ASHRAE 1 – Lab Exhaust Stakeholder Meeting 3

California Statewide Utility Codes and Standards Program

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Overview

- **Two Measures:**
  - **VAV Supply and Exhaust at the Zone Level**
  - **Energy Recovery (Run Around Coils)**

ASHRAE 1 – Lab Exhaust

Proposed Code Changes

5.1.1 Section 101 Definitions. Add new definition for Covered Process and Covered Process Load as follows

COVERED PROCESS includes the following:

- Datacom equipment
- Laboratory exhaust
- Garage exhasut
- Kitchen ventilation
- Refrigerated warehouses

COVERED PROCESS LOAD is a load resulting from a covered process

5.1.2 Section 101 Definitions. Modify existing definitions for Process and Process Load as follows

EXEMPT PROCESS is an activity or treatment that is not related to the space conditioning, lighting, service water heating, or ventilating of a building as it relates to human occupancy and is not listed as a covered process.

EXEMPT PROCESS LOAD is a load resulting from an exempt process.

5.1.3 Modify Section 121(e) as follows

121(e) Design and Control Requirements for Quantities of Outdoor Air. All mechanical ventilation and space-conditioning systems shall be designed with and have installed ductwork, dampers, and controls to allow outside air rates to be operated at the larger of (1) the minimum levels specified in Section 121(b)1 or (2) the rate required for make-up of exhaust systems that are required for an exempt process, for a covered process, for control of odors, or for the removal of contaminants within the space.

Proposed Code Changes

5.1.4 Modify exceptions to Section 122(b) as follows

EXCEPTION to Section 122(b)[Criteria for Zonal Thermostatic Controls]: Systems serving ~~zones~~ exempt process load that must have constant temperatures to prevent degradation of materials, a process, plants or animals.

5.1.5 Modify exceptions to Section 123 as follows

EXCEPTION 3 to Section 123 [Pipe Insulation]: Piping that serves ~~process loads,~~ gas piping, cold domestic water piping, condensate drains, roof drains, vents, or waste piping.

5.1.6 Modify Section 141(c) as follows

141(c) [Calculation of Budget and Energy Use] 3. Energy excluded. The following energy shall be excluded:

A. ~~Process~~ Exempt process loads;

Add fan power limit and exception for lab exhaust components from 90.1

5.1.7 Modify Section 144(c) as follows

144(c) Power Consumption of Fans. Each fan system used for comfort space conditioning shall meet the requirements of Item 1 or 2 below, as applicable. Total fan system power demand equals the sum of the

power demand of all fans in the system that are required to operate at design conditions in order to supply air from the heating or cooling source to the conditioned space, and to return it back to the source or to exhaust it to the outdoors; however, total fan system power demand need not include the additional power demand caused solely by air treatment or filtering systems with final pressure drops more than 245 pascals or one-inch water column (only the energy accounted for by the amount of pressure drop that is over 1 inch may be excluded), or fan system power caused solely by exempt process loads.

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ASHRAE 90.1-2010 Fan Power Credits for Labs

TABLE 6.5.3.1.1B Fan Power Limitation Pressure Drop Adjustment

Device	Adjustment
Credits	
Fully ducted return and/or exhaust air systems	0.5 in. w.c. (2.15 in. w.c. for laboratory and vivarium systems)
Return and/or exhaust airflow control devices	0.5 in. w.c.
Exhaust filters, scrubbers, or other exhaust treatment	The pressure drop of device calculated at fan system design condition
Particulate Filtration Credit: MERV 9 through 12	0.5 in. w.c.
Particulate Filtration Credit: MERV 13 through 15	0.9 in. w.c.
Particulate Filtration Credit: MERV 16 and greater and electronically enhanced filters	Pressure drop calculated at 2× clean filter pressure drop at fan system design condition
Carbon and other gas-phase air cleaners	Clean filter pressure drop at fan system design condition
Biosafety cabinet	Pressure drop of device at fan system design condition
Energy Recovery Device, other than Coil Runaround Loop	(2.2 × Energy Recovery Effectiveness—0.5 in w.c. for each airstream
Coil Runaround Loop	0.6 in. w.c. for each airstream
Evaporative humidifier/cooler in series with another cooling coil	Pressure drop of device at fan system design condition
Sound Attenuation Section	0.15 in. w.c.
Exhaust system serving fume hoods	0.35 in. w.c.
Laboratory and vivarium exhaust systems in high-rise buildings	0.25 in. w.c./100 ft of vertical duct exceeding 75 ft

Proposed Code Changes

5.1.8 Modify Section 144(d) as follows

EXCEPTION 4 to Section 144(d) [Reheat/Recool Minimums]: Zones in which specific humidity levels are required to satisfy exempt process ~~needs~~loads.

5.1.9 Modify exceptions to Section 144(e)1 as follows

EXCEPTION 2 to Section 144(e)1 [Economizers]: Where the use of outdoor air for cooling will affect other systems, such as humidification, dehumidification, or supermarket refrigeration systems, so as to increase overall building TDV energy use.

~~EXCEPTION 4 to Section 144(e)1 [Economizers]: Where it can be shown to the satisfaction of the enforcing agency that the use of outdoor air is detrimental to equipment or materials in a space or room served by a dedicated space conditioning system, such as a computer room or telecommunications equipment room.~~

EXCEPTION 3 to Section 144(f) [SAT reset]: Zones in which specific humidity levels are required to satisfy exempt process needs.

EXCEPTION 3 to Section 123 [Pipe Insulation]: Piping that serves ~~process loads,~~ gas piping, cold domestic water piping, condensate drains, roof drains, vents, or waste piping.

EXCEPTION to Section 122(b)[Criteria for Zonal Thermostatic Controls]: Systems serving exempt process ~~zones~~ load that must have constant temperatures to prevent degradation of materials, a process, plants or animals.

5.1.10 Modify exceptions to Section 144(f) as follows

EXCEPTION 3 to Section 144(f) [SAT reset]: Zones in which specific humidity levels are required to satisfy exempt process needs.

Proposed Code Changes

5.1.11 Add new requirement to 144 as follows

Buildings with laboratory exhaust systems where the minimum circulation rate to comply with code or accreditation standards is ≤10 ACH or less than the design exhaust airflow shall be capable of reducing zone exhaust and makeup airflow rates to the regulated minimum circulation values, or the minimum required to maintain pressurization relationship requirements whichever is larger.

5.1.12 Add a new laboratory HVAC system to the ACM

VAV AHU with 100% OSA supply with preheat coil and cooling coil

CV Exhaust Modeled as a plug load in an unconditioned space equal to the scheduled MHP of the exhaust fans.

VAV zone controls with the airflow minimums to match those mandated by the AHJ for each lab space occupancy.

Add exception for constant volume exhaust where required by code, AHJ or the facility EH&S department

Proposed Code Changes

5.2 Reach Code (Title 24, Part 11)

5.2.1 Add new requirement to the prescriptive section of the reach code

Buildings with laboratory exhaust systems having a total exhaust rate greater than X cfm (or ft2) and a minimum air change rate greater than Y air changes per hour shall incorporate a heat recovery system to precondition makeup air from laboratory exhaust. The heat recovery system must have a sensible recovery effectiveness of greater than or equal to X.

Typical Practice

- 6-12 ACH ventilation
- 100% OSA constant volume reheat systems
- 3,000 fpm exhaust at the stack
- 4”-6” pressure on the supply and exhaust fans
- Supply air temperature reset
- Constant volume fume hoods

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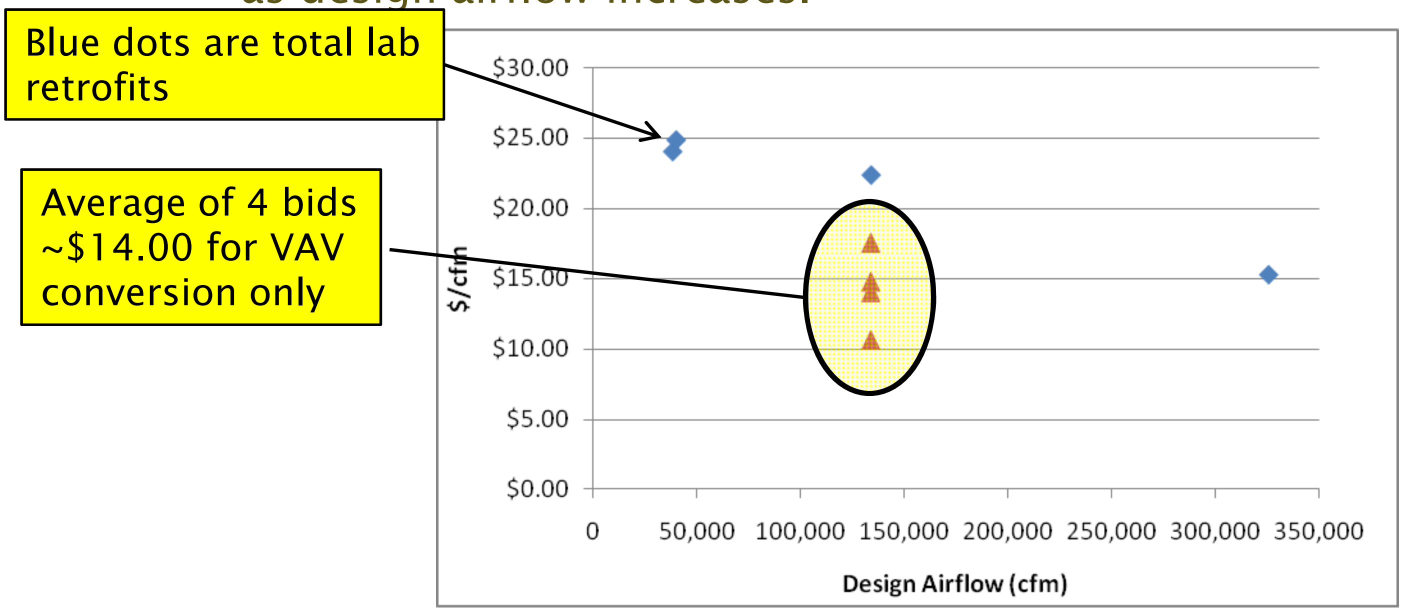
VAV Fume Exhaust

- Standard off the shelf technologies
- Saves fan energy (supply and exhaust)
- Reduces reheat, heating and cooling
- Improves comfort
- Safer during remodels and retrofits
- Some hoods will remain CV

Estimated Cost - VAV

- Retrofits
  - Costs below come from 4 major lab retrofit project. These costs are very conservative.
  - Average cost: $22/cfm (VAV and other measures). $/cfm cost decreases as design airflow increases.



- New construction
  - Case study done by Labs 21: $4.2/cfm

Estimated Energy Savings - VAV

- Simulation results
  - Calibrated DOE 2 model based on actual lab at Stanford
  - Vary minimum ACH
    - Decreasing savings as minimum/design airflow ratio increases.

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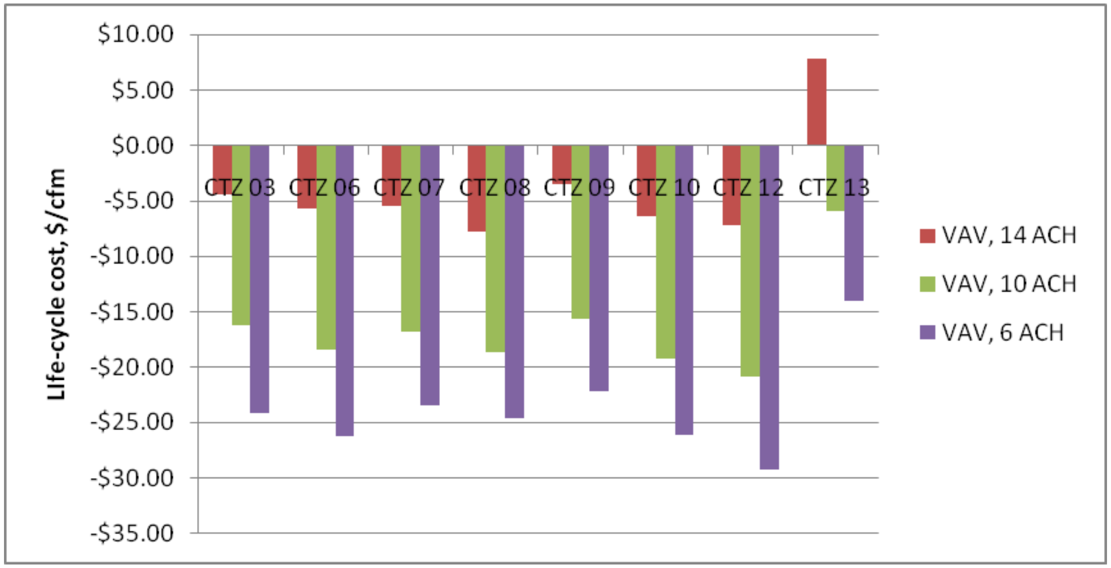
LCC - VAV

- Simulation results graphical



ASHRAE 1 – Lab Exhaust

LCC - VAV

- Simulation results tabular

			6 ACH		14 ACH	
Climate Zone	City	Incremental cost ($/cfm)	PV of energy cost savings	LCC of VAV	PV of energy cost savings	LCC of VAV
3	Oakland	$14.27	-$38.38	-$24.11	-$18.75	-$4.48
6	Torrance	$14.27	-$40.55	-$26.28	-$19.95	-$5.68
7	San Diego	$14.27	-$37.69	-$23.42	-$19.74	-$5.47
8	Fullerton	$14.27	-$38.88	-$24.61	-$22.01	-$7.74
9	Los Angeles	$14.27	-$36.46	-$22.19	-$17.77	-$3.50
10	Riverside	$14.27	-$40.41	-$26.14	-$20.61	-$6.34
12	Sacramento	$14.27	-$43.49	-$29.22	-$21.50	-$7.23
13	Fresno	$14.27	-$28.24	-$13.97	-$6.43	$7.84

Stakeholder Concerns

- Speed of response
  - See next slide, all systems surveyed used the ASHRAE 110 test methods
- Feedback on system failure
  - We'll add these as a requirements:
    - Audible or visible alarm on low face velocity
    - Audible or visible alarm on room air balance
- Commissioning
  - We'll add an acceptance test

Stakeholder Concern: Speed of Response

3.4.1.1 TSI Response: Dan Schuster of Bayside Mechanical

The TSI gear responds very quickly.

- The end to end response is about 3 seconds
- The controllers responds to a change in input in 100mS (0.1 Second) and the controlled devices (actuators) go full stroke in 1.5 seconds.
- A fume hood exhaust damper actuator travel from about 1/4 damper position (sash closed) to ¾ damper position (sash full open).
- It takes a typical user about 1-2 seconds to fully open or close a hood.
- So the control system is as fast or faster than the user.
- Room pressure controllers have a similarly fast operation.

Stakeholder Concern: Speed of Response

3.4.1.2 Phoenix Response: Rich Yardley of Newmatic Engineering

The Phoenix system has a total response time of about 0.60 seconds, and that even includes the air transport delay (the time it takes for the air to start moving after you open a damper).

Many systems promise performance, but the reality is that they can't react that fast. A system's total response time needs to take multiple factors into account:

1. Hood sensing technology - Phoenix Controls has ALWAYS used sash sensing. As soon as a sash starts opening (whether horizontally, vertically, or a combination thereof), our system starts to respond. Immediately.
2. Systems that use sidewall sensing (sometimes erroneously referred to as face velocity sensing) are guaranteed to fail a speed test: they don't begin to respond until the system has already started to fail.
3. Valve actuation - Of course you need a high-speed actuator. It needn't travel full stroke in 1 second, but it needs to respond fast enough to accommodate a "worst case" scenario

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(e.g., raising a vertical sash from minimum to maximum at a rate of 1.5 fps). That usually equates to 2 to 3 seconds for full stroke.

Stakeholder Concern: Speed of Response

4. Pressure independence - Pressure changes occur both locally and at adjacent and downstream devices. The pressure independence of the system must respond in a fraction of a second (not normal in HVAC controls ... most respond in 60 to 90 seconds to maintain system stability).
5. Overall control system response - There are a lot of "moving parts" in a control system. All components must by synchronized to provide the proper response time with stability. This is easier said than done. Phoenix Controls does it so well that it seems easy. The only way I've seen "others" approach our speed of response with stability is by limiting the hood turndown to a very narrow range (2:1 or less).
6. "Other" devices - as you stated, the supply valve and general exhaust valve must be similarly responsive to the fume hood valve. Otherwise room pressure relationships will be compromised, and in some cases, fume hood containment will be compromised (when the room is "starved" of air).

Stakeholder Concern: Speed of Response

- From Siemens

On April 22, 2004, Ben Larue and Jeff Waters of Siemens Building Technologies conducted tests on the airflow in O'neil Building Laboratories 218 and 236. The results of the ASHRAE-110 face velocity and smoke tests on hoods 218N, 218S, and 236M are attached. The balancer's report on room airflow will be sent separately.

In summary, the two Siemens-controlled fume hoods in Lab 218, and the Phoenix-controlled fume hood in room 236 performed adequately and contained smoke at the design sash height of 18 inches.

The average of five ASHRAE-110 time response tests on the Siemens fume hoods was 2.2 seconds to the stop of sash movement, and 3.6 seconds to within 10% of setpoint. The Phoenix hood averaged 1.8 seconds to the stop of sash movement (controlled by the operator) and 3.0 seconds to within 10% of setpoint.

The most significant factor in the fume hoods' ability to contain smoke was the equipment placed in the hoods. At the start of testing, the face of hood 218 South was completely blocked on the right side with 3-gallon plastic bottles. Smoke escaped from the hood, which is the criteria for failure of the ASHRAE-110 test. We demonstrated this to the Lab Supervisor, Ruth Post, and several hood operators. They removed the plastic containers, and the hood passed the smoke test. Dead air was observed in front of large temperature baths in hood 218 North and at least one hood in Lab 236. Large objects should be elevated on two-inch blocks.

Both the Siemens controls in Lab 218 and the Phoenix controls in Lab 236 performed adequately to maintain negative pressurization and containment in the fume hoods.

Stakeholder Concerns

- The proposed standard should include the following statement:
  - "All laboratory hoods must be designed, constructed, maintained, and operated in accordance with Title 8 of the California Code of Regulations sections 5143, 5141.1, and 5141.2."
  - We will consider this or alternately a statement at the front of Title 24 2013 that states clearly that the Title 24 does not preempt existing health and safety codes. The following statement is from 90.1 2010.

> **2.4** This standard shall not be used to circumvent any safety, health, or environmental requirements.

VAV Non-Energy Benefits

- Safety
  - All valves are pressure independent, remodels in other spaces on a common supply or exhaust does not impact the operation of other zones (a problem with CV systems).
  - Systems measure airflows and report on low hood face velocity and loss of room pressure
- Acoustics
  - Documented by pre and post measurements by Charles Salter Associates on Stauffer I and II on the Stanford Campus
- Comfort
  - Reduction of drafts due to lower airflow (this also increases safety).
- Maintenance
  - VAV operation reduces wear on motors, belts and bearings

Next Steps- VAV

- Make changes as noted in slides
  - Fan power in 144(c) per ASHRAE 90.1
  - Add exception to new 144 requirement for VAV allowing constant volume exhaust where required by code, AHJ or the facility EH&S department.

Estimated Cost, Heat Recovery

- Based on two run-around coils:
  - Low Effectiveness ~30%
  - High Effeciveness ~50%
- Costs from manufacturer's quotes

	$/cfm
Coils (low eff)	$0.40
Coil (high eff)	$1.01
Pumps	$0.12
Piping	$0.62
Total (high eff)	**$1.75**
Total (low eff)	**$1.14**

LCC – Heat Recovery

- 4 climates (3, 8, 9 and 12)
- 2 Efficiencies 30% and 50%
- CV and VAV
- 10ACH and 18 ACH

LCC – Heat Recovery Base and Reach Codes

Base Code (Part 6) TDVs

	10 ACH				18 ACH			
	CV		VAV		CV		VAV	
	Eff = 0.30	Eff = 0.50	Eff = 0.30	Eff = 0.50	Eff = 0.30	Eff = 0.50	Eff = 0.30	Eff = 0.50
CTZ03	$1.03	$3.75	$0.16	$0.76	$0.96	$3.66	$0.35	$1.05
CTZ08	$1.55	$4.44	$0.58	$1.07	$1.12	$3.73	$0.54	$1.06
CTZ09	$0.12	$2.23	-$0.47	-$0.41	$0.40	$2.59	-$0.28	-$0.07
CTZ12	-$1.88	-$0.42	-$2.24	-$2.51	-$1.43	$0.15	-$1.59	-$1.45

Not cost effective (CTZ03, CTZ08)

Cost effective for VAV CZ 9 & all of CZ 12 (CTZ09, CTZ12)

Reach Code (Part 11) TDVs

	10 ACH				18 ACH			
	CV		VAV		CV		VAV	
	Eff = 0.30	Eff = 0.50	Eff = 0.30	Eff = 0.50	Eff = 0.30	Eff = 0.50	Eff = 0.30	Eff = 0.50
CTZ03	$0.81	$4.00	-$0.29	$0.28	$0.74	$3.89	$0.01	$0.73
CTZ08	$1.57	$5.01	$0.35	$0.80	$1.04	$4.12	$0.33	$0.82
CTZ09	-$0.25	$2.20	-$1.00	-$1.09	$0.10	$2.65	-$0.73	-$0.62
CTZ12	-$2.95	-$1.39	-$3.40	-$3.95	-$2.36	-$0.65	-$2.49	-$2.49

Not cost effective (CTZ03, CTZ08)

Cost effective for VAV CZ 9 & all of CZ 12 (CTZ09, CTZ12)

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Energy Results

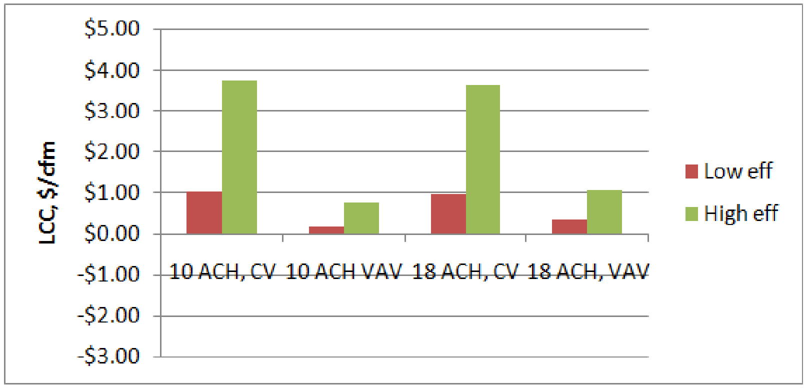

Figure 13. 15-year life-cycle cost, CTZ 3

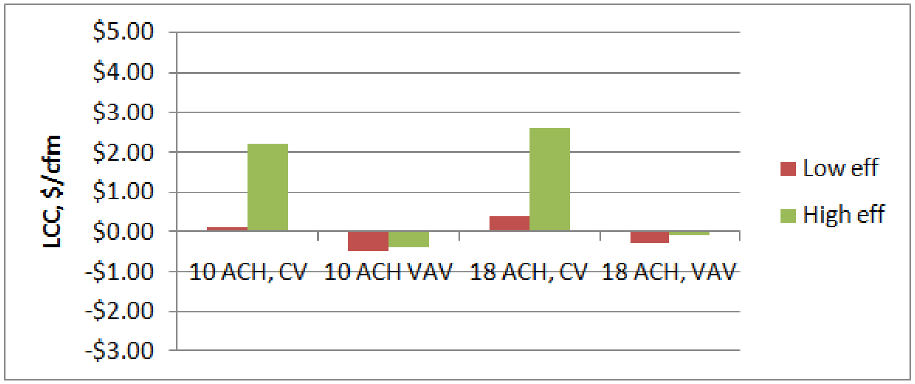

Figure 15. 15-year life-cycle cost, CZ 9

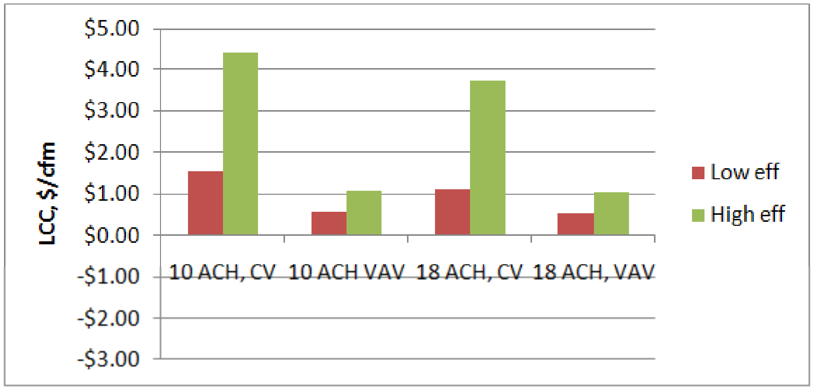

Figure 14. 15-year life-cycle cost, CZ 8

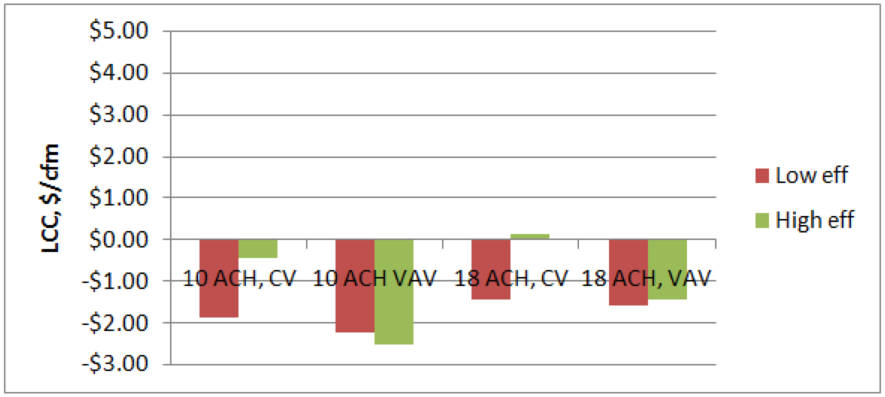

Figure 16. 15-year life-cycle cost, CTZ 12

ASHRAE 1 – Lab Exhaust

Energy Results

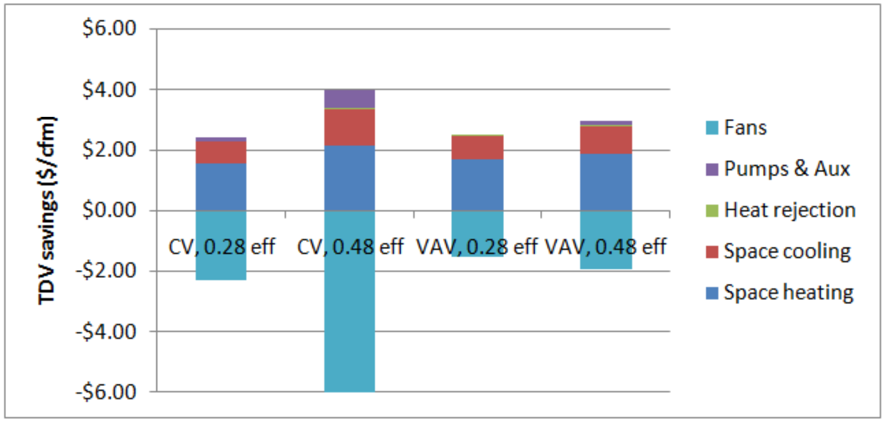

Figure 5. 15-year energy savings by end-use, CTZ 3, 10 ACH

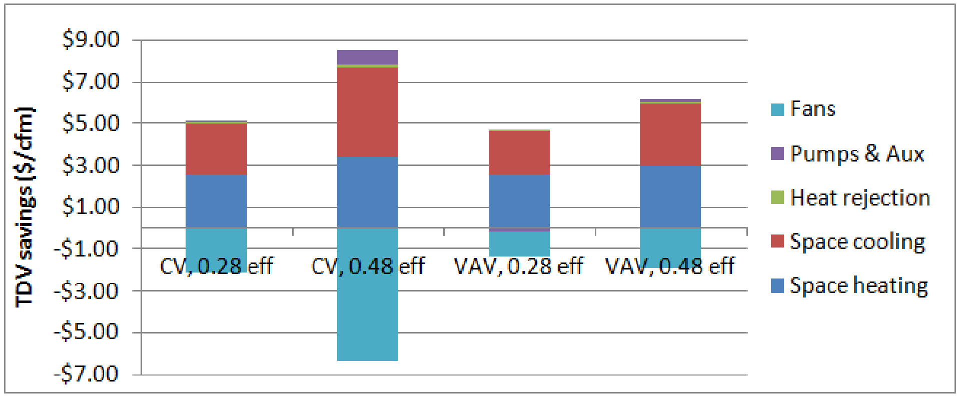

Figure 9. 15-year energy savings by end-use, CTZ 12, 10 ACH

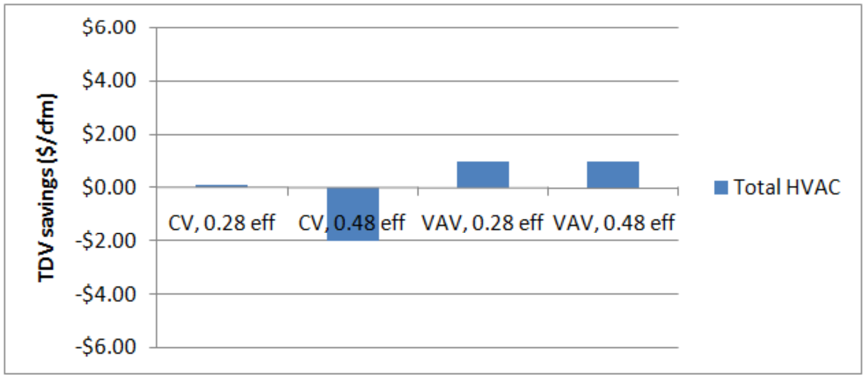

Figure 6. Total 15-year energy savings, CTZ 3, 10 ACH

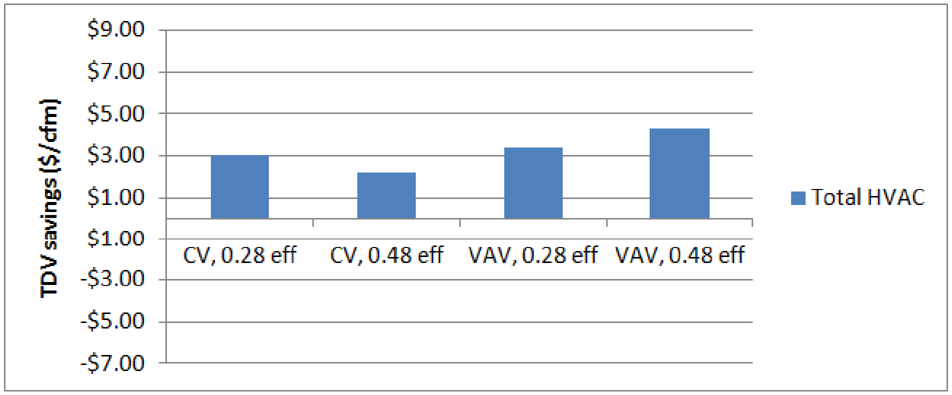

Figure 10. Total 15-year energy savings, CTZ 12, 10 ACH

Stakeholder Concerns

- We also have strong reservations about heat recovery systems that rely on coils or other impediments to free air flow being place within exhaust ducting.
  - We will examine this

Next Steps – Heat Recovery

- Run in more climates
- Consider for reach code

Questions

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QUESTIONS & COMMENTS

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