecting suitable, uninterrupted periods was not practical for the more than 1,000 homes studied. In this case, multiple years of data increased the team’s ability to find suitable analysis periods for every home. With 1 year of data, more than half the homes had to be disregarded because data quality was poor; however, with 3 years of data, more than 95% of the data were useful for analysis.

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Simulation Inputs

HVAC

- Ground source heat pumps: 3.8 coefficient of performance/ 19.4 seasonal energy efficiency ratio, vertical bore
- Cooling set points: 71°–76°F
- Heating set points: 68°–71°F
- Leaky ducts: 7.5% of total flow

ENVELOPE

- Infiltration: 7–10 ACH50
- Wall Insulation: Fiberglass batt, grade 3 installation, R-11
- Ceiling Insulation: Fiberglass batt, grade 3 installation, R-19
- Windows: Double pane, metal, 0.44 solar heat gain coefficient, 0.38 U-value
- Foundation: Uninsulated, slab on grade

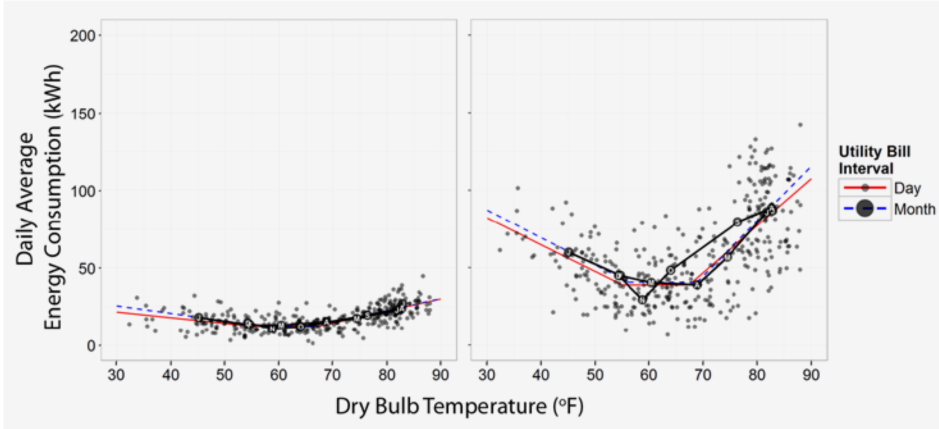
LIGHTING, APPLIANCES, AND WATER HEATING

- Miscellaneous electric loads: 0.5–1.5 times the Building America Benchmark[1]
- Default schedules
- Lighting: 25% compact fluorescent

1 Hendron, R.; Engebrecht, C. (2010). Building America Research Benchmark Definition, Updated December 2009. NREL/TP-550-47246. Golden, CO: National Renewable Energy Laboratory. *nrel.gov/docs/fy10osti/47246.pdf*

For more information, see the Building America report, *Analysis of Pre-retrofit Building and Utility Data,* at: *buildingamerica.gov*

Image credit: All images were created by the IBACOS team.



The above image illustrates the differences between the measured energy consumption of two homes. The overlaid inverse modeling results quantify in simple terms the differences between the homes and allow for comparison on more terms than simply total annual energy consumption. Note how the models with monthly resolution inputs (solid red lines) closely align with the daily (dashed blue lines). Good-quality monthly data are adequate for simple weather normalization using linear models.

Lessons Learned

- The climate zone is an important consideration. For example, these communities' hot-humid climate tends toward reduced heating loads; therefore, model heating estimates were less reliable than those made in colder climates.
- Some homes showed significantly higher cooling and heating slopes than expected for the given heating, ventilation, and air conditioning equipment. This may indicate that occupants used supplemental electric resistance heaters, or that thermostats or heat pumps malfunctioned.
- When screening utility data, shifts in occupant-driven energy consumption must be accounted for. Such shifts are generally caused by changes in occupancy (either vacancy or occupant vacations).
- No significant differences were found between the inverse modeling results from monthly and daily resolution utility data. With daily resolution data, researchers can be selective about which data to use in the analysis; however, with monthly data, only 2 months can be removed before the data quality is insufficient for analysis (according to ANSI/BPI-2400-S-2012).