IMPROVING THE BUILT ENVIRONMENT

CARB

Challenges and Solutions for Multifamily Modeling

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Building AMERICA
U.S. Department of Energy

Overview

- **Multifamily modeling in BEopt**

- **BA HSP for multifamily?**
  - Benchmark Definition (based on IECC and Federal minimum appliance standards)
  - Use Profiles

- **Infiltration measurements**

- **New metric for existing?**

Apartment vs. Whole-Building

- Currently only can model apartments in BEopt
  - Can not distinguish common areas from living areas
  - 5 bedroom max
  - Can only specify single components (mechanicals and appliances)
  - Benchmark source energy home size adjuster assumes typical home 2,400 ft^2 and 3 bedrooms
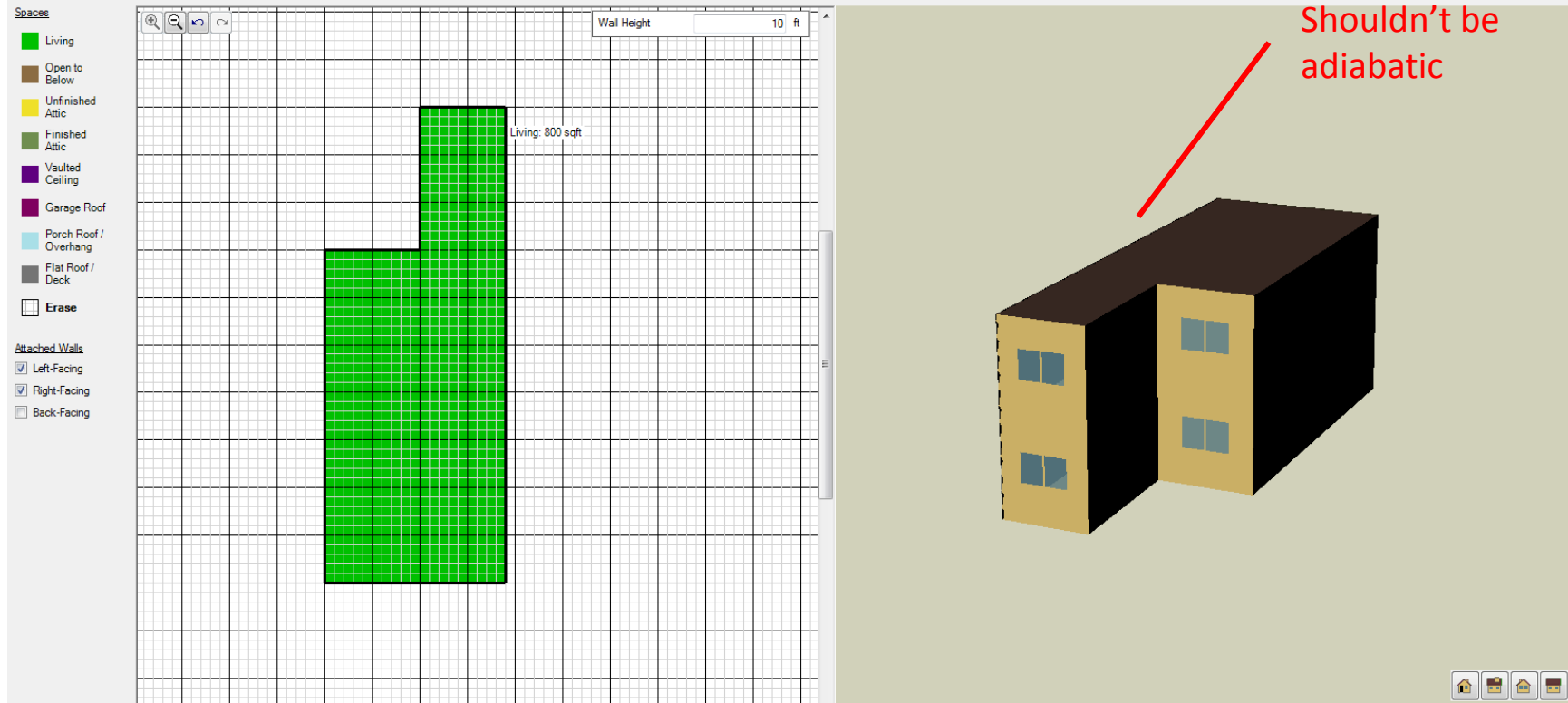
What We Can Do in BEopt
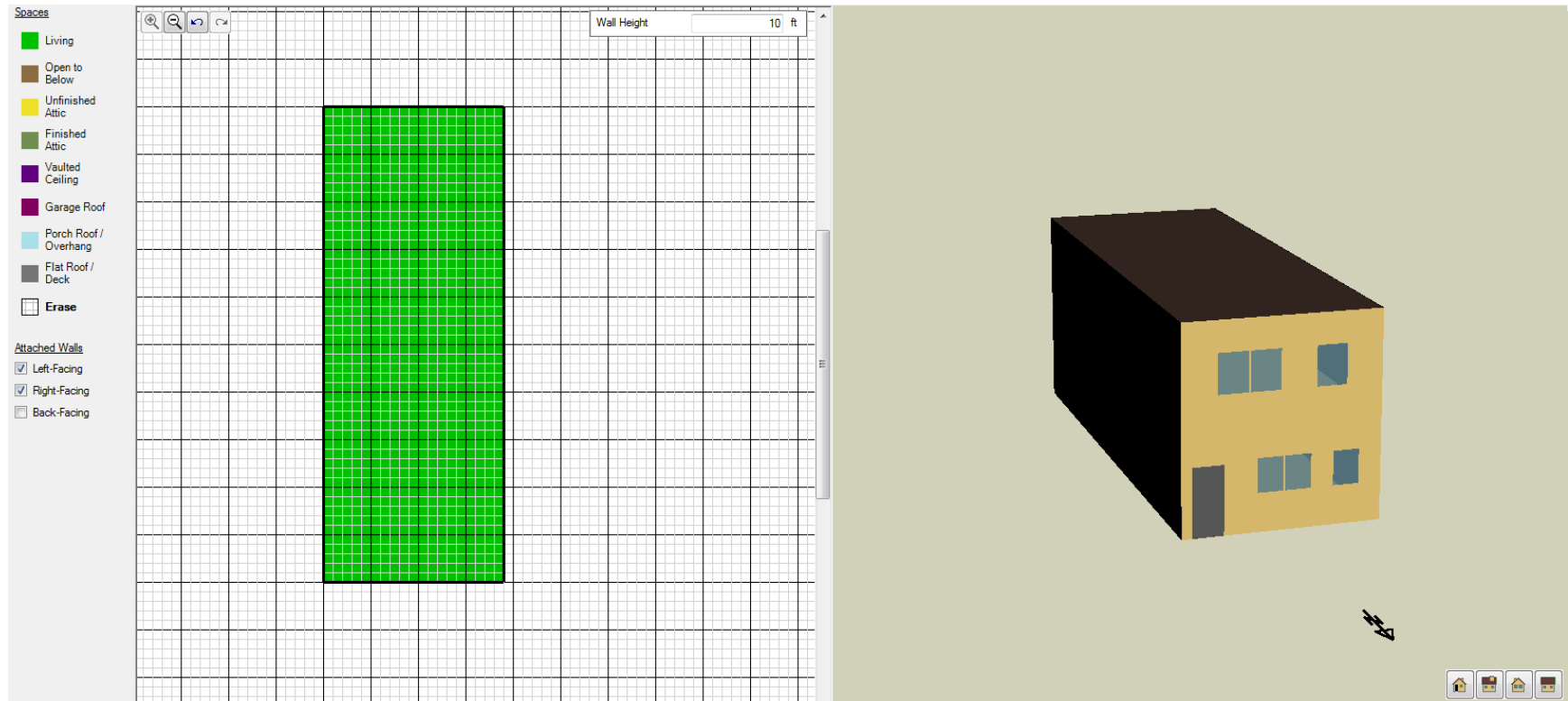
■ Attached townhouses with rectangular floor plans

What We Can't Do in BEopt

- Attached townhouses with slight changes in geometry (rear view)

Federal Water Heating Standards

- **Residential**
  - Energy Factor

- **Commercial**
  - Thermal Efficiency
  - Standby Loss

	Residential (2004)	Commercial (2003)	
	Energy Factor	Thermal Efficiency	Standby Loss
Electric	0.97-0.00132V	N/A	0.3+27/V (%/hr)
Gas	0.67-0.0019V	80%	Q/800+100$\sqrt{V}$ (Btu/hr)
Oil	0.59-0.0019V	80%/78%*	Q/800+100$\sqrt{V}$ (Btu/hr)
* Storage oil water heaters (≥10 gal)have a lower standard			

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Federal Water Heating Standards

- **Residential**
  - Energy Factor

- **Commercial**
  - Thermal Efficiency
  - Standby Loss

Example:

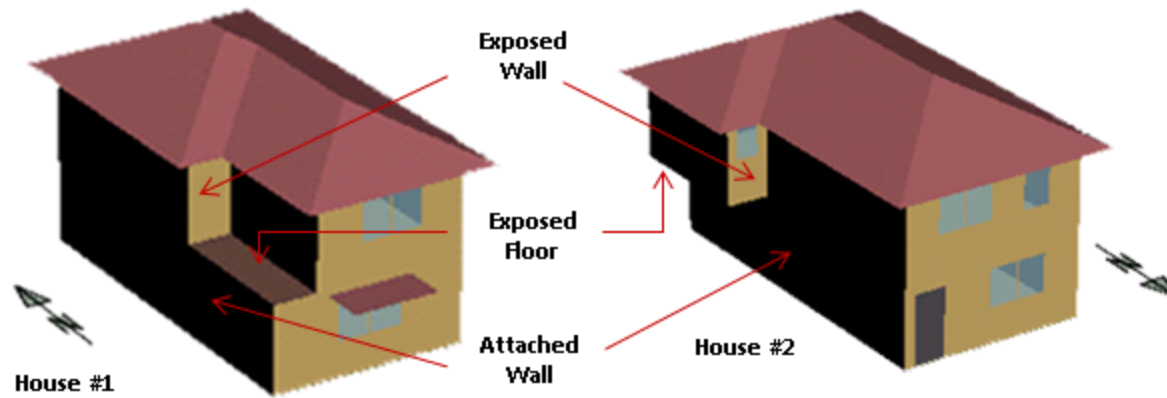|	Residential - Equivalent	Commercial Standard
Thermal Efficiency	78%	80%
Standby Loss (Btu/hr)	315	715

- 40 gal
- Gas
- 15,354 Btu/hr
- 0.594 EF (Federal min)
- 0.78 RE (BEopt default)

What We Really Can't Do in BEopt

- Overlapping units

- No way to set exposed floors and walls as adiabatic

- Central mechanical and hot water systems

- Room-by-room lighting analysis approach

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Workarounds

- Create weighted R-values for walls

- Use fake garages, attics, or flat roofs with high R-values

- Model central systems as individual

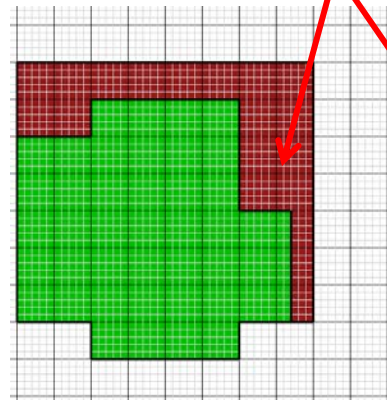- Downside: Can't model Benchmark correctly

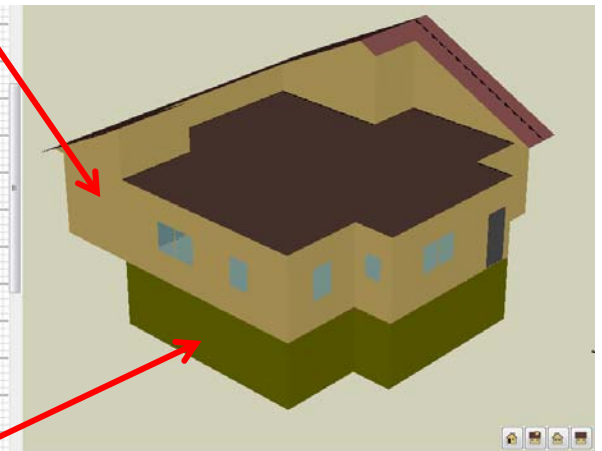## Using Dummy Zones:

Unfinished Basement: Ceiling R-1000

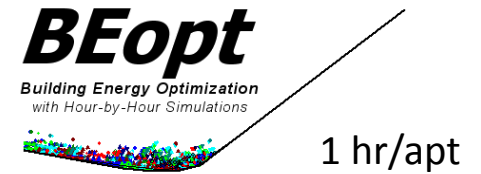Interzonal Walls: R-1000

Finished Roof: R-1000

Dummy Garage Zone

Dummy Basement

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Alternatives

BEopt
Building Energy Optimization
with Hour-by-Hour Simulations

1 hr/apt

- Alternatives don't have these issues:

REM/*Rate*™

EnergyGauge USA

eQUEST

e+ EnergyPlus

| 1.5 hrs/apt | 1.5 hrs/apt | 40 hrs/bldg | >>40 hrs/bldg |

- But, they can't do optimization

- Many modeling capabilities are not as good or more complicated

- Benchmark not built in

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BA HSP for Multifamily?

- House Simulation Protocols for new construction based on:
  - Residential IECC 2009
  - Residential Federal minimum appliance standards
- Low-Rise Multifamily Buildings may include commercial components:
  - Commercial appliance standards (usually based on input rate)

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Recirculation Systems

- Recirculation systems uncommon in single family

- In multifamily, 65% of load is lost in distribution[1]

- Recirculation controls very important
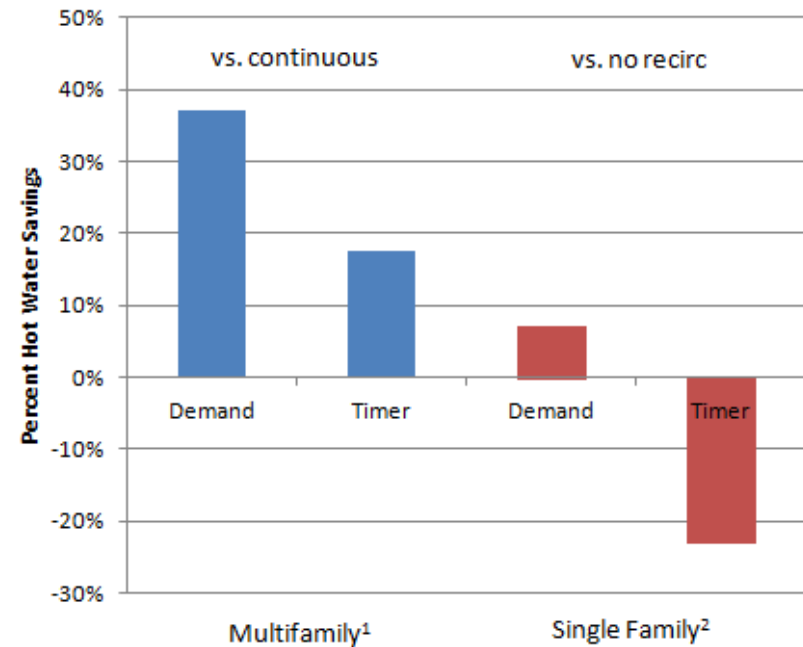
[1] "Resolving the Circulation Dilemma in Multifamily Buildings" *Home Energy* Sept/Oct. 2012
[2] BEopt 2.0

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SF vs. MF assumptions

- Use profiles based on single-family houses
  - Occupancy
  - Hot Water
  - Appliances
  - Lighting
  - Miscellaneous
- Should we use different profiles for multifamily?

BA HSP Annual Loads

|	Electricity (kWh/yr)	Gas (therms/yr)
Refrigerator	434	
Clothes Washer	$38.8 + 12.9N_{br}$	
Clothes Dryer (electric)	$538.2 + 179.4N_{br}$	
Clothes Washer (gas)	$43 + 14.3N_{br}$	$19.5 + 6.5N_{br}$
Dishwasher	$87.6 + 29.2N_{br}$	
Range (electric)	$250 + 83N_{br}$	
Range (gas)	$40 + 13.3N_{br}$	$14.3 + 4.8N_{br} + 0.001FFA$
MELs (gas+electric)	$1{,}595 + 248N_{br} + 0.426FFA$	
MELs (electric)	$1{,}703 + 266N_{br} + 0.454FFA$	

BA HSP for Multifamily? (cont.)

- Retrofit of multifamily complex
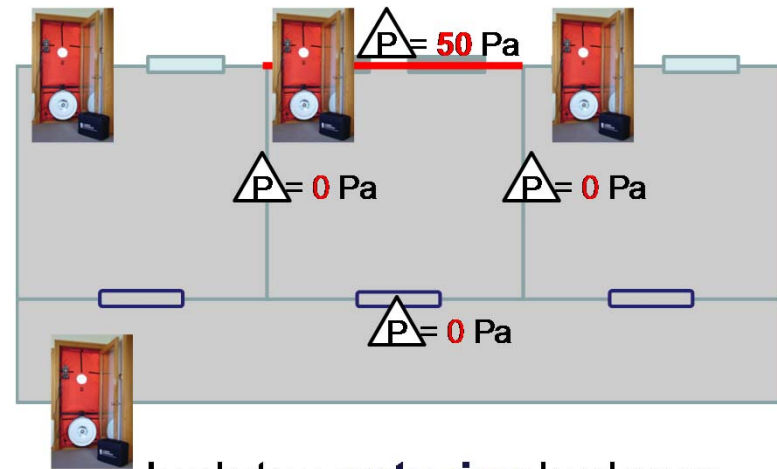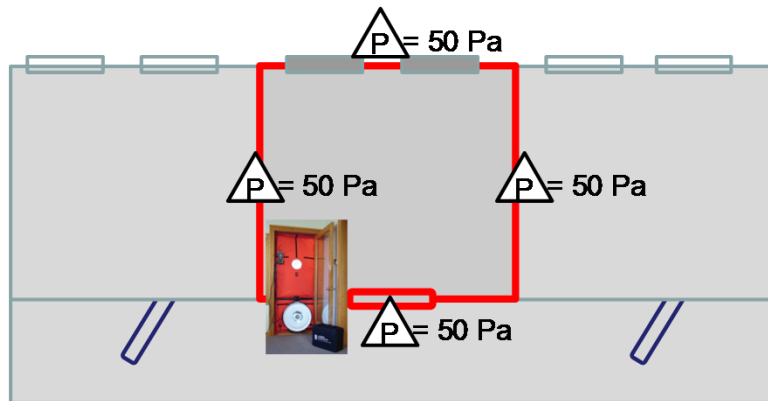
- ~ 500 sq ft apartments

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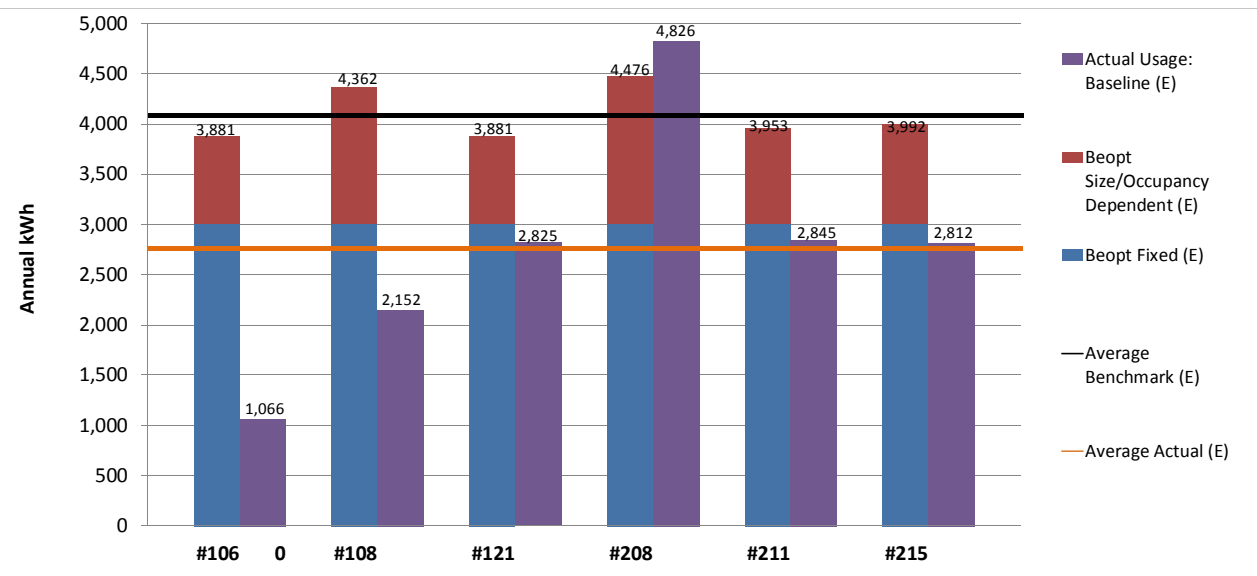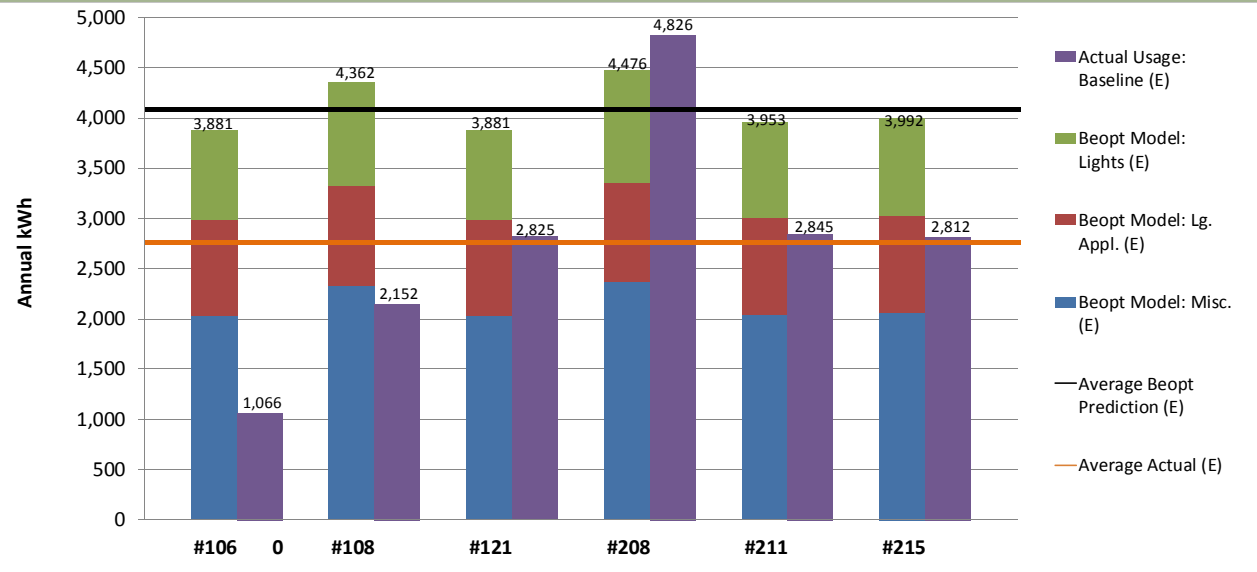
Measuring Infiltration

- Solo Blower Door (Single-Family Detached Homes)
  - Measures total infiltration into house/unit
- Guarded Blower Door (Attached/Multifamily Units)
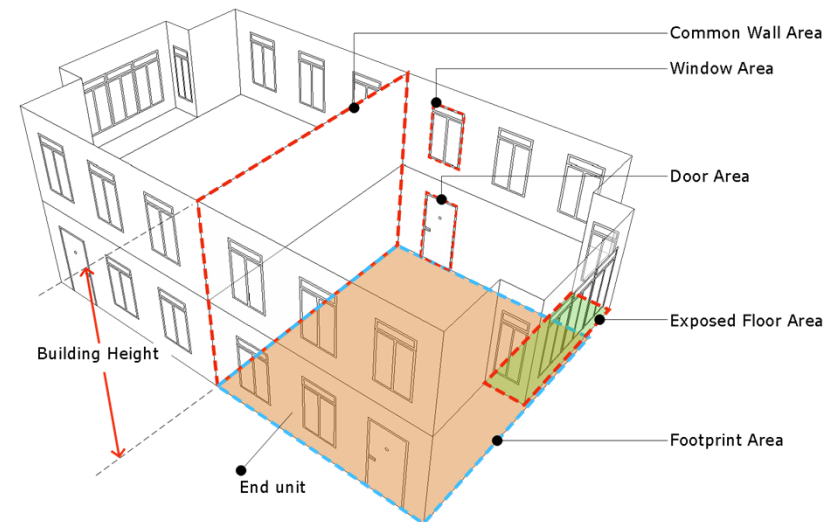 - Measures infiltration to outside

P = 50 Pa
P = 50 Pa
P = 50 Pa
P = 50 Pa

P = 50 Pa
P = 0 Pa
P = 0 Pa
P = 0 Pa

Isolates **exterior** leakage

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CARB Research

- Develop an empirical equation for predicting guarded blower door from solo test

- Use database of solo and guarded test values to develop equation based on building characteristics

Common Wall Area
Window Area
Door Area
Exposed Floor Area
Footprint Area
Building Height
End unit

Preliminary Results

- **Five Statistically Significant Variables**
  - Unit Location (End or Interior)
  - Ductwork Location (Conditioned or Unconditioned)
  - Floor Level (Top, Bottom, or Middle)
  - Common Wall to Total Surface Area Ratio
  - Window Area to Total Exposed Surface Area Ratio
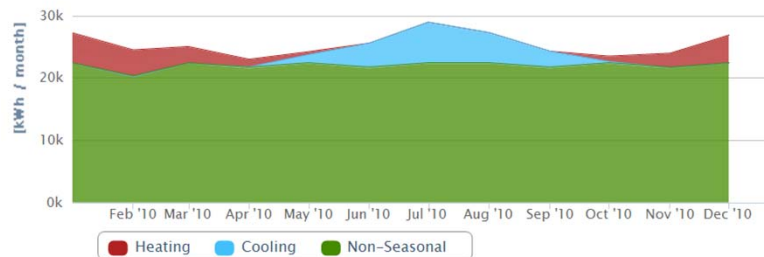

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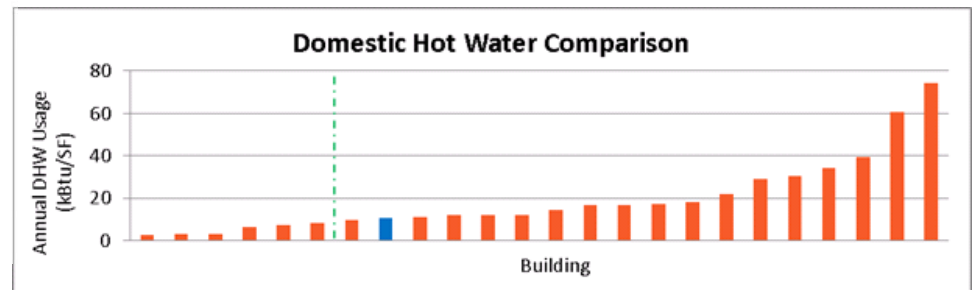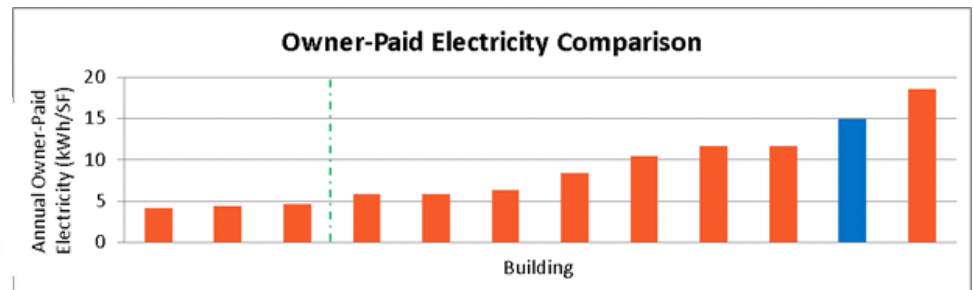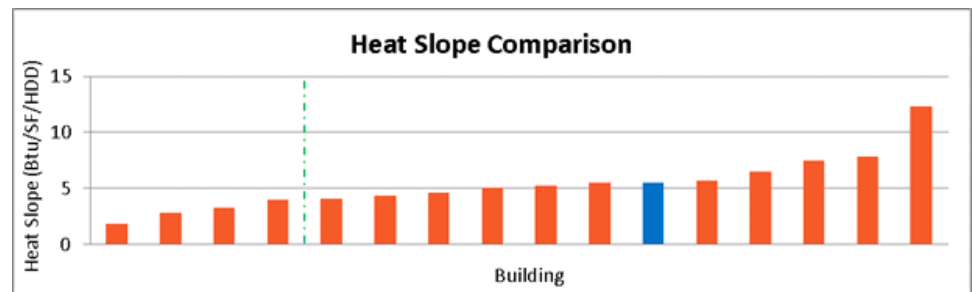*Improving the Built Environment Since 1972*
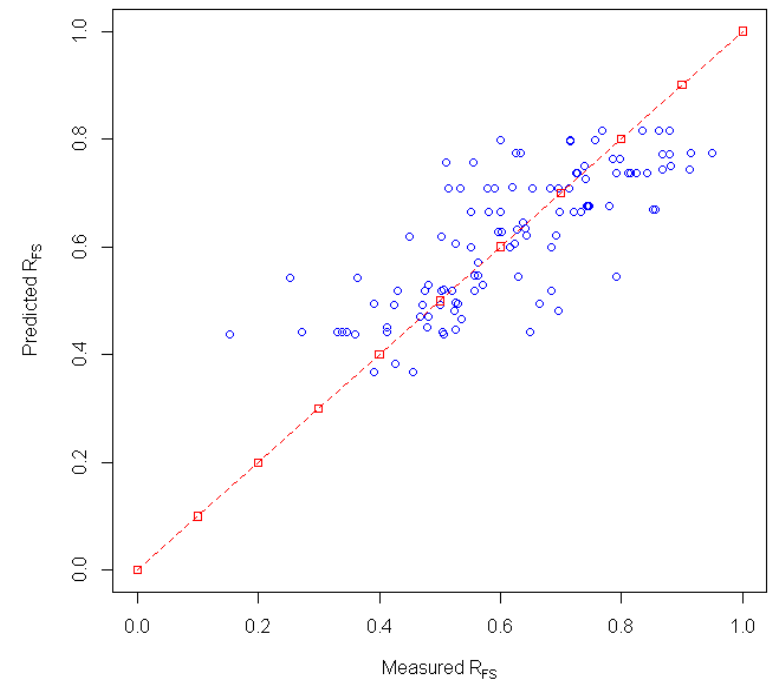
Existing Building Metric

- Change the metric: use a Btu/ft^2 goal rather than a savings percentage over existing conditions.

Annual Summary:

		End Use	
Usage:	300,586 kWh	Heating:	21,475.21 kWh
Spend:	$26,952	Cooling:	15,831.82 kWh
Rate:	$0.09 / kWh	Non-Seasonal:	263,279.34 kWh

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