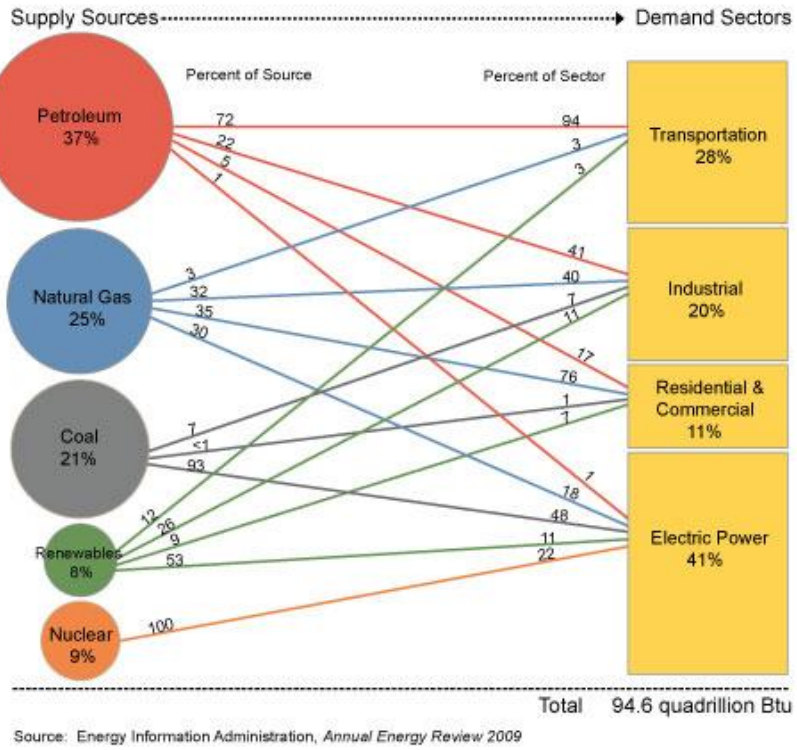
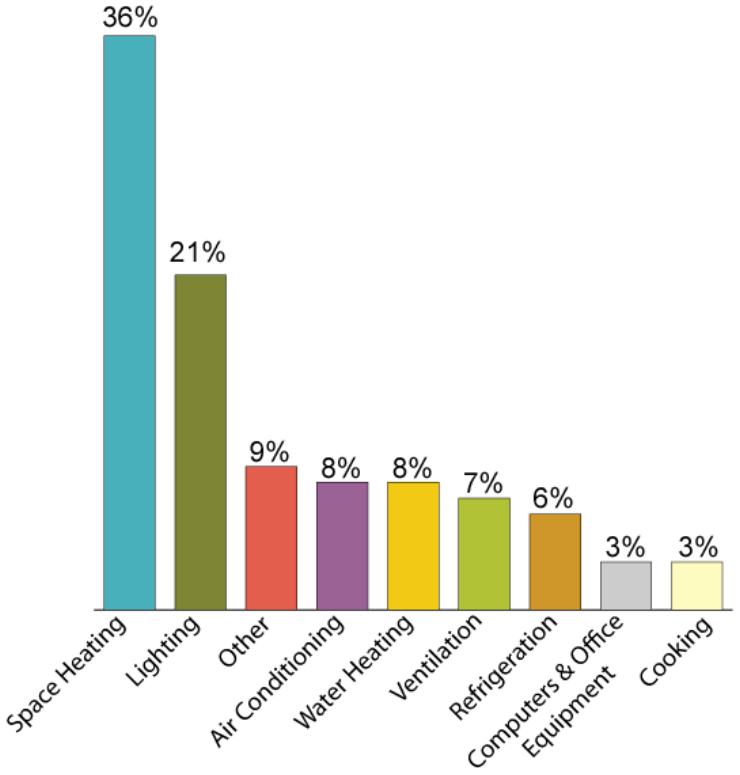
Sustainable Retrofitting

ROB WARNER



Source: Energy Information Administration, *Annual Energy Review 2009*

Energy Use in Commercial Buildings, 2003



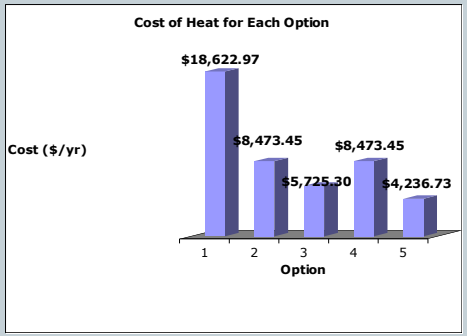
Source: U.S. Energy Information Administration, *2003 Commercial Building Energy Consumption Survey,* Table E1A (September 2008).

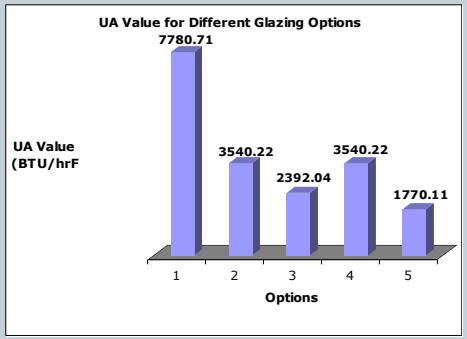

North Providence
Wanskuck
Mt Pleasant
Providence
East Providence
Johnston
Silver Lake
Thornton
Cranston
Washington Park
Seekonk
Rehoboth
Taunton Ave
Providence St
Riverside
Barrington
Theodore Francis Green Memorial State Airport
Child St
Warwick
Old Buttonwoods
Greenwich Bay
East Greenwich
Post Rd
Cal Rodman Hwy
Bristol
Bay Islands
Rhode Island
Massachusetts

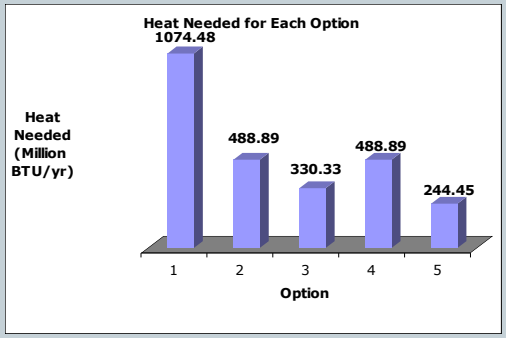
Retrofitting Proposals

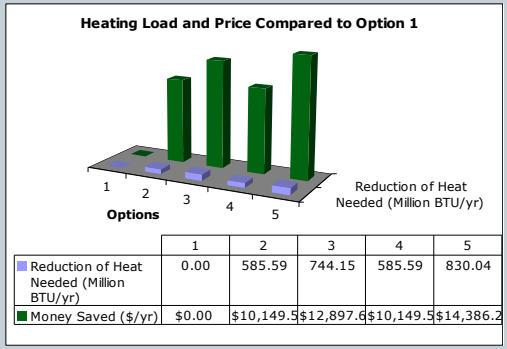
1. BAU
2. Exterior Storm
3. + Low-e Coating
4. Double paned
5. + Argon, low-e

ANNUAL COSTS	Natural Gas	Savings
Baseline Design Case	$ 6,061	-
Exterior Wall Insulation	$ 4,353	$ 1,708
Improved Window Glass	$ 2,278	$ 3,783
Increased HVAC Efficiency	$ 2,021	$ 4,040



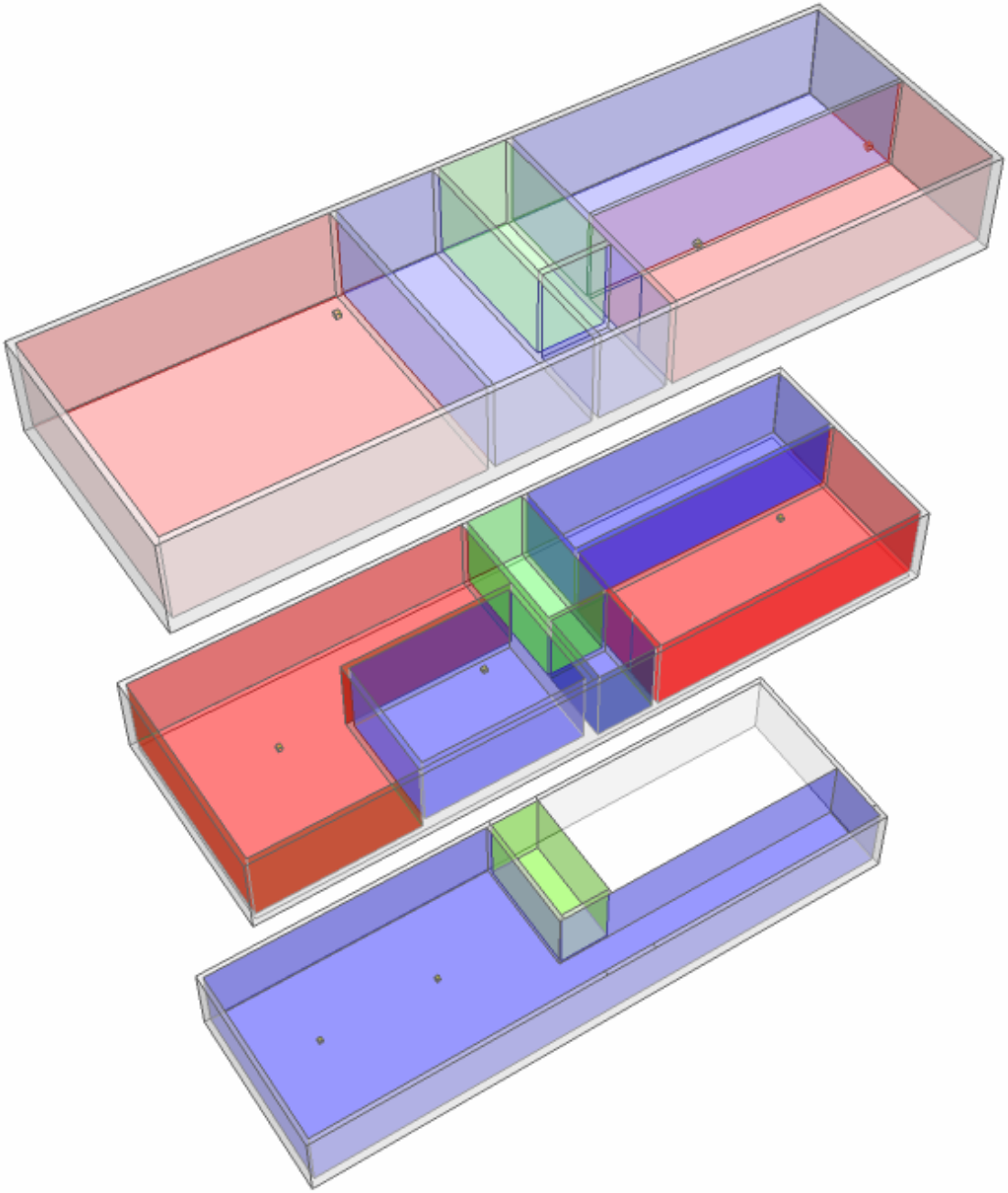






Loggers

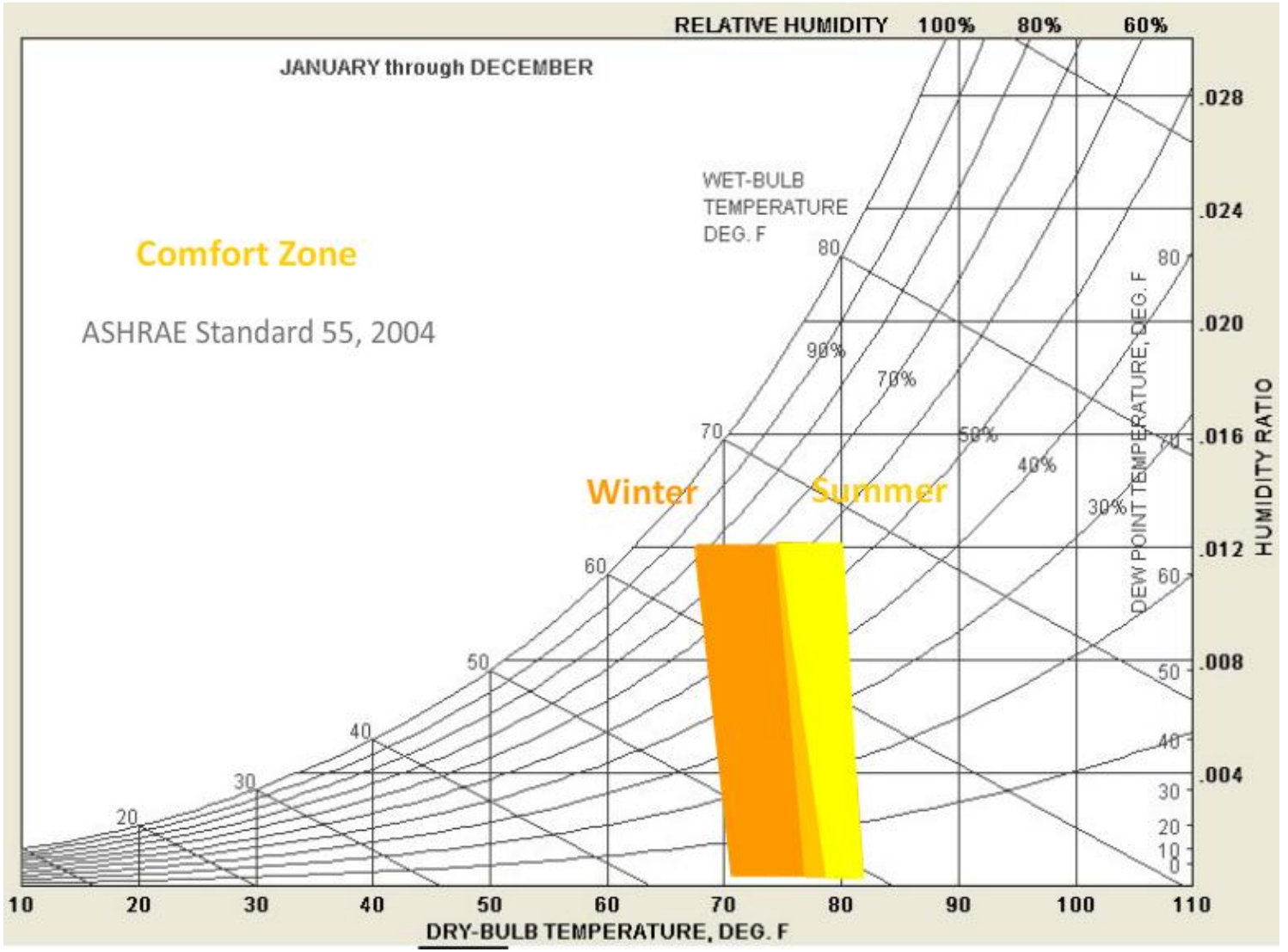
Location		Model	Sensors	Range
1st floor	Core	HOBO U12-012	Temperature/Relative Humidity/Light	-4° to 158°F, 5% to 95% RH, 1 to 3k lumens/fts
	West	HOBO U10-003	Temperature/Relative Humidity	-4° to 158°F, 25% to 95% RH
2nd floor	East	HOBO U10-003	Temperature/Relative Humidity	-4° to 158°F, 25% to 95% RH
	Core	HOBO U12-012	Temperature/Relative Humidity/Light	-4° to 158°F, 5% to 95% RH, 1 to 3k lumens/fts
	West	HOBO U10-003	Temperature/Relative Humidity	-4° to 158°F, 25% to 95% RH
3rd Floor	East	HOBO U10-003	Temperature/Relative Humidity	-4° to 158°F, 25% to 95% RH
	Core	HOBO U12-012	Temperature/Relative Humidity/Light	-4° to 158°F, 5% to 95% RH, 1 to 3k lumens/fts
	West	HOBO U10-003	Temperature/Relative Humidity	-4° to 158°F, 25% to 95% RH
Roof	Core	HOBO Pro v2 - U23-001	Temperature/Relative Humidity	-40° to 158°F, 0-100% RH
	West	HOBO Pendant 8bit - UA-002-08	Temperature/Light	-4° to 158°F ,0 to 30k lumens/ft2
North Façade		HOBO Pro v2 - U23-001	Temperature/Relative Humidity	-40° to 158°F, 0-100% RH
South Façade		HOBO Pendant 8bit - UA-002-08	Temperature/Light	-4° to 158°F, 0 to 320k lux

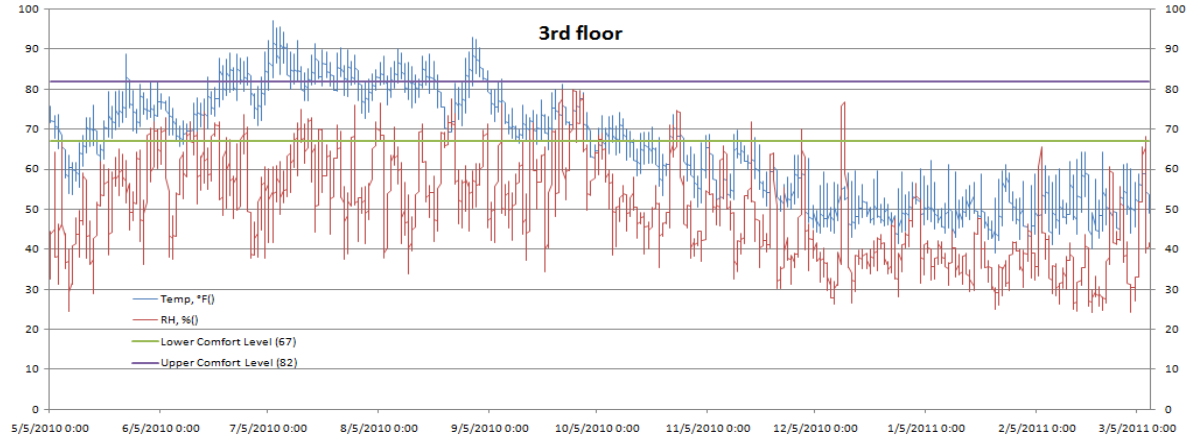



MODINE


Shield


Manville
Fiber Glass Insulation
Manville
Fiber Glass Insulation

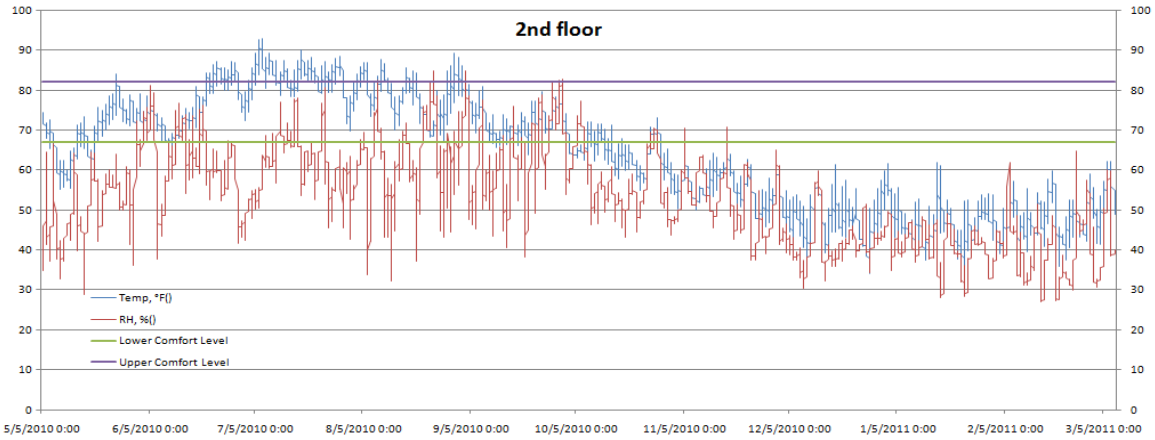

RELATIVE HUMIDITY 100% 80% 60%
JANUARY through DECEMBER
WET-BULB TEMPERATURE DEG. F
Comfort Zone
ASHRAE Standard 55, 2004
Winter
Summer
90%
70%
50%
40%
30%
DEW POINT TEMPERATURE, DEG. F
HUMIDITY RATIO
.028
.024
.020
.016
.012
.008
.004
10 20 30 40 50 60 70 80 90 100 110
DRY-BULB TEMPERATURE, DEG. F

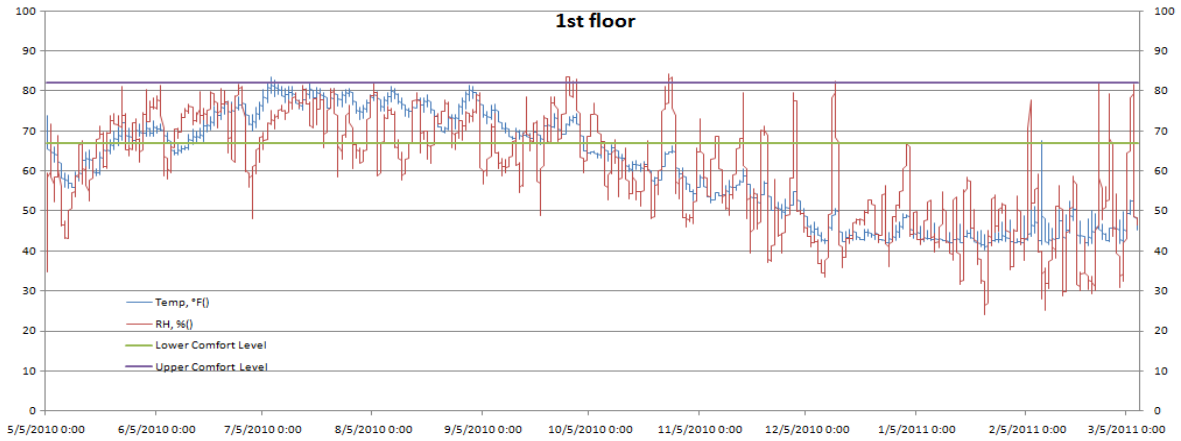


Percent within Comfort Zone

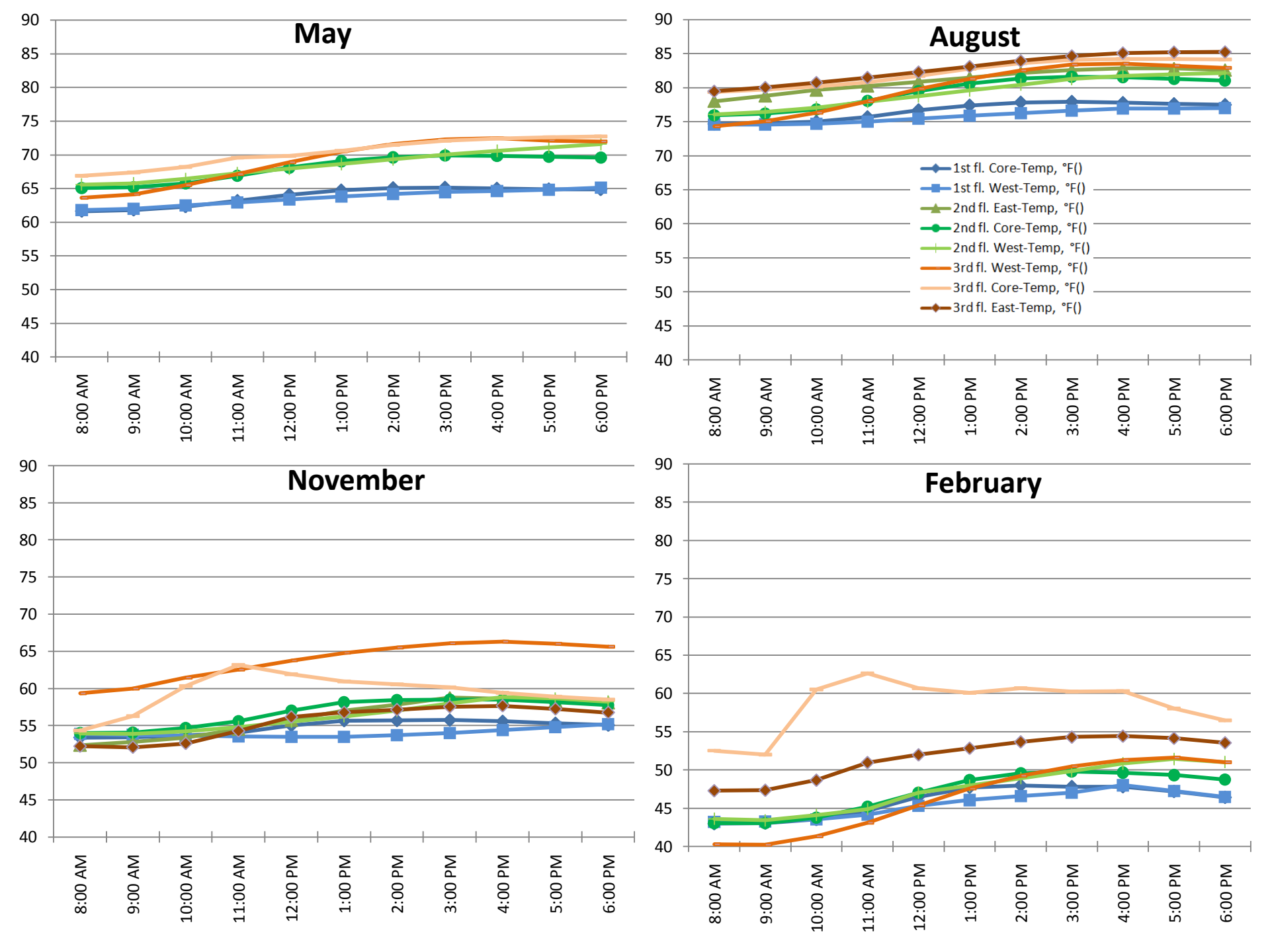
- Temperature: 35.7%
- Relative Humidity
  - Summer: 62.2%
  - Annual: 83.0%

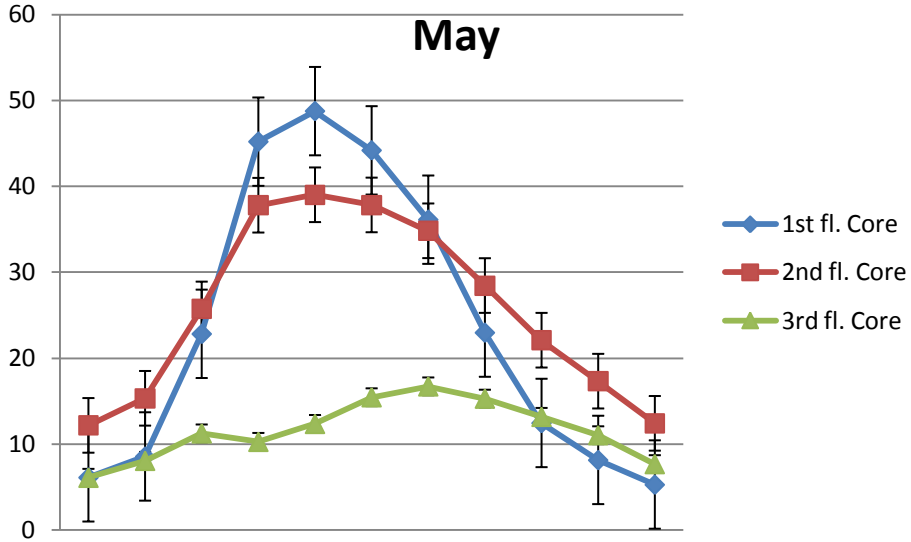
- Temperature: 35.6%
- Relative Humidity
  - Summer: 49.9%
  - Annual: 77.2%

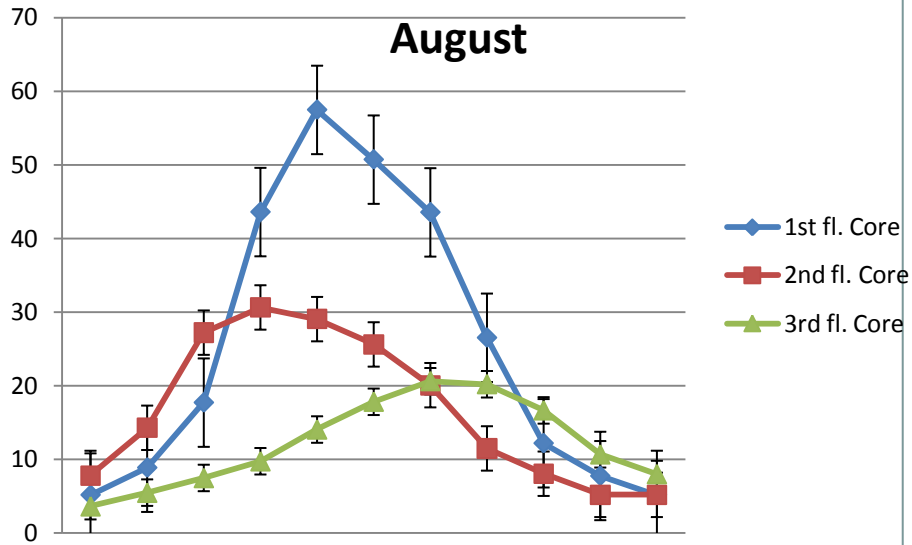


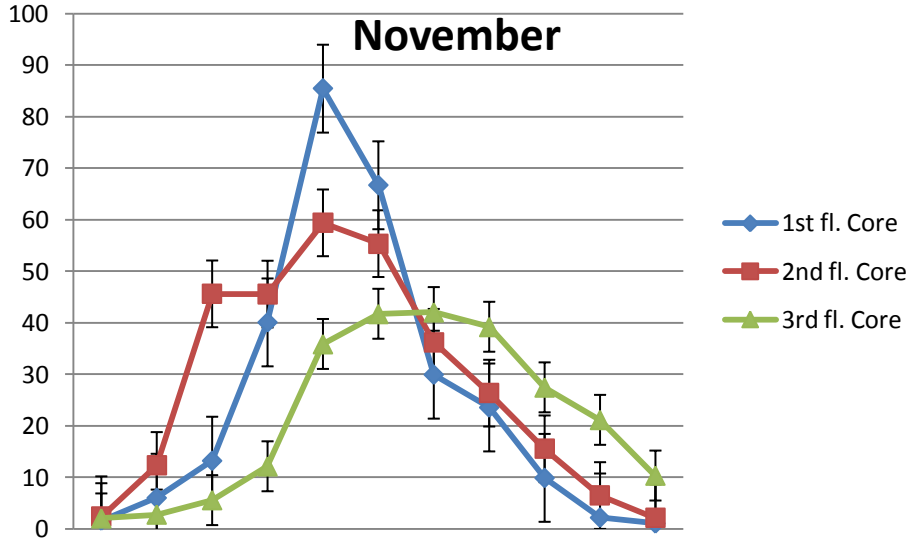


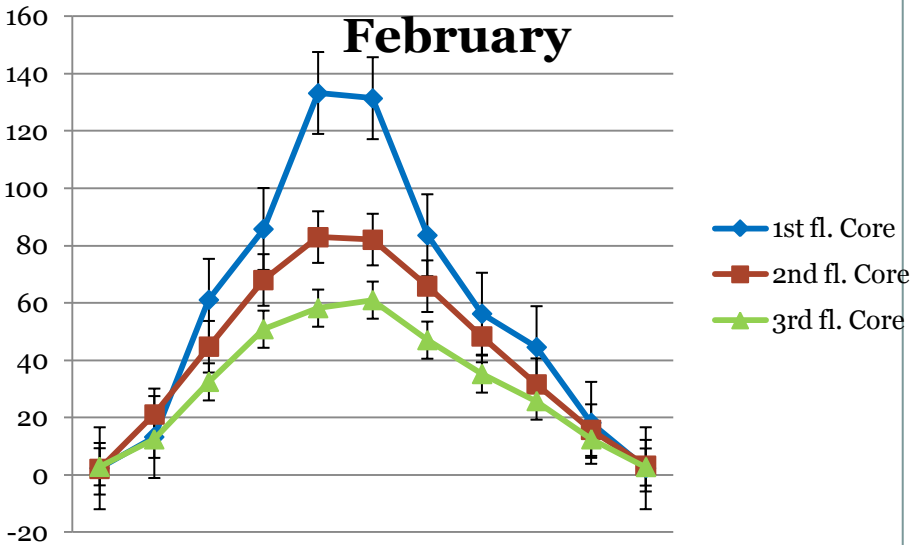
- Temperature: 40.6%
- Relative Humidity
  - Summer: 11.4%
  - Annual: 58.9%


May
August
November
February
90
85
80
75
70
65
60
55
50
45
40
8:00 AM
9:00 AM
10:00 AM
11:00 AM
12:00 PM
1:00 PM
2:00 PM
3:00 PM
4:00 PM
5:00 PM
6:00 PM
1st fl. Core-Temp, °F()
1st fl. West-Temp, °F()
2nd fl. East-Temp, °F()
2nd fl. Core-Temp, °F()
2nd fl. West-Temp, °F()
3rd fl. West-Temp, °F()
3rd fl. Core-Temp, °F()
3rd fl. East-Temp, °F()


May
60
50
40
30
20
10
0
1st fl. Core
2nd fl. Core
3rd fl. Core


August
70
60
50
40
30
20
10
0
1st fl. Core
2nd fl. Core
3rd fl. Core


November
100
90
80
70
60
50
40
30
20
10
0
1st fl. Core
2nd fl. Core
3rd fl. Core

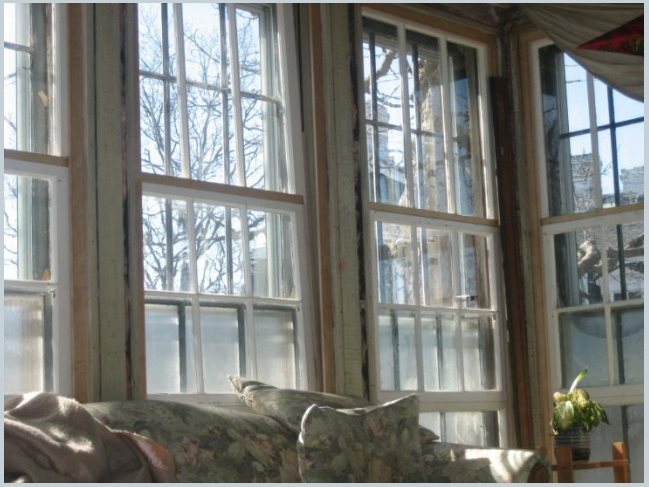

February
160
140
120
100
80
60
40
20
0
-20
1st fl. Core
2nd fl. Core
3rd fl. Core

Solar Gain		
Solar Radiation (annual avg.)	3.1	kWh/m2/day
Area of the South-facing windows	110.00	m2
Solar gain = insolation x glazing area	124,461.83	kwh/yr
	424,701.11	kBtu/yr
x SHGC .86	**365,242.95**	**kBtu/yr**
Heat-loss of windows	610,443.38	kBtu/yr
Gain w/ double-paned addition	146,097.18	kBtu/yr
Accompanying heat loss	138,875.75	kBtu/yr

Thermal Comfort/IAQ vs. Energy Performance

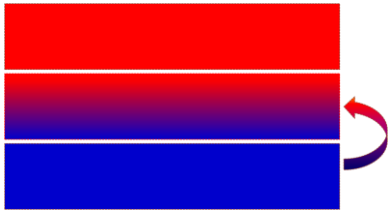
- Air Quality
- Moisture relief
- Occupant comfort

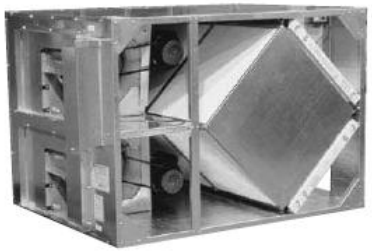
- Tighter envelope
- Window performance



Solution: ERV

- Moisture retention/regulation
- Disperse coolth
- Reduce energy costs





RenewAire Energy Recovery Ventilation — *Simplicity - Reliability - Performance*

LOG OUT | PROJECTS | QUICKCALCS | WEATHER DATA | CHANGE PASSWORD | E

Project: 30 burnside > Unit: ERV-1

Schedule | Ventilation | Annual Savings | Images | Reference Materials

	Heating		Cooling	
Number of months system on most days:	7		5	
Operation Hours per Week:	112		112	
Degree Days:	5754	Base 65 F	2013	Base 55 F
Fuel Type:	NG		Electric	
System Efficiency:	80	% Seasonal Eff	10	SEER/EER
Fuel Cost:	1.23	$ / therm	0.16	$ / kWh
Demand Charge:			10.00	$ / kW / Month

Save and Calculate Annual Savings

Annual Ventilation Load	Heating Season	Cooling Season
No Energy Recovery (BTUs)	119,812,090	41,915,491
With RenewAire ERV (BTUs)	31,151,143	10,898,028
RenewAire Savings (BTUs)	88,660,946	31,017,463
Annual Energy Cost/Savings	**Heating Season**	**Cooling Season**
No Energy Recovery	$1,842.11	$670.65
With RenewAire ERV	$478.95	$174.37
RenewAire Savings	$1,363.16	$496.28
Total Energy Savings With RenewAire		**$1,859.44**

Simple Payback

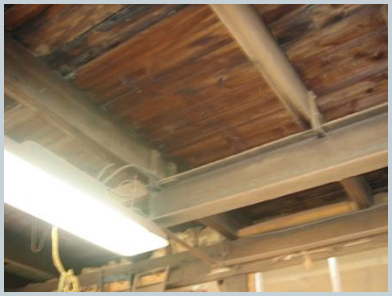
Installed ERV Cost:	$ 12000.00
Utility and Government Rebates:	$ 6000.00
Conventional Ventilation System Installed Cost:	$ 1205.00
Conventional AC System Installed Cost:	$ 0.00

Save and Calculate Simple Payback

Net RenewAire Cost Over Conventional Alternatives:	$4,795.00
Annual Energy Savings:	$1,859.44
Annual Demand Savings:	$0.00
Total Annual Savings:	$1,859.44
Simple Payback:	**2.6 Years**

Hurdles

- Occupant Participation
- Complex Envelope
  - Antique windows
  - Variation in efficiency
- Infiltration/ventilation



Ideal Conditions

- Blower Door Test/infiltration rates
  - Within + into building
- Air quality
- Air flow analysis
- Qin

Acknowledgements

- Dave Ford, John Cobb, Jon Goff , Herreshoff
- Chris Bull, Michelle Flagg
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- Kate Goldstein, ‘08
- Kert Teichurt

Thank You!