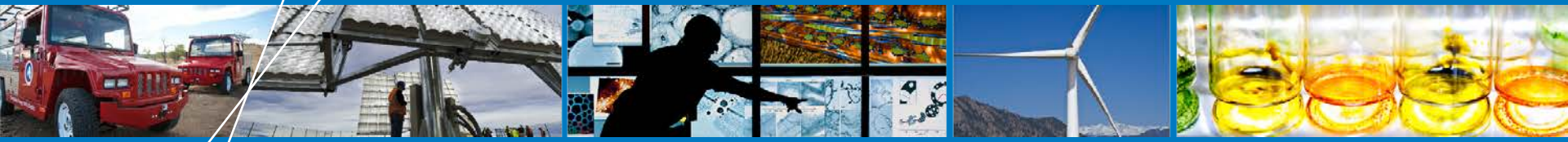
NREL
NATIONAL RENEWABLE ENERGY LABORATORY

Building Energy Simulation Test for Existing Homes (BESTEST-EX)



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Goals of NREL Analysis Accuracy R&D

- **Provide industry with the tools and technical information needed to improve the accuracy and consistency of analysis methods**
- **Reduce the risks associated with purchasing, financing, and selling energy efficiency upgrades**
- **Enhance software and input collection methods considering impacts on accuracy, cost, and time of energy assessments**

BESTEST-EX Goals

- Test software predictions of retrofit energy savings in existing homes
- Ensure building physics calculations and utility bill calibration procedures perform up to a minimum standard
- Quantify impact of uncertainties in input audit data and occupant behavior

What is BESTEST-EX?

The current test suite:

- **Compares audit software predictions to state-of-the-art detailed simulation program results (EnergyPlus, SUNREL, DOE2.1E)**
- **Evaluates limitations of audit software**
- **Tests basic building physics algorithms and calibration methods associated with audit software**
- **Specifies audit software inputs for an existing home and several retrofit measures**
- **Tests include retrofit measures applicable to two climates: one cold and one hot**

How does it work?

- Audit software completes two types of test cases: “Building Physics” and “Utility Bill Calibration”
- Test suite prescribes the building simulations to be performed
- Audit software developers create models according to specifications, run their software programs, and submit simulation results
- Simulation results are compared with reference results

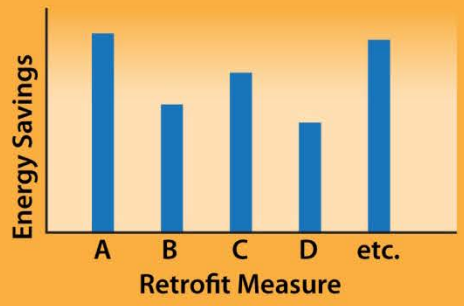
“Building Physics” Cases

BESTEST-EX Document

- Defines a representative existing home and several retrofit measures
- Provides inputs necessary to model existing home and retrofits

R-wall = 5.1
ELA = 196 in^2
Tstat = 68°F
etc.

- Presents average retrofit energy savings predictions using state-of-the-art detailed simulation programs (EnergyPlus, DOE2.1E, SUNREL)



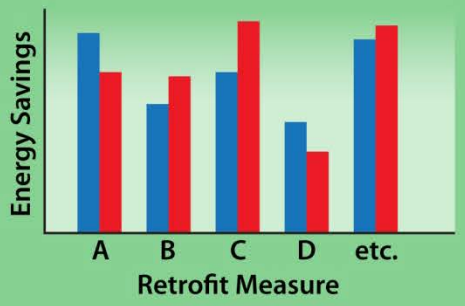
Inputs

Audit Software Provider

- Creates model of existing home using inputs from test
- Predicts retrofit energy savings

Results

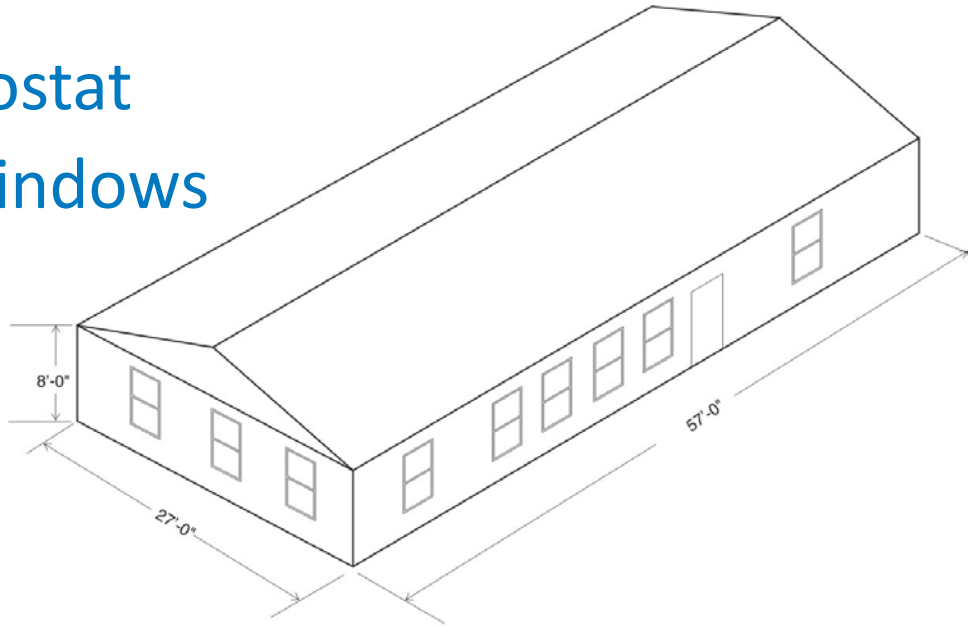
Results



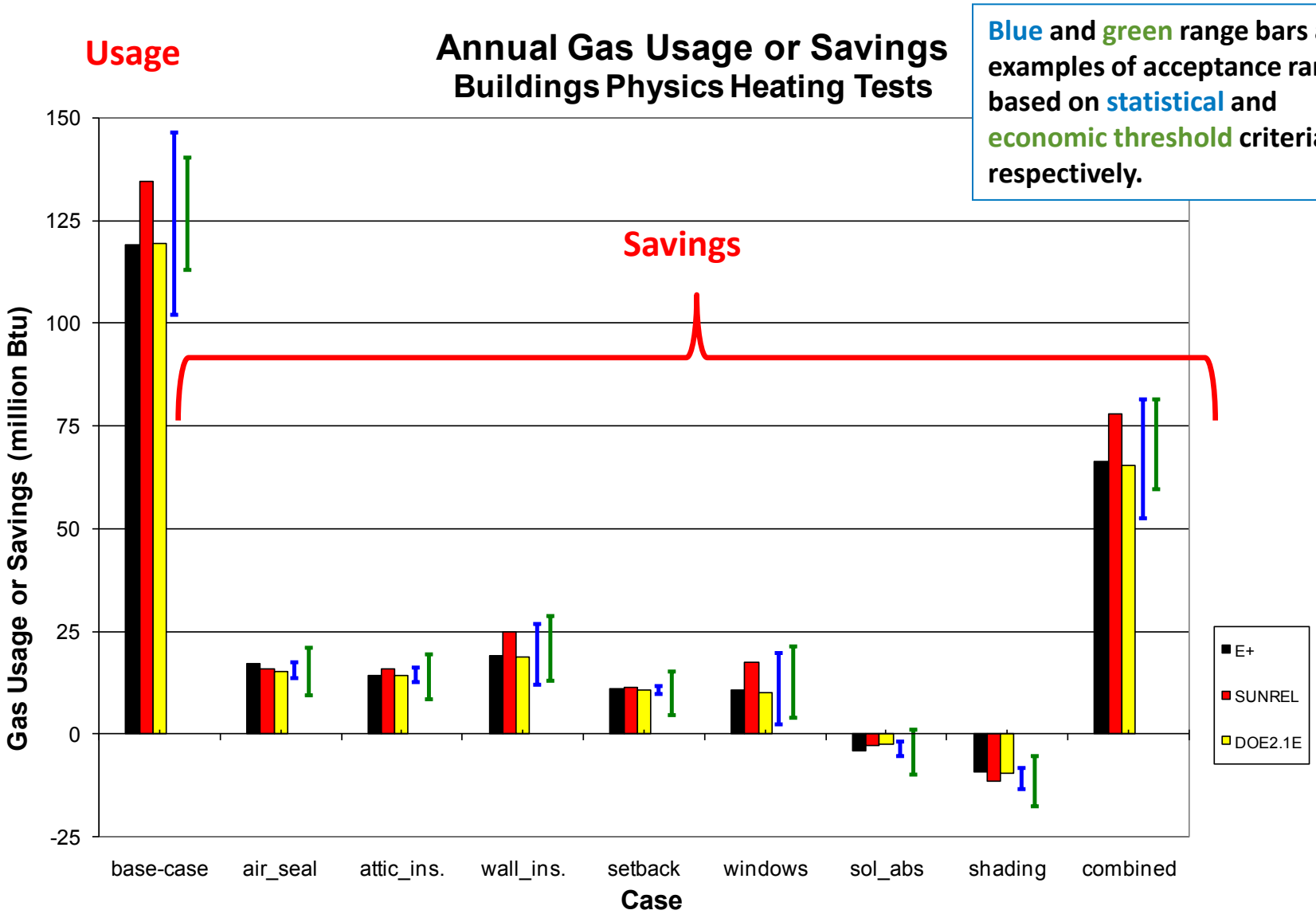
“Building Physics” Cases

The following retrofit measures are included in the current test suite:

- Air Sealing
- Attic Insulation
- Wall Insulation
- Programmable Thermostat
- Low-e Double-Pane Windows
- Reflective (Cool) Roof
- Exterior Shading
- Combined Measures



“Building Physics” Reference Results



“Utility Bill Calibration” Cases

BESTEST-EX Document

- Defines an existing home and retrofit measures
- Provides *approx input ranges* for key model inputs

R-wall = 4.5–6.2
Tstat = 60–75°F
etc.

- Presents utility bills generated by:

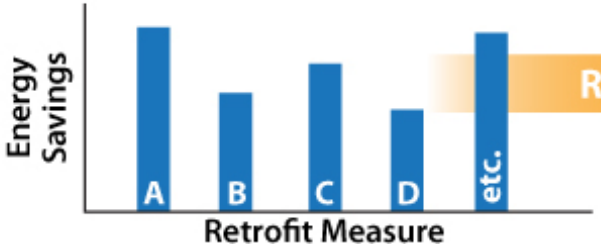
A) randomly selecting key model *explicit inputs* from *approximate input ranges*

B) running test cases with selected *explicit inputs* in EnergyPlus, DOE2.1E, and SUNREL (ref sims)

C) averaging ref sim results for bills

Input Ranges

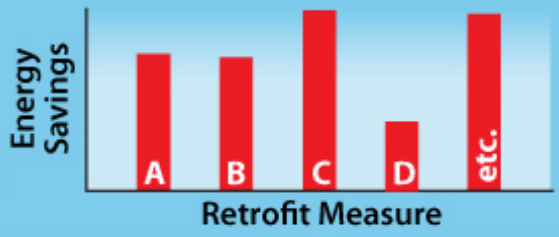
Utility Bills



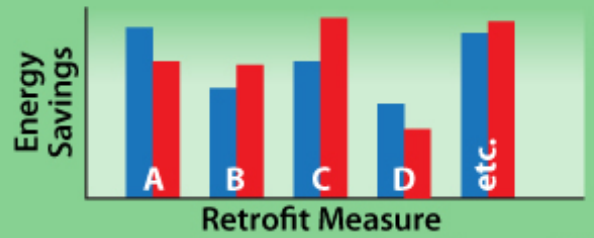
Reference Results

Tested Program Provider

- Creates model of existing home knowing *approx input ranges*
- Calibrates model inputs using utility bills
- Predicts retrofit energy savings



Tested Program Results



- Also compare tested program *calibrated inputs* with ref sim *explicit inputs*

Limitations

- BESTEST-EX is a repeatable procedure that tests how well audit software predictions compare to the current state of the art in building energy simulation. There is no direct truth standard. However, reference software have been subjected to validation testing, including comparisons with empirical data
- Interim Test Procedure does not specify how the calibration must be performed for the “Utility Bill Calibration” cases
- The set of cases in the Interim Test Procedure is a subset of possible retrofit scenarios applied in a subset of U.S. climate zones

Potential Future Work

- BESTEST-EX is multi-generational
- Refinements to existing cases and additional cases, as needed
- Additional cases: mechanical equipment replacement, duct sealing, etc.
- Compare pre-retrofit consumption and retrofit energy savings results to empirical data: revise test cases based on empirical data comparison, as needed
- Submit test suite for inclusion in maintained standards, such as ASHRAE 140

Acknowledgements

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- Others: CEC, EPA, Earth Advantage, LBNL, NYSERDA, Navigant, RESNET, TAMU
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- Former NREL (Marcus Bianchi)