



Exhale Fans

Building Energy Modeling and Simulation

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Background



- Goal:
 - *Evaluate the potential for Exhale Fans to reduce building energy consumption during the cooling season by allowing an increase in the thermostat cooling setpoint temperature*



Air Velocity Impact on Thermal Comfort



- Make use of ASHRAE Standard 55 (Fanger's Thermal Comfort Model) to understand the impact of enhanced air flow on thermal comfort
- Example:
 - 74°F drybulb temperature
 - 20 fpm local air velocity

Possible to maintain similar comfort indices at:

 - 76°F drybulb temperature
 - 50 fpm local air velocity



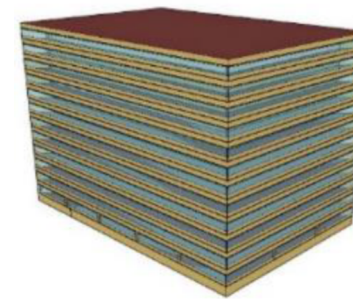
ANSI/ASHRAE Standard 55-2017
(Supersedes ANSI/ASHRAE Standard 55-2013)
Includes ANSI/ASHRAE addenda listed in Appendix N

**Thermal Environmental
Conditions for
Human Occupancy**

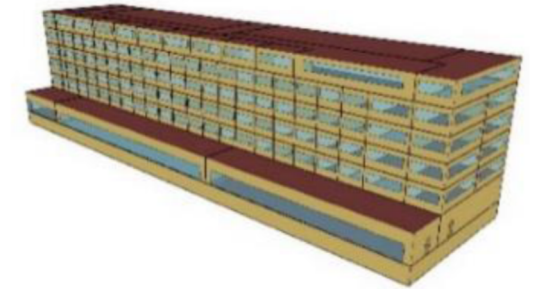
Building Analysis



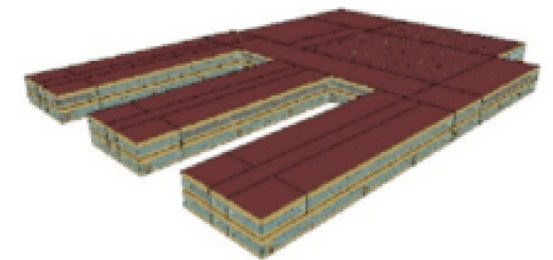
- Three Building Types (ASHRAE 2016 Energy Standard)
 - Large Office
 - Large Hotel
 - Secondary School
- Three Climate Zones
 - Zone 2A:Hot/Humid – Tampa, FL
 - Zone 4A:Mixed/Humid – New York, NY
 - Zone 5B:Dry – Denver, CO
- Thermostat Cooling Setpoint Temperature
 - Baseline (as defined in the prototypical building model)
 - Baseline + 2°F
 - Baseline + 4°F



Large Office



Large Hotel



Secondary School

Large Office Building



- Zone Summary (23)

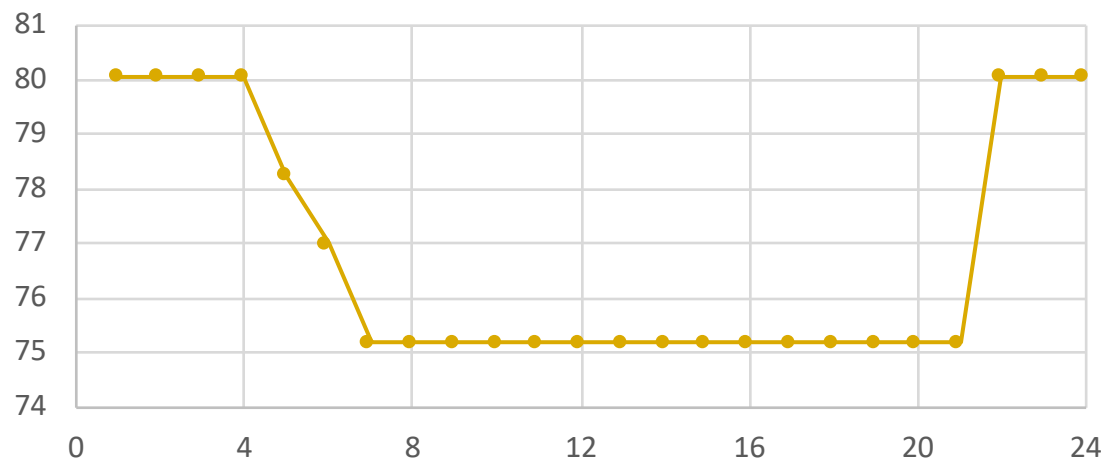
	Area [ft^2]
BASEMENT	29918
CORE_BOTTOM	26868
CORE_MID	26868
CORE_TOP	26868
PERIMETER_BOT_ZN_3	3374
PERIMETER_BOT_ZN_2	2174
PERIMETER_BOT_ZN_1	3374
PERIMETER_BOT_ZN_4	2174
PERIMETER_MID_ZN_3	3374
PERIMETER_MID_ZN_2	2174
PERIMETER_MID_ZN_1	3374
PERIMETER_MID_ZN_4	2174
PERIMETER_TOP_ZN_3	3374
PERIMETER_TOP_ZN_2	2174
PERIMETER_TOP_ZN_1	3374
PERIMETER_TOP_ZN_4	2174
GROUNDFLOOR_PLENUM	38353
MIDFLOOR_PLENUM	38353
TOPFLOOR_PLENUM	38353
DATACENTER_BOT_ZN_6	390
DATACENTER_MID_ZN_6	390
DATACENTER_TOP_ZN_6	390
DATACENTER_BASEMENT_ZN_6	8436
Total	498593

Not included in comfort cooling results

- Controls Summary

- 17 potential thermostat control objects
- 2 schedules implemented
 - Differentiation for weekdays, weekends, holidays

Weekday Thermostat Setpoint Temperature



Large Office Building Results



	Zone 2A - Miami		
	Baseline Temperatures	Baseline +2F	Baseline +4F
Annual Comfort Cooling Electric Energy (kWh)	497,991	471,138	435,060
Comfort Cooling Energy Electric Savings (kWh)	-	26,853	62,931
Comfort Cooling Energy Savings (%)	-	5.4%	12.6%

	Zone 4A – New York		
	Baseline Temperatures	Baseline +2F	Baseline +4F
Annual Comfort Cooling Electric Energy (kWh)	227,699	192,946	204,011
Comfort Cooling Energy Electric Savings (kWh)	-	34,753	23,687
Comfort Cooling Energy Savings (%)	-	15.3%	10.4%

Outlier

	Zone 5B – Denver		
	Baseline Temperatures	Baseline +2F	Baseline +4F
Annual Comfort Cooling Electric Energy (kWh)	173,533	160,704	152,507
Comfort Cooling Energy Electric Savings (kWh)	-	12,829	21,025
Comfort Cooling Energy Savings (%)	-	7.4%	12.1%

Large Hotel



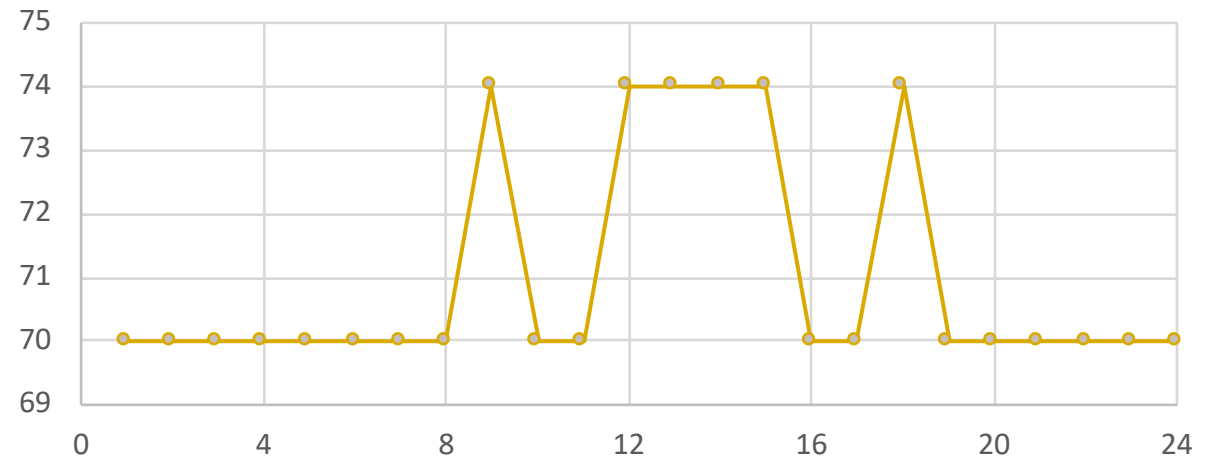
- Zone Summary (22)

	Area [ft^2]
BASEMENT	21300
RETAIL_1_FLR_1	722
RETAIL_2_FLR_1	836
MECH_FLR_1	1768
STORAGE_FLR_1	1020
LAUNDRY_FLR_1	840
CAFE_FLR_1	2033
LOBBY_FLR_1	14081
ROOM_1_FLR_3	420
ROOM_2_FLR_3	420
ROOM_3_MULT19_FLR_3	264
ROOM_4_MULT19_FLR_3	264
ROOM_5_FLR_3	420
ROOM_6_FLR_3	420
CORRIDOR_FLR_3	4192
ROOM_1_FLR_6	420
ROOM_2_FLR_6	420
ROOM_3_MULT9_FLR_6	264
BANQUET_FLR_6	3570
DINING_FLR_6	3570
KITCHEN_FLR_6	1112
CORRIDOR_FLR_6	4436
Total	122121

- Controls Summary

- 16 potential thermostat control objects
- 4 schedules implemented
 - Differentiation for weekdays, weekends, holidays, and unoccupied rooms

Occupied Guest Room Thermostat Setpoint



Large Hotel Results



	Zone 2A - Miami		
	Baseline Temperatures	Baseline +2F	Baseline +4F
Annual Comfort Cooling Electric Energy (kWh)	859,442	811,392	771,275
Comfort Cooling Energy Electric Savings (kWh)	-	48,050	88,167
Comfort Cooling Energy Savings (%)	-	5.6%	10.3%

	Zone 4A – New York		
	Baseline Temperatures	Baseline +2F	Baseline +4F
Annual Comfort Cooling Electric Energy (kWh)	333,950	311,267	292,050
Comfort Cooling Energy Electric Savings (kWh)	-	22,683	41,900
Comfort Cooling Energy Savings (%)	-	6.8%	12.5%

	Zone 5B – Denver		
	Baseline Temperatures	Baseline +2F	Baseline +4F
Annual Comfort Cooling Electric Energy (kWh)	207,181	189,375	174,792
Comfort Cooling Energy Electric Savings (kWh)	-	17,806	32,389
Comfort Cooling Energy Savings (%)	-	8.6%	15.6%

Secondary School



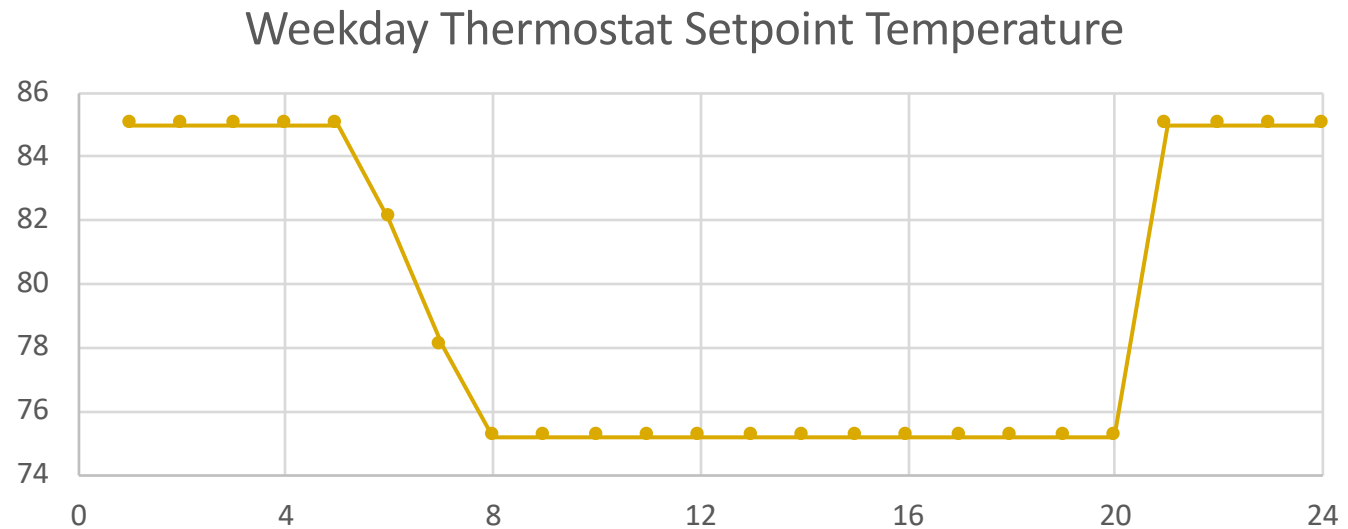
- Zone Summary (46)

	Area [ft^2]		Area [ft^2]
CORNER_CLASS_1_POD_1_ZN_1_FLR_1	1066	MULT_CLASS_1_POD_3_ZN_1_FLR_2	5134
CORNER_CLASS_1_POD_1_ZN_1_FLR_2	1066	CORRIDOR_POD_3_ZN_1_FLR_1	3444
MULT_CLASS_1_POD_1_ZN_1_FLR_1	5134	CORRIDOR_POD_3_ZN_1_FLR_2	3444
MULT_CLASS_1_POD_1_ZN_1_FLR_2	5134	CORNER_CLASS_2_POD_3_ZN_1_FLR_1	1066
CORRIDOR_POD_1_ZN_1_FLR_1	3444	CORNER_CLASS_2_POD_3_ZN_1_FLR_2	1066
CORRIDOR_POD_1_ZN_1_FLR_2	3444	MULT_CLASS_2_POD_3_ZN_1_FLR_1	5134
CORNER_CLASS_2_POD_1_ZN_1_FLR_1	1066	MULT_CLASS_2_POD_3_ZN_1_FLR_2	5134
CORNER_CLASS_2_POD_1_ZN_1_FLR_2	1066	MAIN_CORRIDOR_ZN_1_FLR_1	12271
MULT_CLASS_2_POD_1_ZN_1_FLR_1	5134	MAIN_CORRIDOR_ZN_1_FLR_2	12271
MULT_CLASS_2_POD_1_ZN_1_FLR_2	5134	LOBBY_ZN_1_FLR_1	2260
CORNER_CLASS_1_POD_2_ZN_1_FLR_1	1066	LOBBY_ZN_1_FLR_2	2260
CORNER_CLASS_1_POD_2_ZN_1_FLR_2	1066	BATHROOMS_ZN_1_FLR_1	2260
MULT_CLASS_1_POD_2_ZN_1_FLR_1	5134	BATHROOMS_ZN_1_FLR_2	2260
MULT_CLASS_1_POD_2_ZN_1_FLR_2	5134	OFFICES_ZN_1_FLR_1	5726
CORRIDOR_POD_2_ZN_1_FLR_1	3444	OFFICES_ZN_1_FLR_2	5726
CORRIDOR_POD_2_ZN_1_FLR_2	3444	GYM_ZN_1_FLR_1	21270
CORNER_CLASS_2_POD_2_ZN_1_FLR_1	1066	AUX_GYM_ZN_1_FLR_1	13433
CORNER_CLASS_2_POD_2_ZN_1_FLR_2	1066	AUDITORIUM_ZN_1_FLR_1	10635
MULT_CLASS_2_POD_2_ZN_1_FLR_1	5134	KITCHEN_ZN_1_FLR_1	2325
MULT_CLASS_2_POD_2_ZN_1_FLR_2	5134	LIBRARY_MEDIA_CENTER_ZN_1_FLR_2	9042
CORNER_CLASS_1_POD_3_ZN_1_FLR_1	1066	CAFETERIA_ZN_1_FLR_1	6717
CORNER_CLASS_1_POD_3_ZN_1_FLR_2	1066	MECH_ZN_1_FLR_1	3681
MULT_CLASS_1_POD_3_ZN_1_FLR_1	5134	MECH_ZN_1_FLR_2	3681
		Total	210888

Secondary School



- Controls Summary
 - 46 potential thermostat control objects
 - 2 schedules implemented
 - Differentiation for weekdays, weekends, and holidays



Secondary School Results



	Zone 2A - Miami		
	Baseline Temperatures	Baseline +2F	Baseline +4F
Annual Comfort Cooling Electric Energy (kWh)	897,689	874,583	852,481
Comfort Cooling Energy Electric Savings (kWh)	-	23,106	45,208
Comfort Cooling Energy Savings (%)	-	2.6%	5.0%

	Zone 4A – New York		
	Baseline Temperatures	Baseline +2F	Baseline +4F
Annual Comfort Cooling Electric Energy (kWh)	376,119	354,931	334,597
Comfort Cooling Energy Electric Savings (kWh)	-	21,189	41,522
Comfort Cooling Energy Savings (%)	-	5.6%	11.0%

	Zone 5B – Denver		
	Baseline Temperatures	Baseline +2F	Baseline +4F
Annual Comfort Cooling Electric Energy (kWh)	267,453	248,908	231,744
Comfort Cooling Energy Electric Savings (kWh)	-	18,544	35,708
Comfort Cooling Energy Savings (%)	-	6.9%	13.4%

Conclusions



- Typical energy savings across building types and climate zones
 - Around 5% for a 2°F increase in thermostat temperature setpoint
 - Around 10% for a 4°F increase in thermostat temperature setpoint
 - Results don't include the Exhale Fan energy consumption, but this is anticipated to be minimal compared to mechanical cooling energy



Questions?