MULTIPLE FAN BLOWER DOOR TESTING - LESSONS LEARNED

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www.southface.org

COURSE DESCRIPTION & LEARNING OBJECTIVES

Southface's multi-year study of small commercial buildings' energy and water consumption includes a study of building air leakage testing. Learn the details of how the testing was performed, how the results were normalized and how the various buildings stacked up. Also, discover and utilize the various templates and toolkits to add multiple fan testing to your arsenal.

- Understand the ACBI program & the Southface process for researching small commercial buildings
- Learn to apply multiple fan BD testing to small commercial projects – grasp the differences compared to testing homes
- Analyze test results and learn from interesting BD videos
- Take advantage of the free Multiple Fan BD Toolkit Resources

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OVERVIEW OF PRESENTATION

- Why small commercial?
- ACBI Overview
- Southface's approach
- A few lessons learned
- Multiple Fan BD testing
- Cool BD videos
- Lessons learned from testing ~50 small commercial buildings
- New free Toolkit resources

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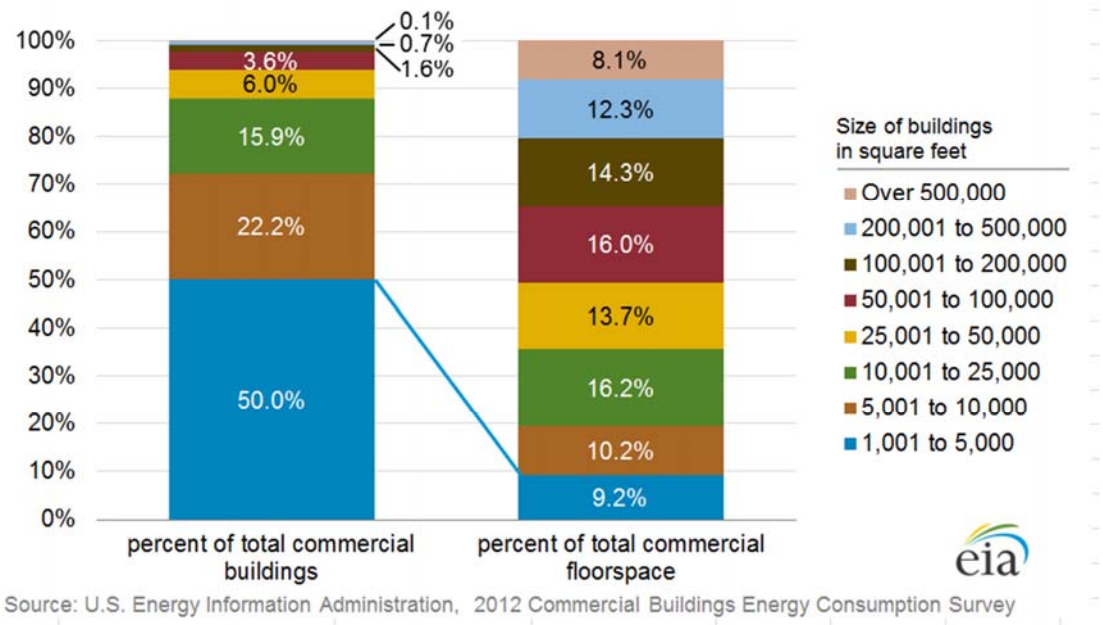
WHY SMALL COMMERCIAL? (≤50K SF)



Source: U.S. Energy Information Administration, 2012 Commercial Buildings Energy Consumption Survey

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AUDITORS & HERS RATERS - SMALL COMMERCIAL

- New market
- Building characteristics
- Systems
- Processes
- Who else is serving this market?

1. Reduce Loads
2. Match Systems to Reduced Loads
3. Use High Efficiency Systems
4. Refine System Integration

Advanced Energy Design Guidelines

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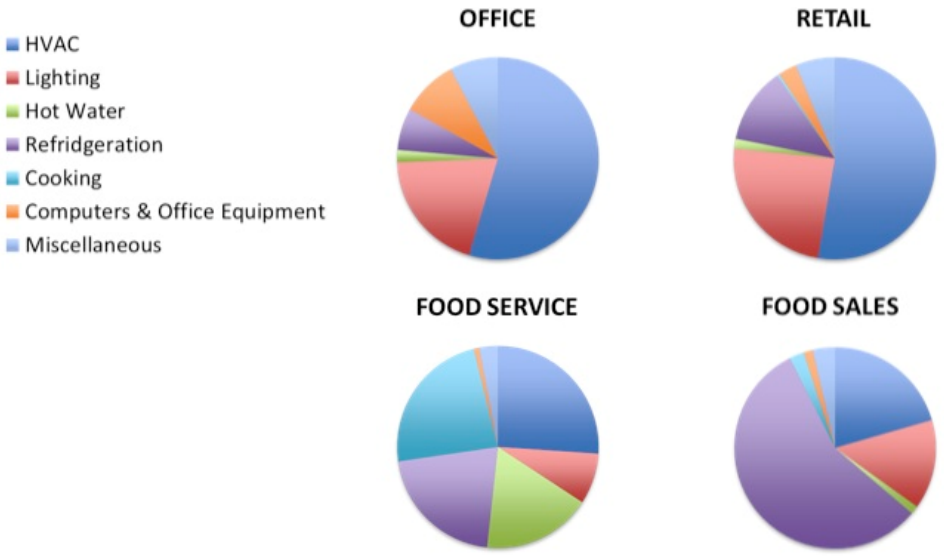
SMALL COMMERCIAL ENERGY CONSUMPTION

What is the biggest use of energy in small commercial buildings?



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ADVANCED COMMERCIAL BUILDINGS INITIATIVE

Research

Demonstrate

Deploy

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PARTNERSHIPS

GRANTS TO GREEN™

OAK RIDGE National Laboratory

RESURGENS 1867 ATLANTA, GA. 1965

ATLANTA BETTER BUILDINGS CHALLENGE

Vermont Energy Investment Corporation

BOYS & GIRLS CLUB OF AMERICA

Georgia Tech College of Architecture

EARTH CRAFT Light Commercial ™

SOUTHFACE APPROACH

20% improvement over existing

1. Benchmark
2. Assessment
3. Analysis
4. Recommendations & Projected Savings
5. Bids & Implementation
6. Verify
7. Ongoing support

BENCHMARK – ENERGY STAR PORTFOLIO MANAGER (ESPM)

MyPortfolio | Sharing | Planning | Reporting | Recognition

Salvation Army Fuqua Boys & Girls Club

405 Lovejoy Street, Atlanta, GA 30313 | Map It
Portfolio Manager Property ID: 3911773
Year Built:2001
Edit

Not eligible to apply for ENERGY STAR Certification

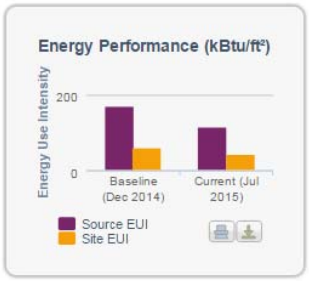
Weather-Normalized Source EUI (kBtu/ft²) Why not score?

Current EUI: 114.8
(18.8% lower than median.)

Baseline EUI: 168.1
(20.6% higher than median.)

Summary | Details | Meters | Go

Metrics Comparison for Your Property & Your Target | Change Time Period



Metric	Jun 2014	Current (Jul 2015)	Target*	Median Property*
ENERGY STAR score (1-100)	Not Available	Not Available	Not Available	50
Source EUI (kBtu/ft²)	205.6	114.8	136.5	141.4
Site EUI (kBtu/ft²)	74.0	40.5	48.1	49.9
Source Energy Use (kBtu)	3,565,592.8	1,991,440.5	2,366,529.3	2,452,736.3
Site Energy Use (kBtu)	1,283,525.9	702,880.8	833,278.8	865,695.5
Energy Cost ($)	41,538.34	28,032.45	29,955.46	34,525.86
Total GHG Emissions (Metric Tons CO2e)	203.8	114.0	135.5	140.4

* To compute the metrics at the target and median levels of performance, we will use the fuel mix associated with your property's current energy use.

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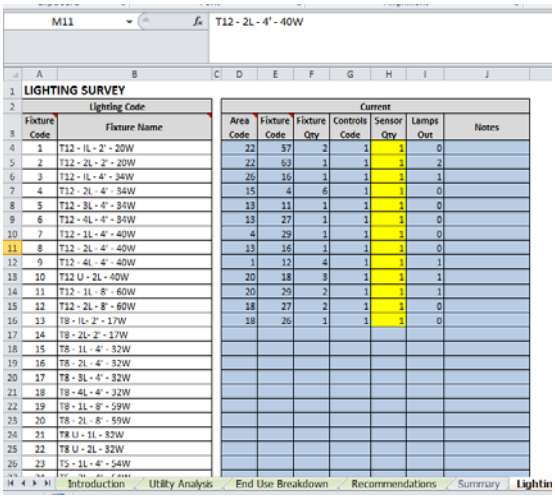
ASSESSMENT & ANALYSIS



M11 | T12 - 2L - 4' - 40W

LIGHTING SURVEY

	Lighting Code		Current					
	Fixture Code	Fixture Name	Area Code	Fixture Code	Fixture Qty	Controls Code	Sensor Qty	Lamps Out	Notes
4	1	T12 - 1L - 2' - 20W	22	57	2	1	1	0	
5	2	T12 - 2L - 2' - 20W	22	63	1	1	1	2	
6	3	T12 - 1L - 4' - 34W	26	16	1	1	1	1	
7	4	T12 - 2L - 4' - 34W	15	4	6	1	1	0	
8	5	T12 - 3L - 4' - 34W	13	11	1	1	1	0	
9	6	T12 - 4L - 4' - 34W	13	27	1	1	1	0	
10	7	T12 - 1L - 4' - 40W	4	29	1	1	1	0	
11	8	T12 - 2L - 4' - 40W	13	16	1	1	1	0	
12	9	T12 - 4L - 4' - 40W	1	12	4	1	1	1	
13	10	T12 U - 2L - 40W	20	18	3	1	1	1	
14	11	T12 - 1L - 8' - 60W	20	29	2	1	1	1	
15	12	T12 - 2L - 8' - 60W	18	27	2	1	1	0	
16	13	T8 - 1L - 2' - 17W	18	26	1	1	1	0	
17	14	T8 - 2L - 2' - 17W							
18	15	T8 - 1L - 4' - 32W							
19	16	T8 - 2L - 4' - 32W							
20	17	T8 - 3L - 4' - 32W							
21	18	T8 - 4L - 4' - 32W							
22	19	T8 - 1L - 8' - 59W							
23	20	T8 - 2L - 8' - 59W							
24	21	T8 U - 1L - 32W							
25	22	T8 U - 2L - 32W							
26	23	T5 - 1L - 4' - 54W							

Introduction | Utility Analysis | End Use Breakdown | Recommendations | Summary | Lightin

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RECOMMENDATIONS

Energy Projects (7)

Name	Date Implemented	Estimated Savings
Domestic hot water loop timer	12/31/2014	$175
High-efficiency appliances	12/31/2014	$4,921
Install vending machine controls	12/31/2014	$161
LED lighting & lighting controls	11/20/2014	$6,875
Low-flow plumbing fixtures	9/30/2014	$344
Remove old appliance	9/1/2014	$105
Upgrade HVAC controls	10/24/2014	$4,204

Total Project Investment

$78,681.00

Total Estimated Savings

$16,785.00

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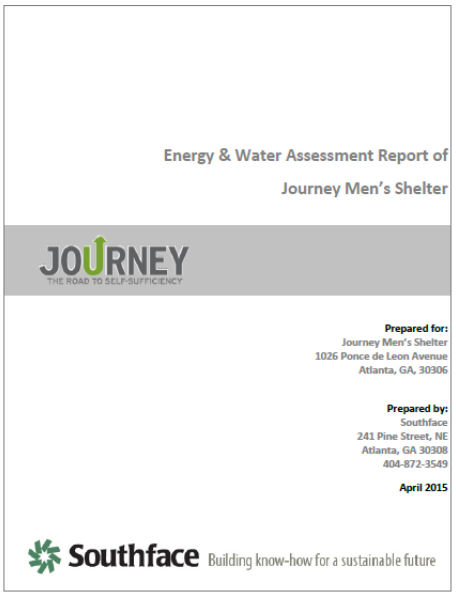
PRESENTATION & REPORT



Energy & Water Assessment Report of

Journey Men's Shelter

JOURNEY

THE ROAD TO SELF-SUFFICIENCY

Prepared for:
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April 2015

Southface Building know-how for a sustainable future

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BIDS, IMPLEMENTATION & VERIFICATION

1. **ENERGY STAR Water Heater**
   - ☐ ENERGY STAR Tankless Water Heater minimum efficiency rating at or above 93% with combustion air inlet and exhaust piping fully ducted to exterior
   - ☐ Activation flow rate at or below lowest flow water fixture (0.5 GPM)
   - ☐ Water temperature max 125°F
   - ☐ Accessible hot water lines insulated to min R-4
2. **Bathroom Efficiency**
   - ☐ Bathroom sinks and hand sink in kitchen (4 sinks total), faucets are WaterSense labeled with maximum flow rate of 0.5 GPM
   - ☐ Shower heads (2 heads tota GPM or less
   - ☐ Toilets (3 toilets total) are si
   - ☐ Urinal (1 urinal total) is Wat
3. **Kitchen Efficiency**
   - ☐ ENERGY STAR Commercial R
   - ☐ ENERGY STAR Residential Re
   - ☐ ENERGY STAR Commercial D booster
   - ☐ Kitchen faucets (up to 2 fau labeled
   - ☐ Pre-rinse spray valves (up to

Performance Comparison

		Progress			Performance Goals	
	Year Ending 12/31/2014 (Baseline)	Year Ending 7/31/2015 (Selected)	% Change	Property's Target	National Median	ENERGY STAR Score of 75
ENERGY STAR Score	N/A	N/A	N/A	N/A	50	75
Energy						
Site EUI (kBtu/ft²)	60.1	40.5	-32.5	48.1	49.9	N/A
Source EUI (kBtu/ft²)	170.6	114.8	-32.7	136.5	141.4	N/A
$	37,444.33	28,032.45	-25.14	29,955.46	34,525.86	N/A
$/ft²	2.16	1.62	-25.14	1.73	1.99	N/A
Greenhouse Gas Emissions						
Metric Tons CO2e/year	169.3	114	-32.66	135.5	140.4	N/A
kgCO2e/ ft2/year	9.8	6.6	-32.66	7.8	8.1	N/A

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LESSONS LEARNED – LIGHT COMMERCIAL

- Commercial Buildings are Systems Too!
  - Subcontractors and repair persons only know what they know
  - "Sprinkler pipes could freeze – better heat the vented attic!"
- Occupants aren't "Owner" of commercial spaces
  - Turn things off? – not my job!
  - "Maybe it's supposed to be on…"
- No feedback
  - Accountant pays utility bills but doesn't share cost implications with others
- Landlord focus is on complaints
  - Often, doesn't care about utilities
- Designers still old school –
  - Cheap first cost rules

Light commercial projects typically don't have facility staff!

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PROGRAM LESSONS LEARNED

- Utility rate structures/rebates matter
- Equipment left on when unoccupied
- Combustion safety
- LED upgrades
  - New LED fixture
  - Keep fixture housing + LED "guts"
  - Swap LED tubes (ballasts)
- Vending machines
- Hot water
- Sprinkler piping
- Implementation ≠ job complete
  - Top down support & education
  - Verification
- Ventilation

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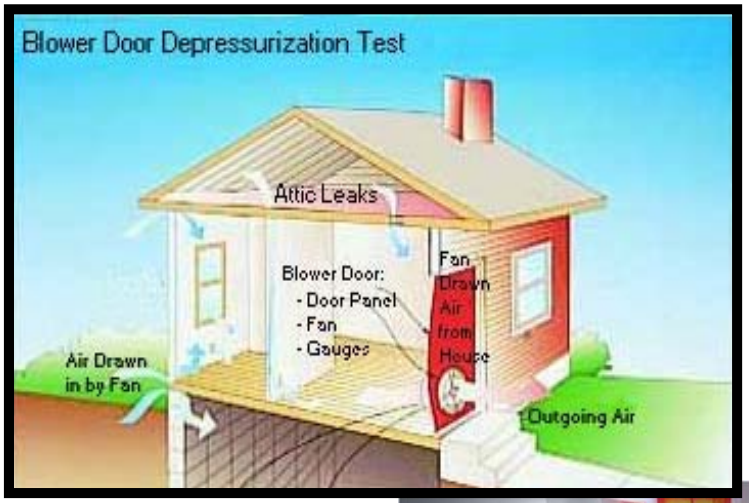
TYPES OF BLOWER DOOR TESTING

- Single Point
- Multipoint
- Multi-Family
  - –Unguarded
  - –Guarded
- Multiple Fan



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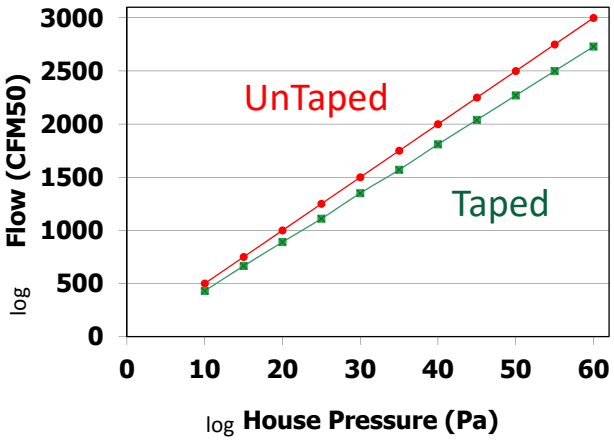
MULTIPOINT BLOWER DOOR TEST

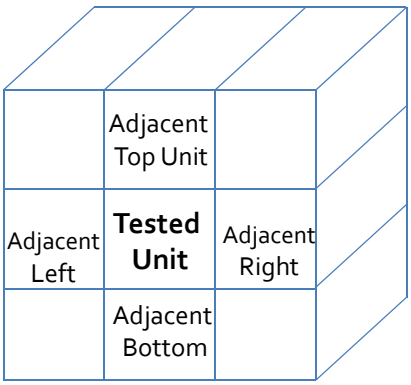
An automated **Multipoint Blower Door (MBD)** Test may be performed using a laptop, software, and a BD fan controller

- In a *MBD test*, the building's actual CFM_{XX} is determined at different pressures
- The results can be plotted to measure the infiltration at any given pressure – providing more accuracy than a single point test
- In theory, this approach reduces error and provides an acceptably accurate measurement of duct leakage via subtraction method



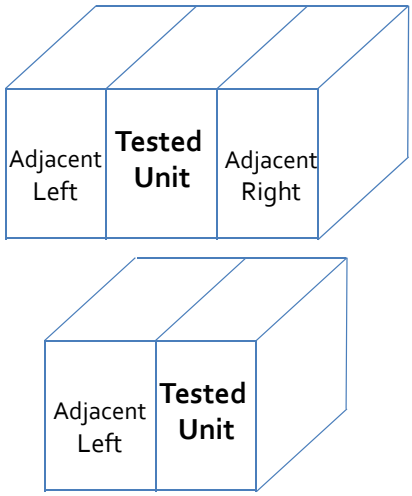
MULTIFAMILY BLOWER DOOR TESTING

- Multi-Family
  - –Unguarded
  - –Guarded



MULTIFAMILY BLOWER DOOR TESTING

- Southface results for MF testing for five projects from 1998-2001
  - Unguarded to Guarded Reduction Range
  - Typical to find "a couple hundred cfm50" across units



Project	Units Tested	Reduction Range	Outliers
'98 Augusta	1	(30%)	
'99 Alexander City	10	(0-18%)	
'00 Sylacauga	9	(11-32%)	48%, 59%
'00 Tallahassee	16	(0-5%)	23%, 26%
'01 Ozark	8	(0-11%)	

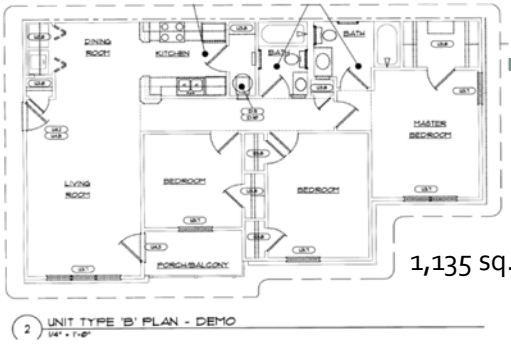
MAPLEWOOD PARK

Research to obtain real test data for ORNL's MULTEA numerical model

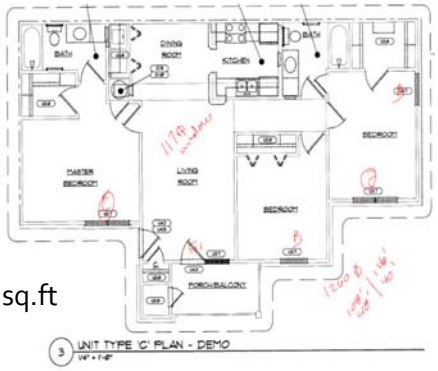
MAPLEWOOD PARK

Three different unit types:

1,040 sq.ft



1,135 sq.ft



1,126 sq.ft

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GUARDED VS. UNGUARDED

Vs.

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TYPICALLY…

Unguarded – A single point infiltration test measures dwelling unit air leakage one time at single reference pressure (50 pa) using a single blower door fan.

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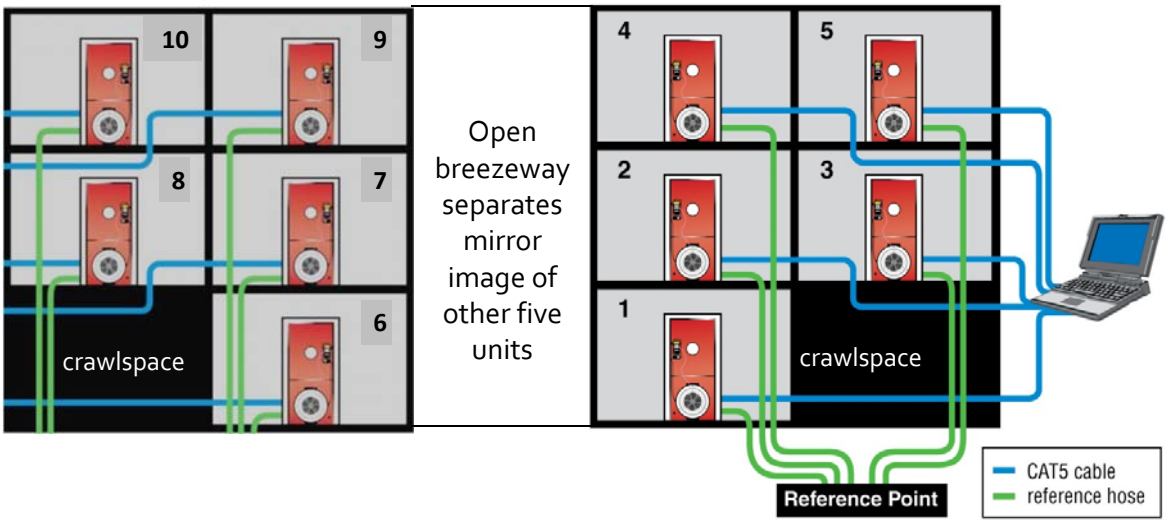
HOWEVER…

Guarded – A guarded test measures dwelling unit air leakage at a reference pressure while inducing the same reference pressure to adjacent dwelling units through the use of multiple blower door fans



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HOW DID WE DO THIS?

Breezeway

High tech bucket

2 of 5 Blower Doors

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RESULTS: MAPLEWOOD PARK

Wing 1				Wing 2			
	CFM50				CFM50		
Unit	Unguarded	Guarded	Difference (%Unguarded)	Unit	Unguarded	Guarded	Difference (%Unguarded)
1	1628	1445	183 (11.2%)	6	1400	1304	96 (6.9%)
2	1435	1101	334 (23.3%)	7	1250	1015	235 (18.8%)
3	1718	1400	318 (18.5%)	8	1275	1027	248 (19.5%)
4	1104	1027	77 (7%)	9	1223	1132	91 (7.4%)
5	1544	1458	86 (5.6%)	10	1225	1149	76 (6.2%)
Total	7429	6431	998 (15.5%)	Total	6373	5627	746 (11.7%)

Top units were tightest!

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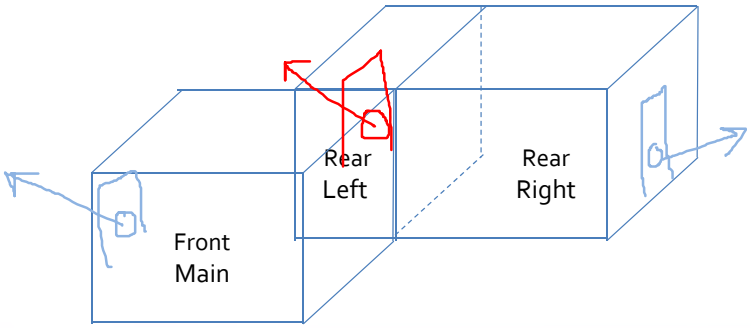
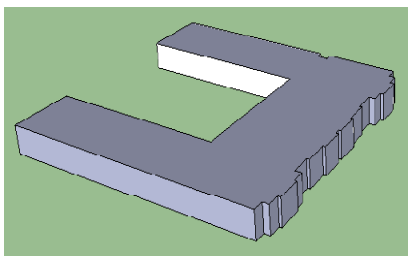
COMPARTMENTALIZATION

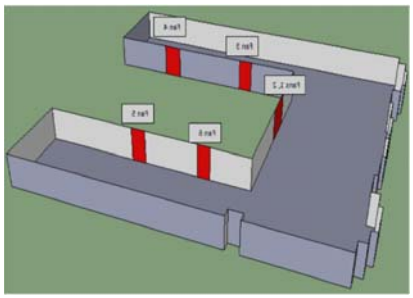
- Some commercial buildings do not openly connect / communicate throughout
  - Different compartments may have different leakage
  - Individually control each BD
  - Designate one BD zone as “master” and others as “submissives” and control all BD’s to maintain consistent pressure between zones

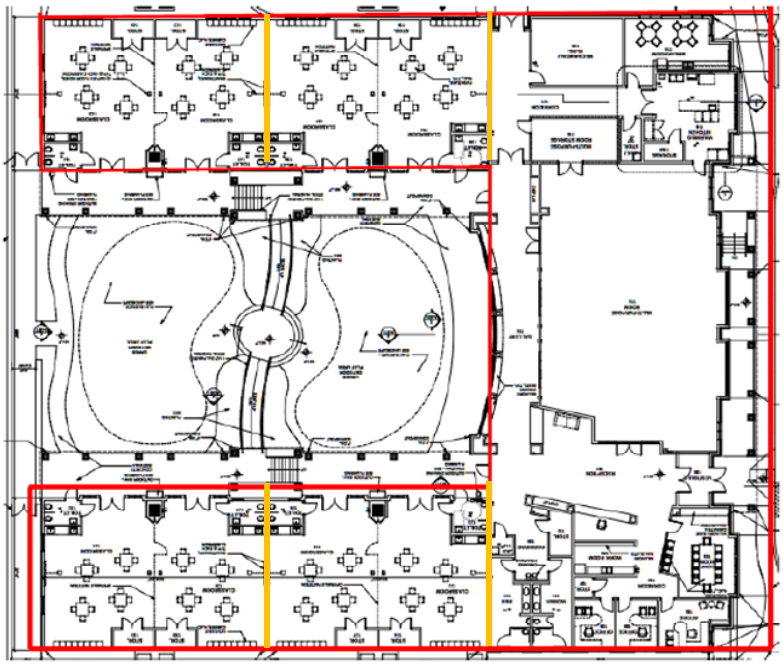


COMPARTMENTALIZATION

- Five distinct compartments



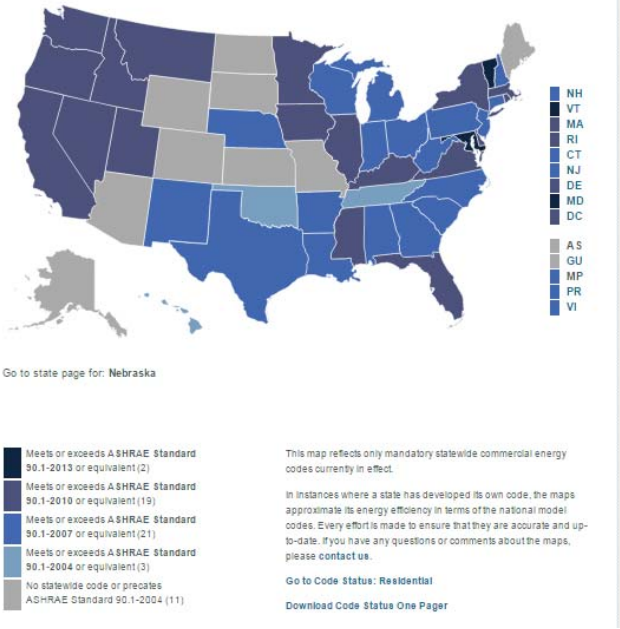




CODES AND PROGRAMS LEAKAGE REQUIREMENTS

Air Leakage Testing

- GSA – new buildings
- Washington – >5 stories
- US Army Corps – new buildings and major renovations
- ASHRAE 189.1
- LEED BD+C
- EarthCraft Light Commercial
- IECC 2012 & beyond



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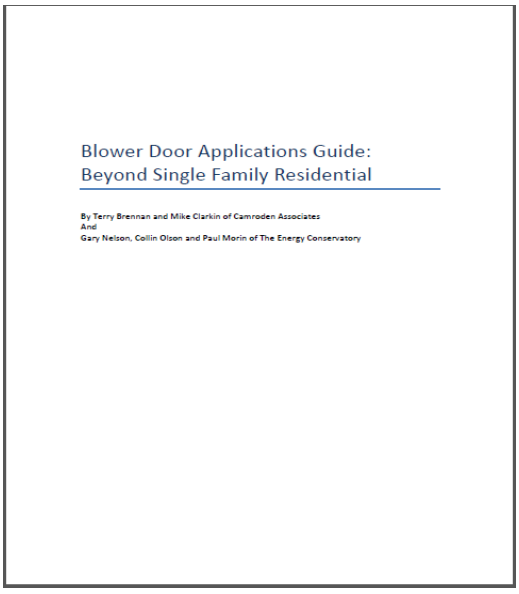
MULTI-FAN BLOWER DOOR TESTING - AN EXCELLENT RESOURCE

http://support.energyconservatory.com/hc/en-us/articles/202478994-Beyond-Residential

- Explains both theory and application
- Great websites, videos and training information from both:
  - Retrotec
  - Energy Conservatory


Blower Door Applications Guide:
Beyond Single Family Residential

By Terry Brennan and Mike Clarkin of Camroden Associates
And
Gary Nelson, Collin Olson and Paul Morin of The Energy Conservatory

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BIG PICTURE TEST PROCESS

- Follow a protocol
- Map equipment location
- Pre-test planning
  meeting of all participants – assign roles/stations
- Gather all equipment – confirm that it works
- Arrive, install equipment & prep building for testing
- Use software to perform testing
- Diagnose leaks and document results

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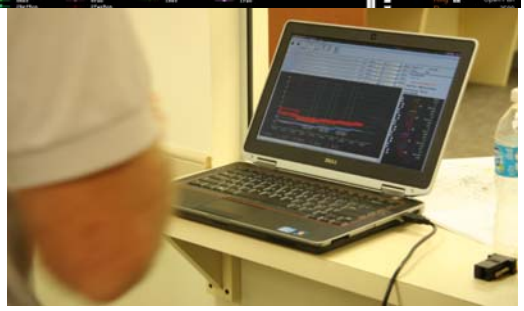
BD TESTING COMMERCIAL BUILDINGS

- Address compartmentalization and guarded/unguarded issues
- Configure hardware and run software
- Prompts
  - for baseline(s)
  - for data recording periods
- Graphs results



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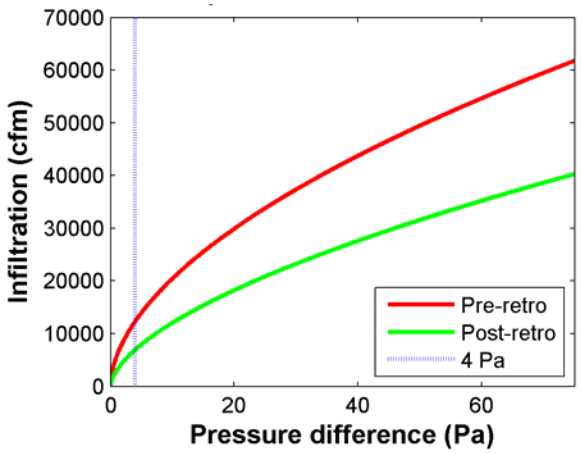
MULTI-POINT CURVE FIT – CONFUSING RESULTS

- ASTM Standard E779-03[3]: multi point test from ±20 Pa to ±75 Pa

Power Law equation: $Q = C * \Delta P^n$

- Q – infiltration rate
- C – flow coefficient
- ΔP – pressure difference across envelope
- n – flow exponent



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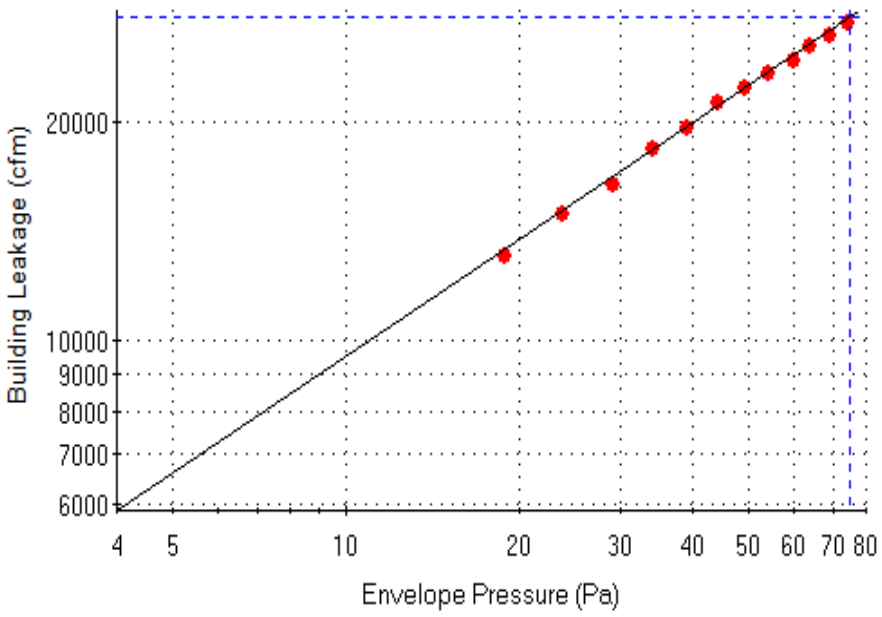
A BETTER WAY TO PLOT THE RESULTS

- Data becomes easier to read when plotted on logarithmic scale
- Curve allows leakage estimation at any pressure (e.g. 4 Pa)



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ELR75 – A BETTER METRIC

Envelope Leakage Ratio @ 75 Pa (CFM75 / shell area)

- Leakage occurs through skin of building (not through volume)
- Normalizing leakage at 75Pa (0.3 in w.c.) based on shell area is most common for commercial buildings

Example Calculation

A 1,280 square foot building has an SFBE of 3,224 square feet and a measured fan flow of 1,483 at CFM_{75}. Determine the Envelope Leakage Ratio at 75 Pa by dividing the cubic feet per minute of air volume moved through the fan by the total square footage of the building thermal envelope.

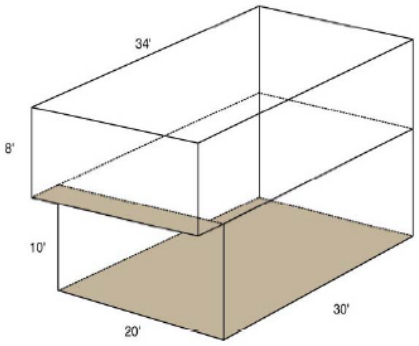
Top Flat Ceiling Area
$20' x\ 34' = \mathbf{680 ft^2}$

Building Envelope Floor Area (includes shaded area)
$20' x\ 30' + 20' x\ 4' = \mathbf{680 ft^2}$

Gross Exterior Insulated Wall Area $= \mathbf{1,864 ft^2}$
1st Floor: $(20' + 30' + 20' + 30) \times 10' = 1{,}000 ft^2$
2nd Floor: $(20' + 34' + 20' + 34') \times 8' = 864 ft^2$

$$SFBE = 680 ft^2 + 680 ft^2 + 1864 ft^2 = \mathbf{3,224 ft^2}$$

$$\textbf{Fan Flow Measurement} = \mathbf{1,483\ CFM_{75}}$$



$$ELR_{75} = \frac{CFM_{75}}{SFBE}$$

$$ELR_{75} = \frac{1{,}483\ CFM_{75}}{3{,}224\ sf}$$

$$ELR_{75} = \mathbf{0.46}$$ *Envelope Passes*

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PREDICTING LEAKAGE?

Is there a Leakage Correlation based on:

- Age / Code in place? Size? Usage type? Construction Materials?

What is baseline & expected range for a standard building in the southeast?
Was there anything predictable?

- Corrugated metal roof connections
- Junctions of two different planes (e.g., roof to wall)
- Junctions of different materials (e.g., metal or wood to block or drywall)
- Hidden pathways (e.g., above the drop ceiling tiles)
- Enforcement of code fire blocking

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- Utility Chases
- Metal Roof Decking
- Gabled Roof Junctions
- Mechanical RTU Penetrations
- Roof Membrane Connections

BD REVEALS COMMON LEAKAGE PATHWAYS

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UTILITY CHASE

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METAL BUILDING ROOF

Roof above shims

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GABLED ROOF

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RTU LEAKAGE

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FLAT ROOFED STRIP MALL

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PARAPET LEAK

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HOW TO GET FOG IN THE RIGHT PLACE

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INFLATED TPO MEMBRANE

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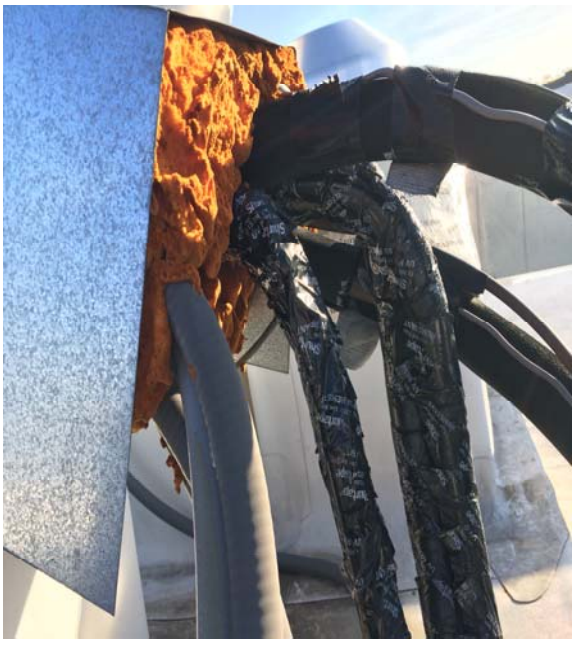
DETAILS



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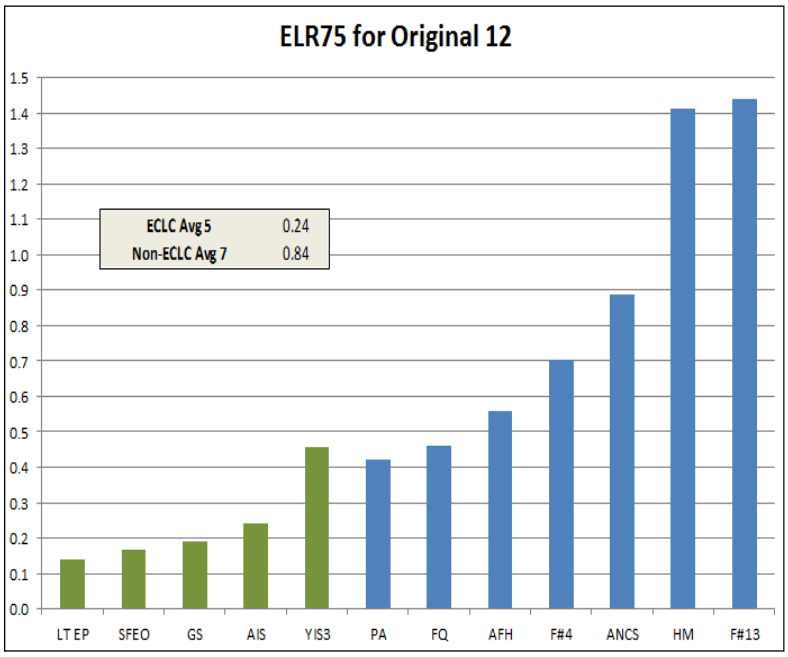
ORIGINAL 12 BUILDINGS

Test Buildings	Date of Test	Cond. Floor Area (s.f.)	SFBE	# of Stories	ELR75	Depressurization @-75Pa (masked)	Pressurization @+75Pa (masked)
	7/17/2014	17,283	48,330	1	**0.240**	11,602	12,355
	7/30/2014	2,318	9,775	1	**0.141**	1,378	1,366
	6/19/2014	3,533	12,437	2	**0.189**	2,353	2,674
	8/6/2014	5,946	11,637	3	**0.167**	1,938	2,331
	9/16/2014	12,864	36,845	1	**0.456**	16,794	20,319
	5/20/2014	11,117	29,008	3	**0.461**	13,365	14,234
	5/15/2014	17,176	41,635	1	**0.560**	23,322	23,539
	4/10/2014	5,910	15,422	1	**0.702**	10,823	9392**
	6/10/2014	34,200	69,600	2	**0.887**	61,751	74,721
	10/10/2014	34,200	69,600	2	**0.578**	40,212	44,683
	5/28/2014	3,035	8,804	1	**1.277**	11,245	12,154
	11/22/2014	3,035	8,804	1	**1.412**	12,428	12,422
	6/19/2014	7,912	20,956	1	**0.423**	8,854	9,234
	7/15/2014	5,020	15,402	2	**1.438**	22,151	22,308

ORIGINAL 12 BUILDINGS



ANALYZING TESTING RESULTS

- **All buildings are created unequal** – no apparent correlation between age, type of construction, location, etc.
- **Air Sealing** – starts at design
- **Existing buildings** – can be retro sealed
- **Designed air barrier** – 0.25 ELR_{75}; (average existing 0.84 – over 3 times leakier!)
- **Modeling tools** vary significantly in predicted savings from air sealing – approximately~10%

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ADDITIONAL BUILDINGS – SIMILAR RESULTS

Test Buildings	Date of Test	Cond. Floor Area (s.f.)	SFBE	# of Stories	ELR75	Depressurization @-75Pa (masked)	Pressurization @+75Pa (masked)
	11/11/2014	4,261	13,219	1	0.429	5,666	5,518
	11/17/2014	6,692	16,829	2	1.201	20,214	19,589
	12/4/2014	2,128	5,760	1	0.623	3,587	3,628
	12/10/2014	1,081	3,562	1	0.626	2,230	2,269
	12/15/2014	1,480	5,480	1	0.562	3,081	3,501
	12/16/2014	2,207	8,878	1	0.750	6,662	6,745
	12/17/2014	1,586	6,743	1	0.761	5,134	5,134
	12/18/2014	1,895	7,907	1	0.737	5,825	5,662
	12/19/2014	1,561	6,674	1	0.330	2,200	2,181
	1/14/2015	12,142	32,873	1	0.639	21,020	22,286
	2/4/2015	3,416	9,336	1	0.493	4,601	4,672
	2/9/2015	4,236	10,390	1	0.500	5,195	5,194
	11/12/2015	11,417	20,297	3	0.184	3,740	4,738
	1/11/2016	3,020	8,123	1	0.517	4,200	4,553
	1/12/2016	4,315	14,359	1	1.028	14,758	16,428
	1/13/2016	3,900	12,000	1	1.244	14,933	15,513
	8/22/2012	21,628	44,259	2	0.339	15,019	n/a
	5/22/2014	11,202	37,370	1	0.188	7,030	n/a
	6/11/2014	1,634	4,847	2	0.394	1,910	2,352
	6/11/2014	500	2,545	1	0.251	638	791
	7/10/2014	6,082	13,937	1	1.021	14,224	
	7/29/2014	4,615	11,165	1	1.296	14,467	15,824
	8/4/2014	4,615	14,668	1	0.581	8,515	
	8/18/2014	4,615	14,668	1	0.422	6,192	6,402
	8/26/2014	1,135	3,949	1	0.313	1,238	
	8/26/2014	1,680	6,409	1	0.360	2,310	
	10/2/2014	1,135	3,949	1	0.13	514	
	10/2/2014	1,680	6,409	1	0.12	798	

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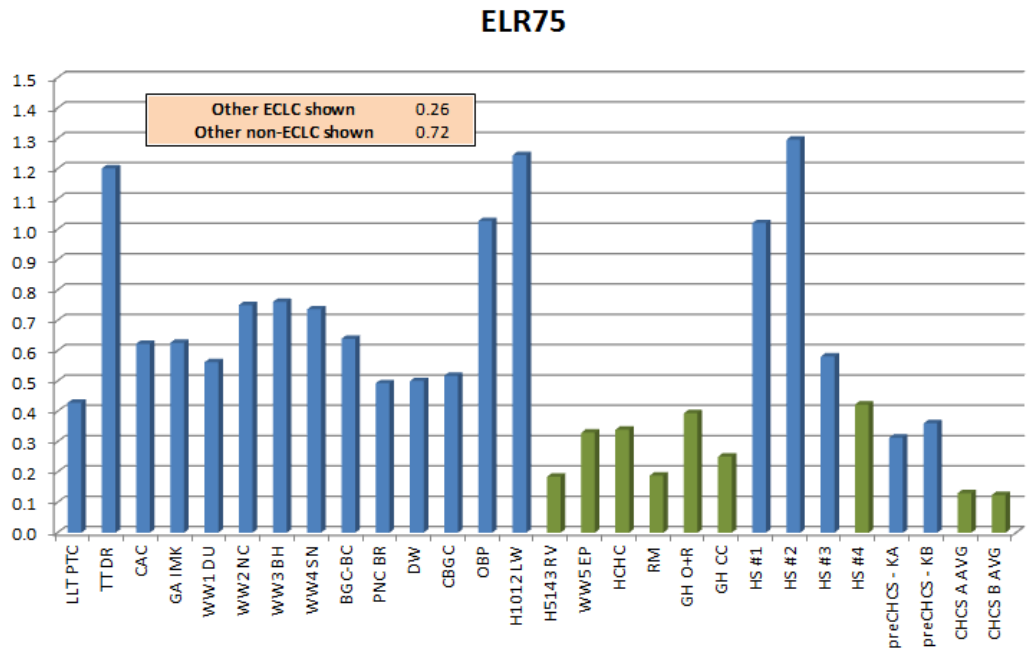
ADDITIONAL BUILDINGS – SIMILAR RESULTS



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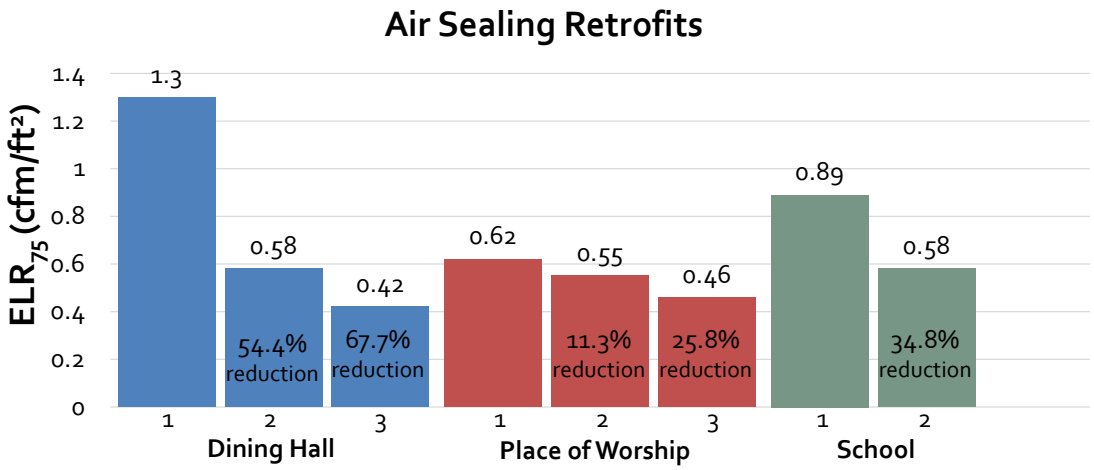
AIR SEALING RETROFITS



Air leakage of existing buildings can be substantially reduced with spray foam

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ENERGY MODELING CHALLENGES

- Commercial building air leakage testing is in its infancy (<400 buildings in largest known database); modeling default values are unsubstantiated
- Input for modeling software varies: ACH_{nat}, ACH_{50}, cfm/ft² of floor area, cfm_4/ft^2 of envelope area @ 4 Pa (ELR_4)
- Testing is conducted at accelerated pressures to minimize other driving forces – must extrapolate from multipoint regression analysis

TESTING PROCEDURE LESSONS LEARNED

- Get floor plans or at least get fire evacuation plan
- Consider a SketchUp model for more cut-up assemblies and to assist in take-off calculations
- Pre meeting – assign tasks and zone responsibilities
- Written test procedure
- Site communication – local contact
  - Signage around building
  - Walkie-talkies
  - Pre-condition of thermostat settings

TESTING PROCEDURE LESSONS LEARNED, CONT.

- Reinforce masking
- Foam insulation tubes / pool noodles at doors with auto closers; door shims
- 1 fan per circuit
- Extension cords, power indicators, long tubing
- Theatrical fog machine, fan, flex duct and pole
- Duplicate fans (if possible, face in alternate directions)
- Ladders, extension cords, batteries, extra kits if available

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HOW TO ESTIMATE NUMBER OF FANS

- Minimum one per "compartment"
- Estimate an ELR75
  - Determine shell area
  - Back out CFM75
- Assume ~5,000 cfm per fan plus one extra fan

- Example: 40' x 60' x 25' building
  - Shell Area: 9800 s.f. (Ceiling: 2400 s.f., Floor 2400 s.f., Walls: 5000 s.f.)
  - Assume leaky ELR75 = 1.5 = CFM75 / 9800 so CFM75 = 14,700
  - 14,700 / 5000 = 2.9 which rounds to 3 and then add 1 for **4 BD's total**

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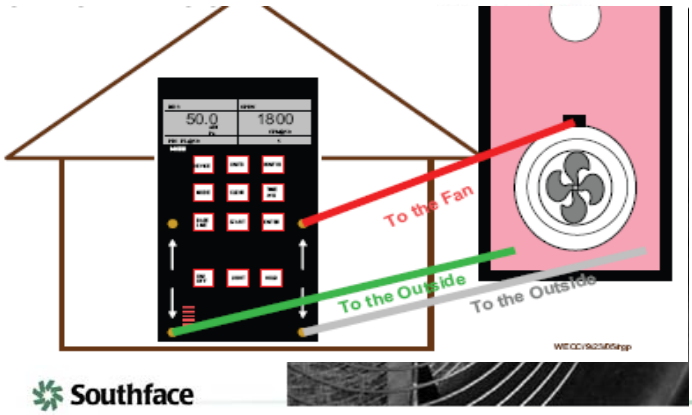
PRESSURIZATION - FANS NEED REF TUBE

The blower door fan pressure is <u>always</u> measured at the flow sensor WRT the **fan inlet side:**

- *the <u>building</u> when depressurizing*
- *the <u>outside</u> when pressurizing – use reference tube*



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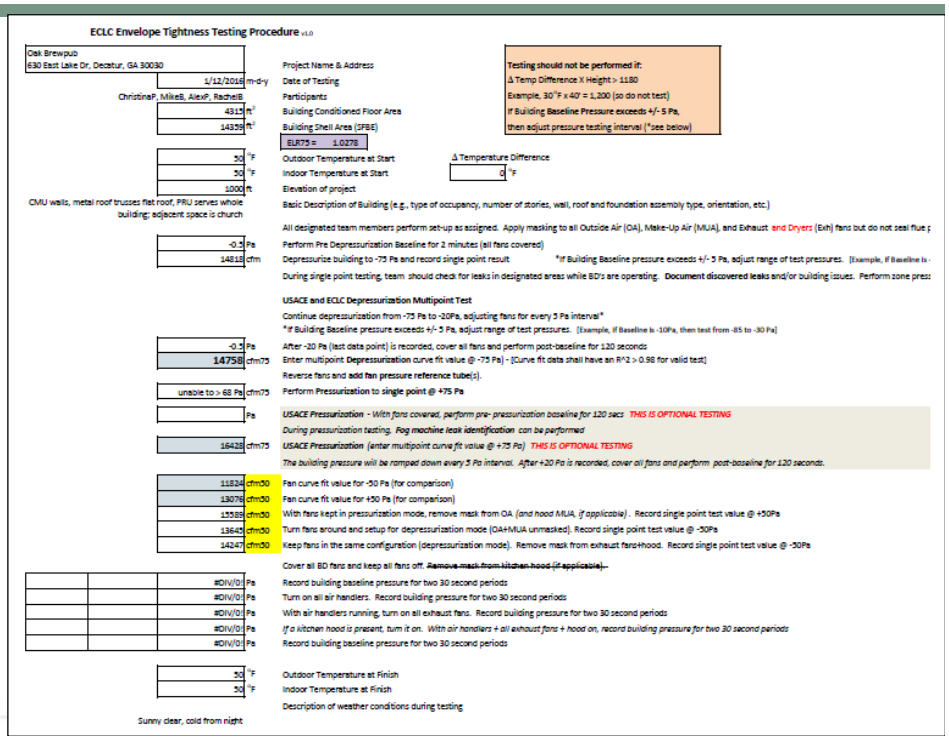
SOUTHFACE RESOURCES – ONE PAGE TEST SHEET

Multi-fan multi-point testing

- Test protocol
- Paper copy is great for results tracking while performing testing
- Spreadsheet version can perform calculations



ECLC Envelope Tightness Testing Procedure v1.0

Oak Brewpub
630 East Lake Dr, Decatur, GA 30030 — Project Name & Address

1/12/2016 — Date of Testing

ChristinaP, MikeB, AlexP, RachelB — Participants

4315 ft² — Building Conditioned Floor Area

14359 ft² — Building Shell Area (SFBE)

ELR75 = 1.0278

Testing should not be performed if:
Δ Temp Difference X Height > 1180
Example, 30°F x 40' = 1,200 (so do not test)
If Building **Baseline Pressure exceeds +/- 5 Pa,**
then adjust pressure testing interval (*see below)

50 °F — Outdoor Temperature at Start

50 °F — Indoor Temperature at Start

Δ Temperature Difference: 0 °F

1000 ft — Elevation of project

CMU walls, metal roof trusses flat roof, PRU serves whole building; adjacent space is church — Basic Description of Building (e.g., type of occupancy, number of stories, wall, roof and foundation assembly type, orientation, etc.)

All designated team members perform set-up as assigned. Apply masking to all Outside Air (OA), Make-Up Air (MUA), and Exhaust and Dryers (Exh) fans but do not seal flue p

Perform Pre Depressurization Baseline for 2 minutes (all fans covered)

-0.5 Pa
14818 cfm — Depressurize building to -75 Pa and record single point result

*If Building Baseline pressure exceeds +/- 5 Pa, adjust range of test pressures. [Example, if Baseline is -

During single point testing, team should check for leaks in designated areas while BD's are operating. **Document discovered leaks and/or building issues.** Perform zone press

USACE and ECLC Depressurization Multipoint Test

Continue depressurization from -75 Pa to -20Pa, adjusting fans for every 5 Pa interval*
*If Building Baseline pressure exceeds +/- 5 Pa, adjust range of test pressures. [Example, if Baseline is -10Pa, then test from -85 to -30 Pa]

-0.5 Pa
14758 cfm75 — After -20 Pa (last data point) is recorded, cover all fans and perform post-baseline for 120 seconds

Enter multipoint **Depressurization** curve fit value @ -75 Pa) - (Curve fit data shall have an R^2 > 0.98 for valid test)

unable to > 68 Pa cfm75 — Reverse fans and **add fan pressure reference tube(s).**

Pa — Perform **Pressurization** to **single point @ +75 Pa**

USACE Pressurization - With fans covered, perform pre- pressurization baseline for 120 secs THIS IS OPTIONAL TESTING

During pressurization testing, Fog machine leak identification can be performed

16428 cfm75 — *USACE Pressurization (enter multipoint curve fit value @ +75 Pa) THIS IS OPTIONAL TESTING*

The building pressure will be ramped down every 5 Pa interval. After +20 Pa is recorded, cover all fans and perform post-baseline for 120 seconds.

11824 cfm50 — Fan curve fit value for -50 Pa (for comparison)

13076 cfm50 — Fan curve fit value for +50 Pa (for comparison)

15589 cfm50 — With fans kept in pressurization mode, remove mask from OA *(and hood MUA, if applicable)*. Record single point test value @ +50Pa

13643 cfm50 — Turn fans around and setup for depressurization mode (OA+MUA unmasked). Record single point test value @ -50Pa

14247 cfm50 — Keep fans in the same configuration (depressurization mode). Remove mask from exhaust fans+Hood. Record single point test value @ -50Pa

Cover all BD fans and keep all fans off. ~~Remove mask from kitchen hood (if applicable).~~

#DIV/0! Pa — Record building baseline pressure for two 30 second periods

#DIV/0! Pa — Turn on all air handlers. Record building pressure for two 30 second periods

#DIV/0! Pa — With air handlers running, turn on all exhaust fans. Record building pressure for two 30 second periods

#DIV/0! Pa — *If a kitchen hood is present, turn it on. With air handlers + all exhaust fans + hood on, record building pressure for two 30 second periods*

#DIV/0! Pa — Record building baseline pressure for two 30 second periods

50 °F — Outdoor Temperature at Finish

50 °F — Indoor Temperature at Finish

Sunny clear, cold from night — Description of weather conditions during testing

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SOUTHFACE RESOURCES

- Assessment toolkit
  - Process
  - Data collection
  - Analysis
  - Report template
  - Implementation checklist
- Quick guides
  - Fire stations
  - Rec centers
  - Small commercial on campus
- Multiple Fan multi-point testing
  - Test protocol
  - Report template

For all attendees, we'll email you a link to these resources

OTHER RESEARCH

- Atlanta Better Buildings Challenge
  - Small commercial campus guides
- Third-party impact
- PPESCO
- EarthCraft Light Commercial Deep Energy

EARTH CRAFT Light Commercial ™

ADDITIONAL RESOURCES

EarthCraft Light Commercial Guidelines

ASHRAE Advanced Energy Design Guides

ASHRAE Advanced Energy Retrofit Guides

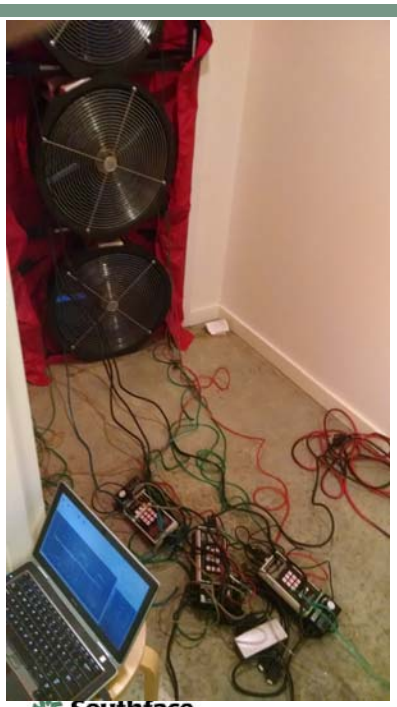
ASHRAE 189.1 – Green Building Standard

ASHRAE Indoor Air Quality Guide

ASHRAE Audit Guide

Core Performance Standard

ACBI RESEARCH PLAN



Benchmark

- Multi-point Blower Door Test
- Measure building pressure under normal operation
- Pressure test for presence/function of dampers
- Measure Intentional Ventilation Rates

Interactions

- Circuit level monitoring
- Outdoor and indoor zonal temperature and Humidity monitoring

Impact

- Calibrate detailed models
- Assess infiltration impact on energy consumption

WHAT'S NEXT?

- Spray foam & moisture accumulation
- IAQ & ventilation
- CAZ guidelines
- Packaging of tools & resources
- Deployment
- Refinement

ACKNOWLEDGEMENTS/CREDITS

- US Department of Energy
- Southface team
- ~50 buildings we have been able to test (and still counting)

RESEARCH HAS NO SHORT CUTS

Questions & Answers

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