BUILDING AMERICA TOP INNOVATIONS HALL OF FAME PROFILE

INNOVATIONS CATEGORY:

3. Effective Guidance and Tools Solutions
3.2 High-Performance Metrics

# House Simulation Protocols (the Building America Benchmark)

Insight Homes of Delaware worked with Building America research partner IBACOS to design and analyze multiple iterations of prototype homes until an optimum combination of efficiency measures was derived.

House Simulation Protocols have helped ensure consistent and accurate energy-efficiency assessments for tens of thousands of new and retrofit homes supported by the Building America program.

BUILDING AMERICA TOP INNOVATIONS

***Recognizing Top Innovations in Building Science*** – The U.S. Department of Energy's Building America program was started in 1995 to provide research and development to the residential new construction and remodeling industry. As a national center for world-class research, Building America funds integrated research in market-ready technology solutions through collaborative partnerships between building and remodeling industry leaders, nationally recognized building scientists, and the national laboratories. Building America Top Innovation Awards recognize those projects that have had a profound or transforming impact on the new and retrofit housing industries on the road to high-performance homes.

***Building America has proven to be a world-class research program that has delivered transformative innovations to the housing industry. A solid technical underpinning has been critical to this success, and that has been provided by simulation protocols that ensure a consistent framework for technical analysis.***

The U.S. Department of Energy's Building America program sponsors projects conducted by its research teams working in the field with home builders and contractors. These teams use a systems engineering process to perform cost and performance assessments relative to each builder or retrofit contractor's standard practice. The energy-efficiency concepts incorporated into the houses are evaluated by conducting iterative design, test, redesign, and retest procedures. This includes assessing cost and performance trade-offs to determine the most cost-effective combination of performance measures, to assess progress toward Building America' goals, and to validate energy simulation models.

The House Simulation Protocols were developed by the National Renewable Energy Laboratory (NREL) to help program members and partners perform these design trade-offs and calculate energy savings for post-retrofit and new-construction test homes built as part of the program (Hendron and Engebrecht 2010).

The Protocols document is divided into the following three sections.

- Section I provides information about design assumptions and analysis methods for new construction, including the Building America B10 Benchmark home and a new construction test home.
- Section II provides similar information for the analysis of existing homes, both pre-retrofit and post-retrofit. Using as many aspects of the real houses as possible, this section also provides default values for components of the house with unknown performance characteristics.
- Section III provides information about standard operating conditions for the analysis of new and existing homes.

NREL conducts a process to continuously improve the accuracy of energy analysis for residential buildings. Reference software is used to simulate the residential buildings in the repository. Inputs come from the collected field data, or where appropriate, are calculated or defaulted. NREL has developed analysis procedures for calculating whole-house energy savings of a post-retrofit or new-construction test

home relative to three base cases: the Building America research benchmark, the builder's standard practice, and the regional standard practice.

NREL uses building simulation analysis to calculate annual energy savings based on side-by-side, short-term field testing of a prototype house and a reference house. For new construction, the reference house equals the Building America Benchmark house, i.e., a home built to the 2009 IECC. For existing homes, the reference home is the pre-retrofit home; default values are given for any system that cannot be measured. To confirm accuracy, the analyses are compared to field-test results.

The table below shows an example of a source energy consumption report for a hypothetical project, before and after retrofits are performed.

**Table 1. Example of Source Energy Consumption by End Use for an Existing Home Project Using Building America Research Benchmark (Hendron and Engebrecht 2010)**

| | Estimated Annual Source Energy | | Source Energy Savings | |
|---|---|---|---|---|
| End Use | Pre-Retrofit (MBtu/yr) | Post-Retrofit (MBtu/yr) | Percent of End-Use | Percent of Total |
| Space heating | 115 | 45 | 61% | 23% |
| Space cooling | 28 | 9 | 67% | 6% |
| DHW | 50 | 14 | 72% | 12% |
| Lighting | 32 | 12 | 61% | 6% |
| Appliances and MELs | 78 | 76 | 3% | 1% |
| OA ventilation | 4 | 4 | 0% | 0% |
| Total Usage | 307 | 161 | 48% | 48% |
| Site generation | 0 | | -76 | 25% |
| Net Energy Use | 307 | 85 | 72% | 72% |

An example of analysis results for a new construction test home (NCTH) design are shown in the table below.

**Table 2. Example Summary of Source Energy Consumption for a New Construction Test Home (NCTH) by End Use Using Building America Research Benchmark (Hendron and Engebrecht 2010)**

| | Estimated Annual Source Energy | | | | Source Energy Savings | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Percent of End Use | | | Percent of Total | | |
| | BA Benchmark | Regional | Builder | NCTH | BA Benchmark | Regional | Builder | BA Benchmark | Regional | Builder |
| End Use | (MBtu/yr) | (MBtu/yr) | (MBtu/yr) | (MBtu/yr) | Base | Base | Base | Base | Base | Base |
| Space heating | 115 | 116 | 116 | 45 | 61% | 61% | 61% | 23% | 23% | 23% |
| Space cooling | 28 | 25 | 25 | 9 | 67% | 63% | 63% | 6% | 5% | 5% |
| DHW | 50 | 50 | 50 | 14 | 72% | 72% | 72% | 12% | 12% | 12% |
| Lighting | 32 | 32 | 32 | 12 | 61% | 61% | 61% | 6% | 6% | 6% |
| Appliances and MELs | 78 | 78 | 78 | 76 | 3% | 3% | 3% | 1% | 1% | 1% |
| OA ventilation | 4 | 4 | 4 | 4 | 0% | 0% | 0% | 0% | 0% | 0% |
| Total usage | 307 | 304 | 304 | 161 | 48% | 47% | 47% | 48% | 47% | 47% |
| Site generation | 0 | 0 | 0 | –76 | | | 25% | 25% | 25% | 25% |
| Net energy use | 307 | 304 | 304 | 85 | 72% | 72% | 72% | 72% | 72% | 72% |

## Default R-Values for Common Insulation Types

The table shows default R-values for common insulation types used in analysis for retrofit homes. NREL derived the values from several sources (Hendron and Engebrecht 2010).

| Insulation Material | Nominal R-Value/in. |
|---|---|
| High-density fiberglass batt | 3.8/in. |
| Low-density fiberglass batt | 3.1/in. |
| Loose-fill fiberglass | 3.2/in. |
| Cellulose | 3.7/in. |
| EPS | 4.0/in. |
| XPS | 5.0/in. |
| Open-cell polyurethane foam | 3.6/in. |
| Closed-cell polyurethane foam | 6.5/in. |
| Rigid polyisocyanurate | 7.2/in. |

## REFERENCES

**Hendron, R. and C. Engebrecht**. 2010. *Building America House Simulation Protocols*. Prepared by the National Renewable Energy Laboratory for the U.S. Department of Energy Building America, http://apps1.eere.energy.gov/buildings/publications/pdfs/building_america/house_simulation_revised.pdf

**Polly, B., N. Kruis, and D. Roberts**. 2011. *Assessing and Improving the Accuracy of Energy Analysis for Residential Buildings*. Prepared by the National Renewable Energy Laboratory for the U.S. Department of Energy Building America, http://apps1.eere.energy.gov/buildings/publications/pdfs/building_america/energy_analysis_resbldgs.pdf