30% Surplus Ventilation air for a LEED Green Point

Penn State ASHRAE Student Branch: February 10, 2009

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Presentation Outline

- LEED
- ASHRAE Std. 62.1
- Opposition To Surplus Ventilation Air
- Why Opposition?
- Some Consequences Of Surplus OA
- Op Cost Details
- 1st Cost Details
- Conclusions.

LEED® for New Construction &
Major Renovations

LEED: Leadership in Energy and Environmental Design

Indoor Environmental Quality

EQ Prerequisite 1: Minimum IAQ Performance

Required

Intent

Establish minimum indoor air quality (IAQ) performance to enhance indoor air quality in buildings, thus contributing to the comfort and well-being of the occupants.

Requirements

Meet the minimum requirements of Sections 4 through 7 of ASHRAE 62.1-2004, Ventilation for Acceptable Indoor Air Quality. Mechanical ventilation systems shall be designed using the Ventilation Rate Procedure or the applicable local code, whichever is more stringent.

Indoor Environmental Quality

Sustainable site	14	20%
H_2O η	5	7%
Energy & Atmos.	17	25%
Mat'ls & Resource	13	19%
IEQ	15	22%
Innovation	5	7%
Max points	69	
Gold: 39-51 points		

EQ Credit 2: Increased Ventilation

1 Point

Intent

Provide additional outdoor air ventilation to improve indoor air quality for improved occupant comfort, well-being and productivity.

Wellbeing: the state of being happy, healthy, or prosperous

Requirements

FOR MECHANICALLY VENTILATED SPACES

- ❑ Increase breathing zone outdoor air ventilation rates to all occupied spaces by at least 30% above the minimum rates required by ASHRAE Standard 62.1-2004 as determined by EQ Prerequisite 1.

ANSI/ASHRAE Standard 62.1-2004
(Includes ANSI/ASHRAE Addenda listed in Appendix H)

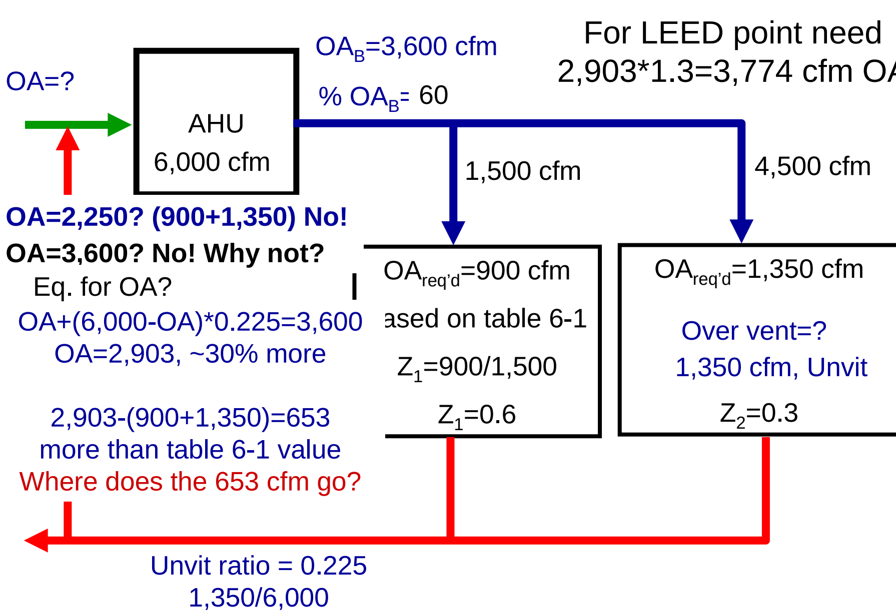
ASHRAE STANDARD

Ventilation for Acceptable Indoor Air Quality

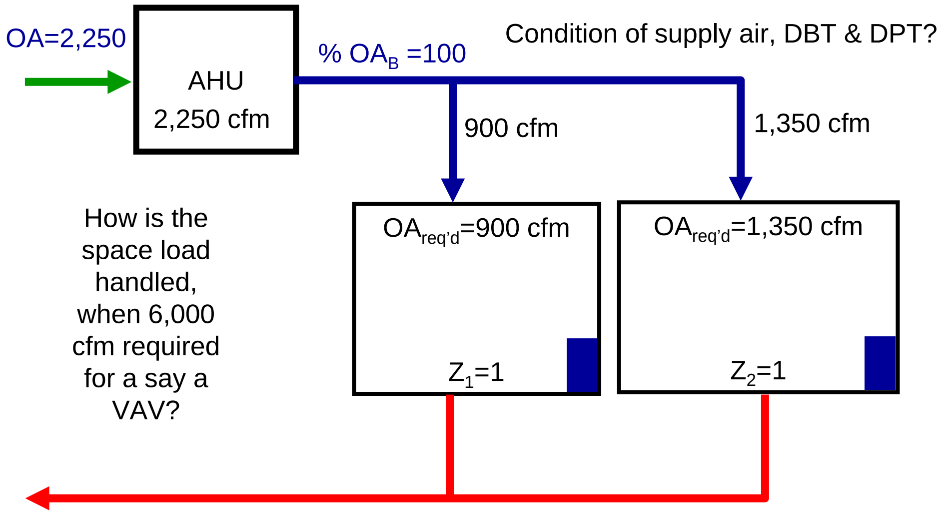
TABLE 6-1 MINIMUM VENTILATION RATES IN BREATHING ZONE
(This table is not valid in isolation; it must be used in conjunction with the accompanying notes.)

Occupancy Category	People Outdoor Air Rate R_p		Area Outdoor Air Rate R_a		Notes	Default Values			Air Class
						Occupant Density (see Note 4)	Combined Outdoor Air Rate (see Note 5)		
	cfm/person	L/s•person	cfm/ft²	L/s•m²		#/1000 ft² or #/100 m²	cfm/person	L/s•person	
Correctional Facilities									
Cell	5	2.5	0.12	0.6		25	10	4.9	2
Day room	5	2.5	0.06	0.3		30	7	3.5	1
Guard stations	5	2.5	0.06	0.3		15	9	4.5	1
Booking/waiting	7.5	3.8	0.06	0.3		50	9	4.4	2
Educational Facilities									
Daycare (through age 4)	10	5	0.18	0.9		25	17	8.6	2
Classrooms (ages 5-8)	10	5	0.12	0.6		25	15	7.4	1
Classrooms (age 9 plus)	10	5	0.12	0.6		35	13	6.7	1
Lecture classroom	7.5	3.8	0.06	0.3		65	8	4.3	1
Lecture hall (fixed seats)	7.5	3.8	0.06	0.3		150	8	4.0	1

Concept behind accompanying notes.



Solving the ventilation issue?



30% surplus air questioned!

Building Sciences

Why Green Can Be Wash

By Joseph W. Lstiburek, Ph.D., P.Eng., Fellow ASHRAE

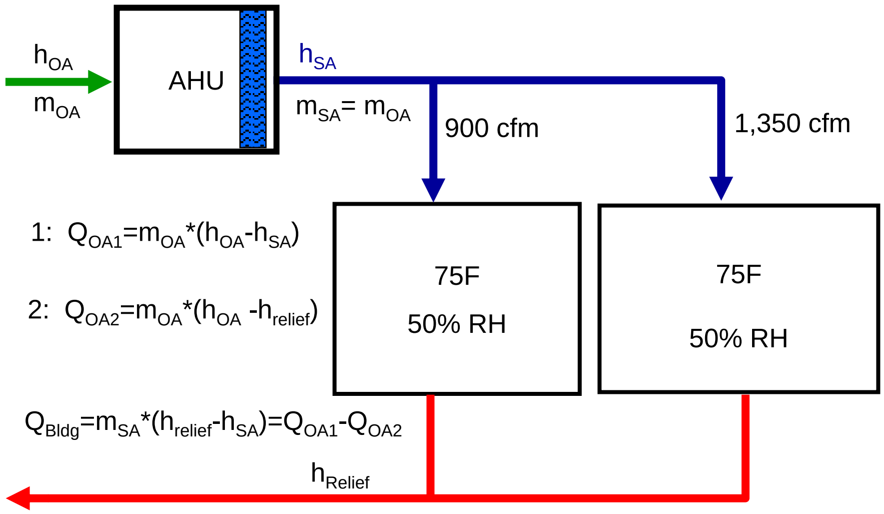
Editor's Note: Letters to the editor are welcome for this column. Send letters to the editor at fturner@ashrae.org. Letters should not

Do you want to save serious energy and serious money?

Then, don't overventilate. This idea of getting green points by increasing the rates above those specified by Standard 62 is just madness. Whatever happened to source control?

Calculating the OA load:

Very important to get correct!



1: $Q_{OA1}=m_{OA}*(h_{OA}-h_{SA})$

2: $Q_{OA2}=m_{OA}*(h_{OA}-h_{relief})$

$Q_{Bldg}=m_{SA}*(h_{relief}-h_{SA})=Q_{OA1}-Q_{OA2}$

So, Q_{OA2} is correct: $Q_{OA1}=Q_{OAcorrect}+Q_{Bldg}$= coil load

Limits of LEED authority

- Some clearly feel that there is no rational basis, or magic, for granting a LEED point when the ventilation air flow rate is increased beyond 62.1.
- Can LEED be ignored? Yes, in the sense that the LEED rating systems are not formal standards in and of themselves. Rather they are criteria established by leaders in the industry on what constitutes good practices to protect the environmental and enhance wellbeing of those impacted by development.
- Those that express disagreement with the LEED rating system probably need to join the industry leaders responsible for the rating systems.
- Conclusion: there is no mandate in LEED, or the law, to garner this point, and many may in fact choose to garner a LEED point by the much simpler installation of a bicycle rack.

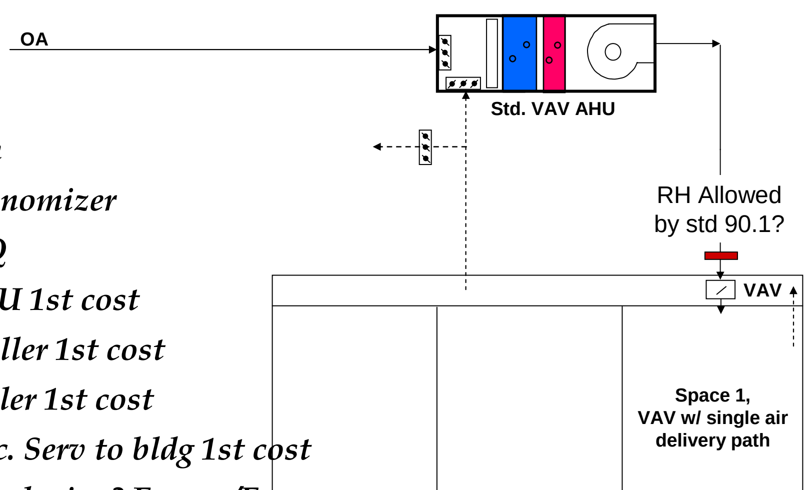
Limits of LEED authority

Limits of LEED authority

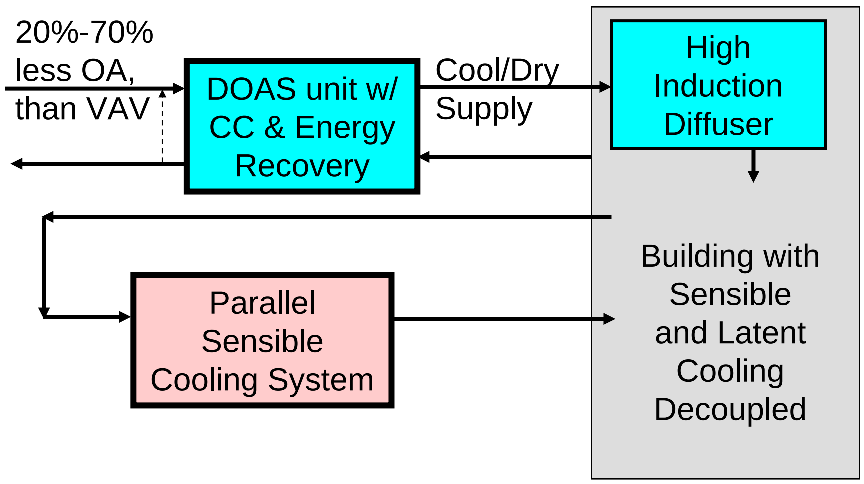
Sustainable Sites		14 Points
Prereq 1	**Construction Activity Pollution Prevention**	Required
Credit 1	**Site Selection**	1
Credit 2	**Development Density & Community Connectivity**	1
Credit 3	**Brownfield Redevelopment**	1
Credit 4.1	**Alternative Transportation**, Public Transportation	1
Credit 4.2	**Alternative Transportation**, Bicycle Storage & Changing Rooms	1
Credit 4.3	**Alternative Transportation**, Low-Emitting & Fuel Efficient Vehicles	1
Credit 4.4	**Alternative Transportation**, Parking Capacity	1

Why question 30% surplus OA?
1st consider a Standard VAV System

- *CC*
- *HC*
- *Fan*
- *Economizer*
- *IEQ*
- *AHU 1st cost*
- *Chiller 1st cost*
- *Boiler 1st cost*
- *Elec. Serv to bldg 1st cost*
- *Conclusion? Energy/Env*



DOAS Defined



Key DOAS Points

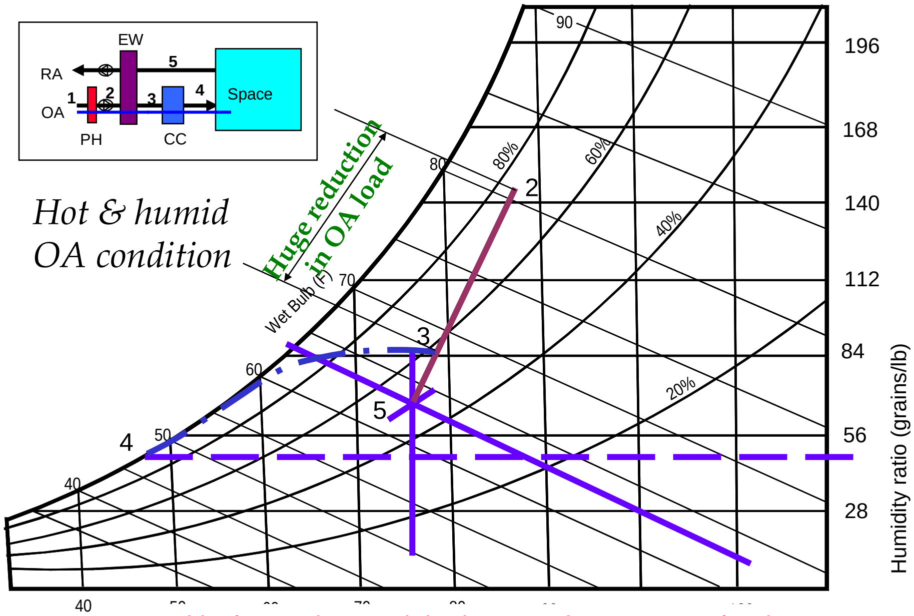
1. 100% OA delivered to each zone via its own ductwork
2. Flow rate generally as spec. by Std. 62.1-2007 or greater (LEED, Latent. Ctl)
3. Employ TER, per Std. 90.1-2007
4. Generally CV
5. Use to decouple space S/L loads—Dry
6. Rarely supply at a neutral temperature
7. Use HID, particularly where parallel system does not use air

How Important Is It To Remove The Space Latent Load With DOAS?

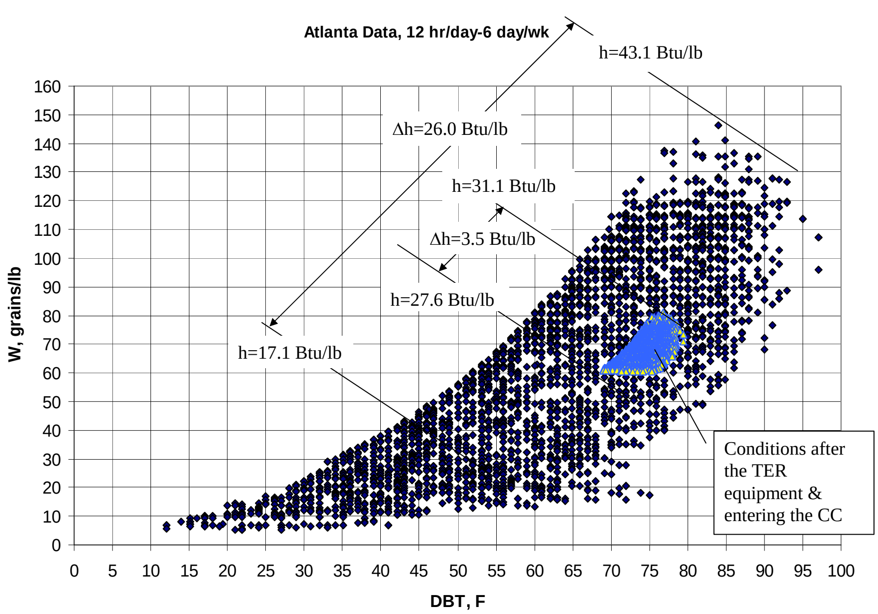
- This has a major impact on the SA DPT required, and hence ***equipment choices***.
- I recommend limiting the latent load born by the terminal equipment to avoid condensation on their cooling coils and in their condensate pans, ***thus avoiding septic issues (i.e. septic amplifiers)***.
- Some may feel that there are millions of septic amplifiers installed with no problems; hence the goal of placing the space latent load on the DOAS is ***thought to be unwarranted***.
- However one of the main goals today of LEED and designers is ***enhanced IEQ. Fact is:*** it's well known that the dark, damp conditions that exist within ***HVAC units contribute to the formation of bacteria, fungus, and other microbes***.

Space Latent Load With DOAS?

- Microorganisms are the primary cause of ***offensive HVAC odors.***
- In addition, microorganisms are known to produce sneezing, wheezing, and other ***adverse <u>wellbeing</u> sensations by building occupants***.
- Biological growth in the condensate pans often cause ***plugged up drain lines, then overflows leading to ugly toxic mold and property damage*** — particularly where routine maintenance is inadequate—unbelievably common.
- These types of problems have been estimated to ***cost US businesses alone $208 billion dollars a year*** in 1996 year dollars—nearly twice that today.
- I fear that all to often ***the industry has accepted these issues as normal, and regrettably see no need for improvement*** —so long as litigation free



Critical to understand the impact of TER on OA load



What Does ASHRAE Std 90.1 Have To Say About Total Energy Recovery?

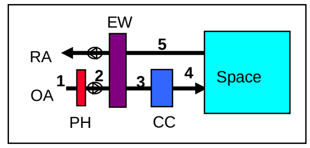
- **6.5.6.1 Exhaust Air Energy Recovery.**
- Individual fan systems shall have total energy recovery equipment with a $\geq$ 50% total energy (Δh) recovery effectiveness when:
  - The design supply air capacity is $\geq$ 5000 cfm (*loop hole 1*) and
  - The design supply air is $\geq$ 70% ***outdoor air***.

TER, What Does ASHRAE Std 90.1 Say?

- **Some Exceptions to 6.5.6.1:**
- Where more than 60% of the *outdoor air* heating energy is provided from site-recovered or site solar energy. *(Loop hole 2)*
- Heating systems in climate zones 1 through 3 (SE US). *(Loop hole 3. Comment: Not applicable: DOASs are cooling/dehumidification systems, with terminal heating where required)*
- Cooling systems in climate zones 3c, 4c, 5b, 5c, 6b, 7, and 8. *(Loop hole 4. Includes most of western US including Alaska, and parts of the extreme Northern parts of the following states: Minnesota, Michigan, North Dakota, and Wisconsin.)*
- Where the largest exhaust source is less than 75% of the design *outdoor air* flow (*Loop hole 5. Comment: with less return air available, the benefit of and EW is diminished*)
- Systems requiring dehumidification that employ energy recovery in series with the cooling coil (*Loop hole 6. Comment: such energy recovery has no bearing on the performance of the EW, and is an unnecessary loophole in 90.1*).

Why question 30% surplus OA? Consider DOAS.

- CC
- HC
- Fan
- Economizer
- IEQ
- AHU 1st cost
- Chiller 1st cost
- Boiler 1st cost
- Elec. Serv to bldg 1st cost
- Conclusion? (1st, op, LCC, env)



How does the 62.1 flow impact DOAS design—w/ space latent load decoupled?

	Occ. Category	cfm/p	SA DPT ^0F
A	Conf. rm	6.2	24.84
B	Lec. cl	8.42	35.9
C	Elem. cl	11.71	42.75
D	Office	17	47.18
E	Museum	9	31.05

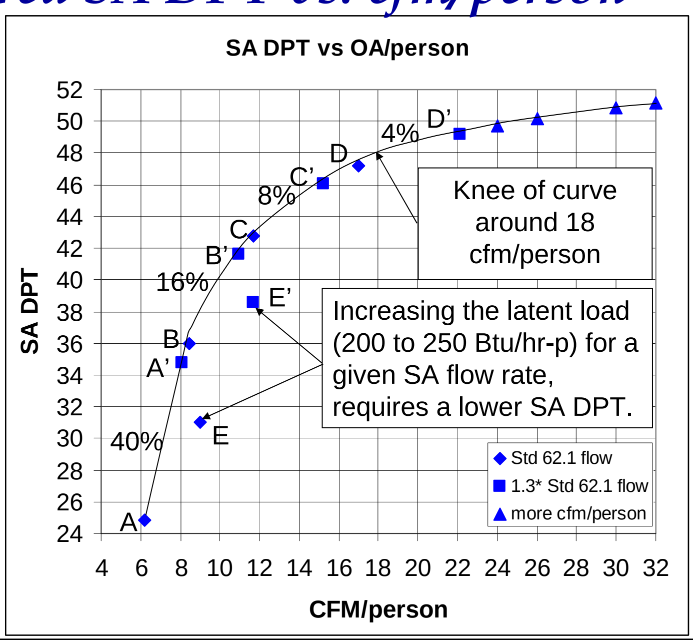
?

How does the 62.1 flow impact DOAS design—w/ space latent load decoupled?

	Occ. Category	cfm/p	SA DPT ^0F	**1.3*cfm/p**	**SA DPT ^0F**
A	Conf. rm	6.2	24.84	**8.06**	**34.75**
B	Lec. cl	8.42	35.9	**10.96**	**41.63**
C	Elem. cl	11.71	42.75	**15.23**	**46.08**
D	Office	17	47.18	**22.1**	**49.2**
E	Museum	9	31.05	**11.7**	**38.56**

Required SA DPT vs. cfm/person

	Occ. Category
A	Conf. rm
B	Lec. cl
C	Elem. cl
D	Office
E	Museum



*Operating costs for a 4,600 cfm & 6,000 cfm (i.e. 1.3*4,600 cfm) DOAS*

- After many assumptions, including operating with and without an EW, energy use and costs were evaluated for a few diverse geographical locations:
  - Atlanta, GA
  - New Orleans, LA
  - Columbus, OH
  - International Falls, MN

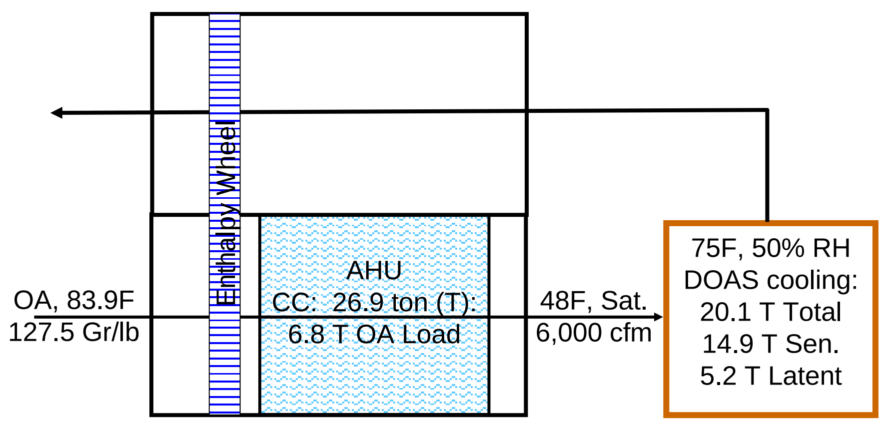
Operating cost

1	2	3	4	5	6	7	8
Flow CFM	**TH, Ton Hrs w/o EW**	**TH w/ 80% Eff EW**	**OP COST w/o EW $**	**OP COST w/ 80% Eff EW-$**	**Hours No Free clg**	**Hrs Some Free clg**	**Lowest Temp Exit EW Cold'st day**
Atlanta, GA simulation data							
4,600	14,826	2,965	$1,038	**$208**	1,561		
6,000	19,330	3,866	$1,353	**$271**	1,561		
4,600	-30,184	-7,502	**-$2,113**	-$525		2,495	
6,000	-39,353	-9,781	**-$2,755**	-$685		2,495	**65**
New Orleans, LA simulation data							
4,600	31,490	6,298	$2,204	**$441**	2,292		
6,000	41,000	8,211	$2,875	**$575**	2,292		
4,600	-17,119	-4,031	**-$1,198**	-$282		1,764	
6,000	-22,320	-5,256	**-$1,562**	-$368		1,764	**67**

Operating cost

1	2	3	4	5	6	7	8
Flow CFM	**TH w/o EW**	**TH w/ 80% Eff EW**	**OP COST w/o EW $**	**OP COST w/ 80% Eff EW-$**	**Hours No Free clg**	**Hrs Some Free clg**	**Lowest Temp Exit EW Cold'st day**
Columbus, OH simulation data							
4,600	7,506	1,500	$525	**$105**	1,092		
6,000	9,786	1,957	$685	**$137**	1,092		
4,600	-47,084	-11,814	**-$3,296**	-$827		2,964	
6,000	-61,387	-15,402	**-$4,297**	-$1,078		2,964	**61**
International Falls, MN simulation data							
4,600	1,934	387	$135	**$27**	308		
6,000	2,521	504	$176	**$35**	308		
4,600	-75,795	-19,210	**-$5,303**	-$1,345		3,748	
6,000	-98,774	-25,045	**-$6,914**	-$1,753		3,748	**59**

How about first cost, 6,000 cfm? Columbus

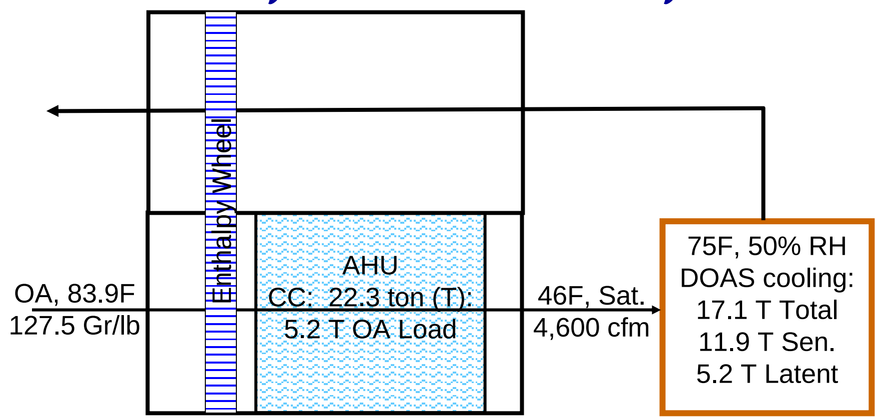


AHU first cost: $19,800 +$12,000 installation.

Air Cooled chiller first cost: $11,400 +$5,000 installation

Total installed cost: $48,200

How about first cost, 4,600 cfm? Col.



AHU first cost: $17,000 +$9,200 installation.
Air Cooled chiller first cost: $11,130 +$5,000 installation
Add FCU's to cover 3 T of lost DOAS space sen.cooling:
first cost: $1,440+($0-$4,300 [3@$1,430 each]) install'n
Total installed cost: $43,770-$48,070

1st and Op Cost summary.

III) Columbus, OH, Economic comparison of 6,000 and 4,600 cfm flow ***without*** EW			
Flow	1st cost	Op. Cost OA	Fan op cost
6,000	$43,900	$685-$4,297=-$3,612	$1,230
4,600	$39,450 to $43,750	$525-$3,296=-$2,771	$950
Extra $ for surplus air	$4,450-$150	-$841	$280
Payback years with surplus air	8 to 0.3 years		
IV) Columbus, OH, Economic comparison of 6,000 and 4,600 cfm flow ***with*** EW			
Flow	1st cost	Op. Cost OA	Fan op cost
6,000	$48,200	$137-$4,297=-$4,160	$1,562
4,600	$43,770 to $48,070	$105-$3,296=-$3,191	$1,204
Extra $ for surplus air	$4,430-$130	-$969	$358
Payback years with surplus air	7 to 0.2 years		

Conclusion #1:

- Choosing to increase the ventilation air to get a LEED point is purely optional—for improved IEQ.
- In most cases, surplus OA is an overall energy saver with DOAS—i.e. also contributes to energy category.
- This is true because a DOAS with an EW operating with surplus OA has very low extra OA cooling energy use and can provide extra free cooling much of the year.
- However with surplus OA, not all geographic locations provide enough energy savings to warrant the modest added first cost of the equipment.

Conclusion #2:

- ***Increasing the ventilation air to spaces*** with low OA cfm/person ***yields big dividends*** in terms of allowing the SA DPT to be elevated while still accommodating all of the occupant latent loads.
- ***This strongly suggests a non uniform ventilation increase strategy***. In other words, if a space combined minimum OA/person is in the 18-20 cfm/person range, do not increase those values at all. But for spaces with the 6 to 18 cfm/person range, increase those values upward close to 18-20 cfm/person range, then step back and assess how close the entire building ventilation has approached a total 30% increase.
- If after ***equalizing the flow rate per person*** to about 18 cfm, the 30% surplus ventilation has been achieved, ***take the LEED point***. Otherwise abandoning the goal of gaining a LEED point by this method may be best.
- ***Such an approach*** should make gaining the LEED point possible while ***significantly simplifying the equipment choices*** and ***avoiding elevated first cost by eliminating the need for below freezing DPTs to some spaces***.

Conclusion #3

- I prefer to see about 18-20 cfm/person delivered for ventilation in spite of lower numbers from 62.1.
- Thanks to total energy recovery and DOAS, it can be energy efficiently and economically achieved compared with VAV systems.
- Fortunately, with DOAS, that is possible by delivering less OA than the minimum required for a VAV system. ***Example from above for the 30% surplus ventilation air LEED point***:
  - VAV **3,774 cfm** OA and
  - DOAS **2,935 cfm** OA

Conclusion #4

- Experts, Pundits, and Others (maybe some in this room) are ***wrong*** about 30% surplus air (for a LEED point) being an energy waste ("***madness***") when applied to DOAS, in most US geographic locations.
- Ventilation surplus is also often warranted (for equipment selection and first cost reasons; topics beyond this presentation) to accommodate latent load without requiring sub freezing SA DPTs to select zones.


Questions
Ans at: http://doas.psu.edu
39