UPGRADING THE UNIVERSITY OF PENNSYLVANIA CHEMISTRY BUILDING

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University of Pennsylvania Chem 73

- 6 floor building (5 + basement)
- 139,575 SF
- New in 1973
- Philadelphia, PA
- Originally constructed as Chemistry Lab and teaching facility

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University of Pennsylvania Chem 73

- CV fume hoods on 5 floors individually exhausted thru roof fans
- (1 fan / lab module)
- Total building exhaust approx. 280,000 CFM
- 24/7 Operation, 365 days/year

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University of Pennsylvania Chem 73

- **Goals**
  - Reduce energy cost - target total exhaust reduction
  - Maintain occupancy and research during renovation
  - Flexibility of open lab spaces
  - Improve ventilation control in labs
  - Improve temperature control throughout building
- **Challenges**
  - CV fume hoods
  - Occupied building; research must continue
  - Replace AHU on each floor
  - MONEY!

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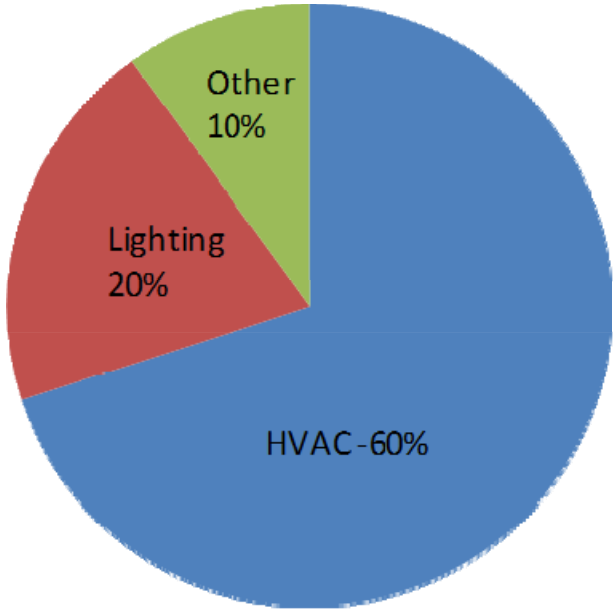
University of Pennsylvania Lab Buildings

- Highest producers of carbon on campus (37%)
- 100% outside air, no recirculation
- Labs use 7 times more energy per square foot than commercial space
- Energy breakdown of a lab building



Cost per CFM
$9.00

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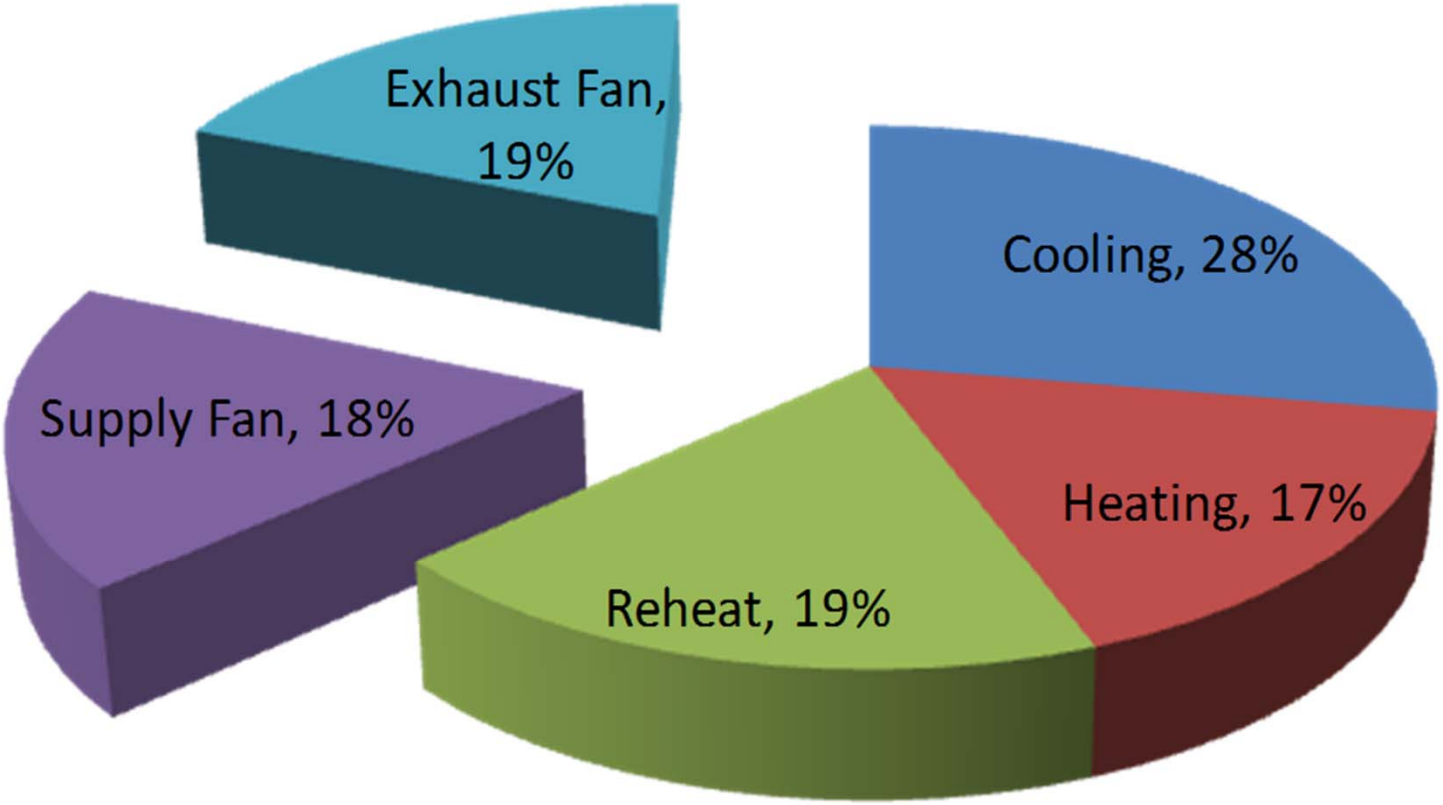
Approximation of Airflow Costs



Cost per CFM
$9.00

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Chem 73 Overall Scope of Work

- Modify hoods
- Upgrade ductwork
- Temporary supply AHU
- Phase tie-ins
- Install new Exhaust before demo
- Floor-by-floor changeover

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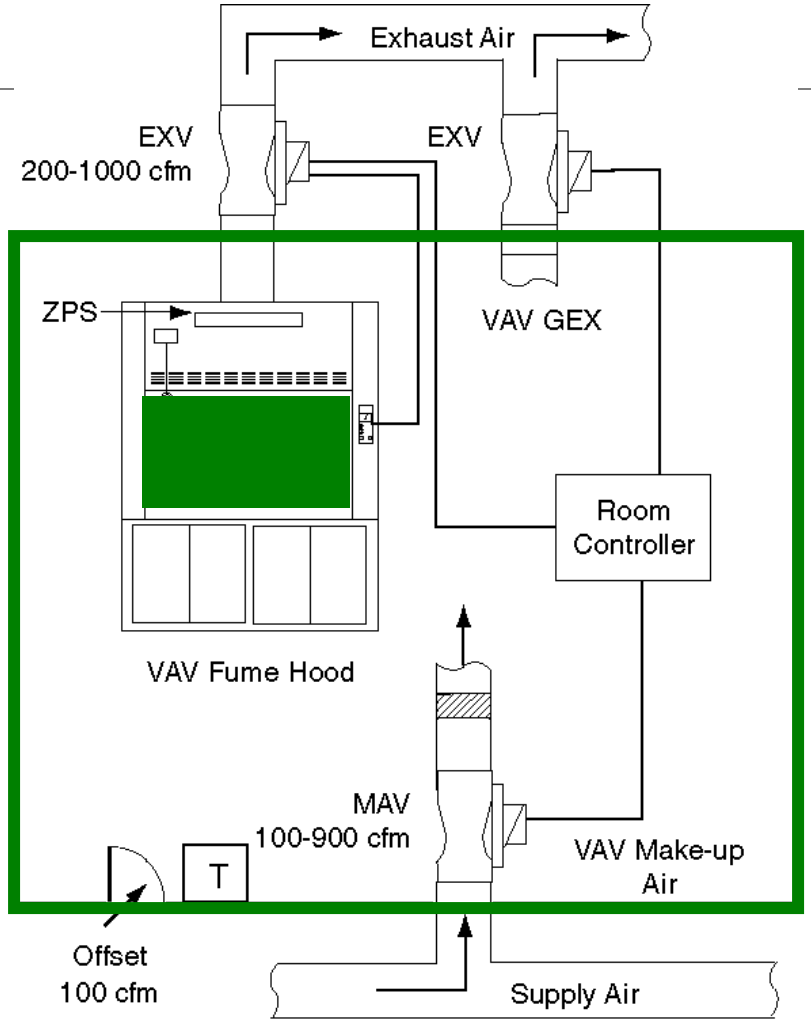
Chemistry Labs – Pressure and Comfort Control



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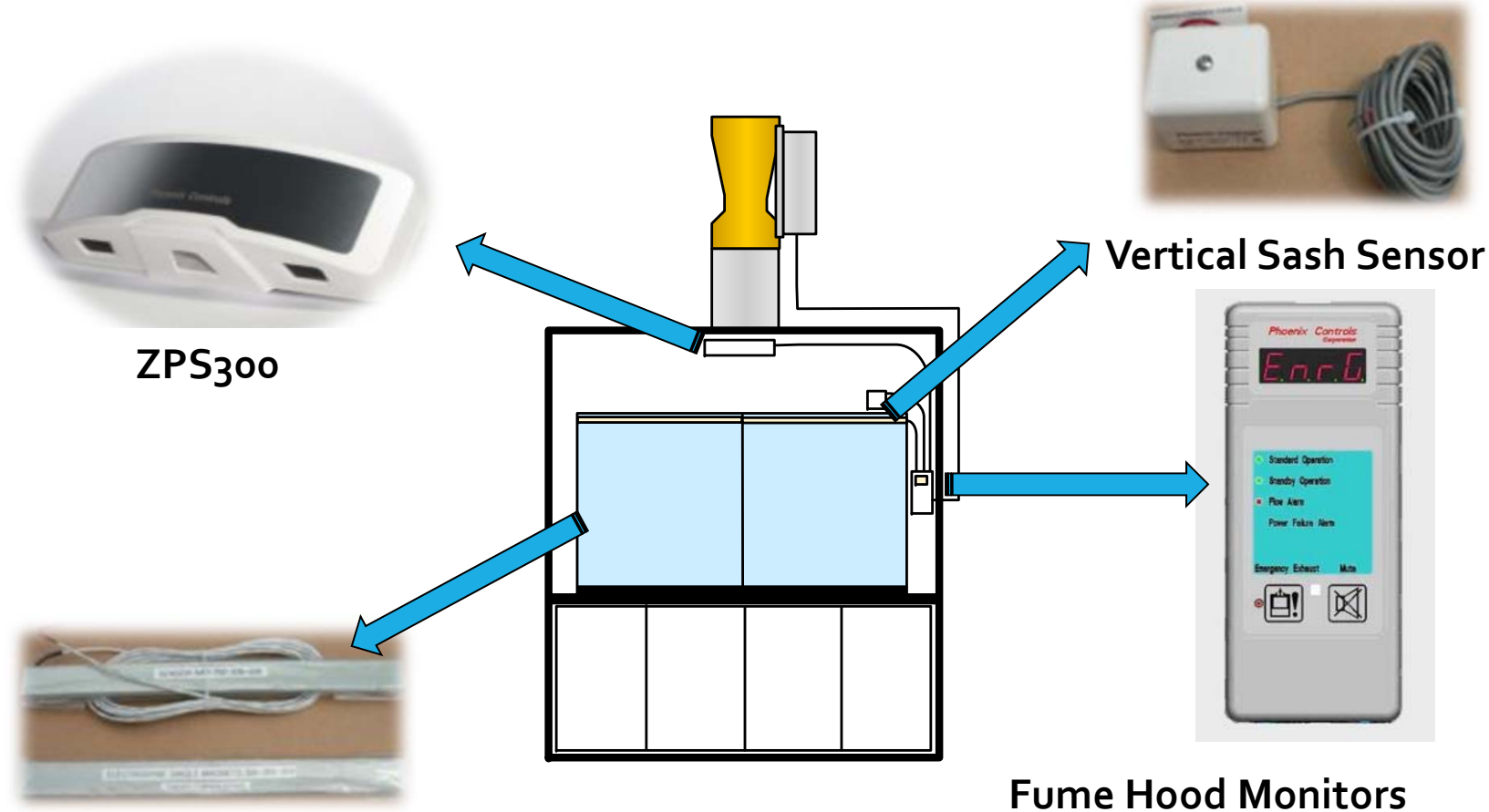
Variable Volume Exhaust Hood



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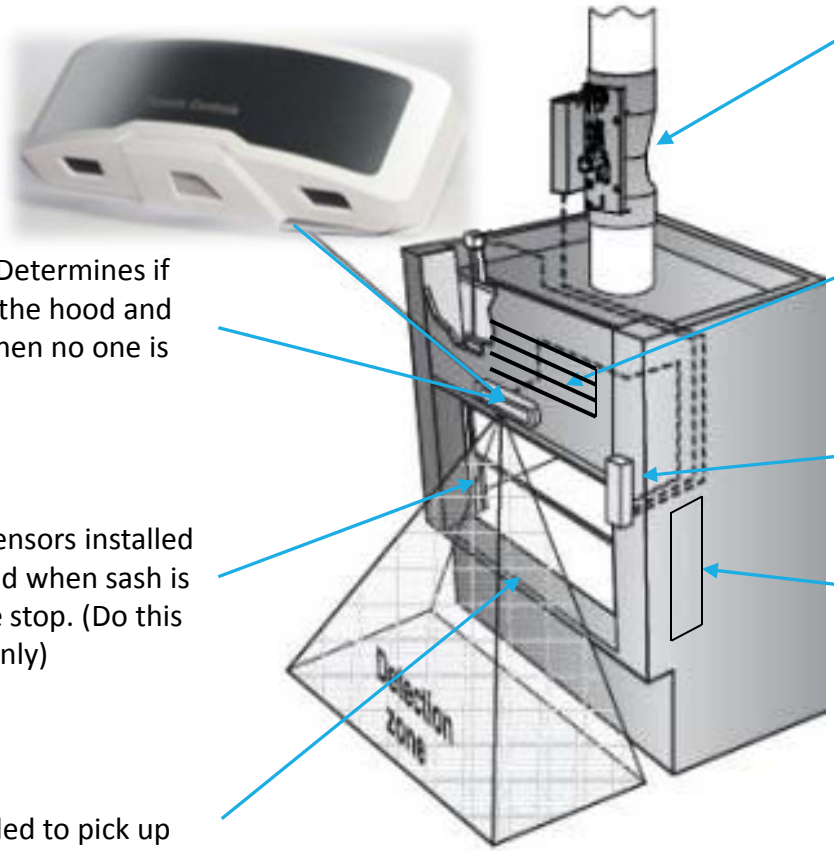
UPENN CHEM 73 FUME HOOD MODIFICATIONS



VAV Venturi Valve changes the airflow based on sash position and occupancy

Bypass Air blocked to allow fume hood to be variable flow

FH Occupancy Sensor Determines if someone is in front of the hood and lowers face velocity when no one is present

Fume hood Monitor alarms if hood is unsafe or sash is too high. Note: Sashes should be closed when not in use.

Sash Stops and sash sensors installed at 18". Alarm will sound when sash is raised higher than the stop. (Do this for set up only)

Side Sashes are permanently closed

Airfoil installed to pick up heavier than air particles

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How Do Control Changes Translate into savings?

Typical Lab Module in Chem. 73 (600 SF / 10'-0" ceiling height)

	No Hoods (CFM)	One Hood (CFM)	Two Hoods (CFM)	Four Hoods (CFM)
Constant Volume Airflow (15 Air Changes Per Hour)	1500	1500	2000	4000
VAV without Zone Presence Sensor; Sashes left open (6 Air changes per hour)	600	1000	2000	4000
VAV with Zone Presence Sensor; Sashes left open (6 Air changes per Hour)	600	600	1200	2400
VAV with Sashes Closed (6 air Changes per Hour)	600	600	600	600
VAV with Air quality sensing (4 Air Changes per hour)	400	400	400	600
SAVINGS of VAV over Constant Volume (per year per lab)	**$ 8,100.00**	**$ 8,100.00**	**$ 12,600.00**	**$ 30,600.00**
Savings of VAV with Air Quality sensing over Constant Volume	**$ 9,900.00**	**$ 9,900.00**	**$ 14,400.00**	**$ 30,600.00**

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Proposed Centralized Exhaust

The Benefits…

- ANSI Z9.5 issued in 1992
- Belts must be inspected Monthly
- 3000 Ft/min Stack velocity; High discharge Plume
- UPenn Wanted Reduced Maintenance

- Wind wake models want higher virtual stack heights and more dilution than existed previously

- Energy recovery required by Code on projects using 100% OA (>5000 CFM)

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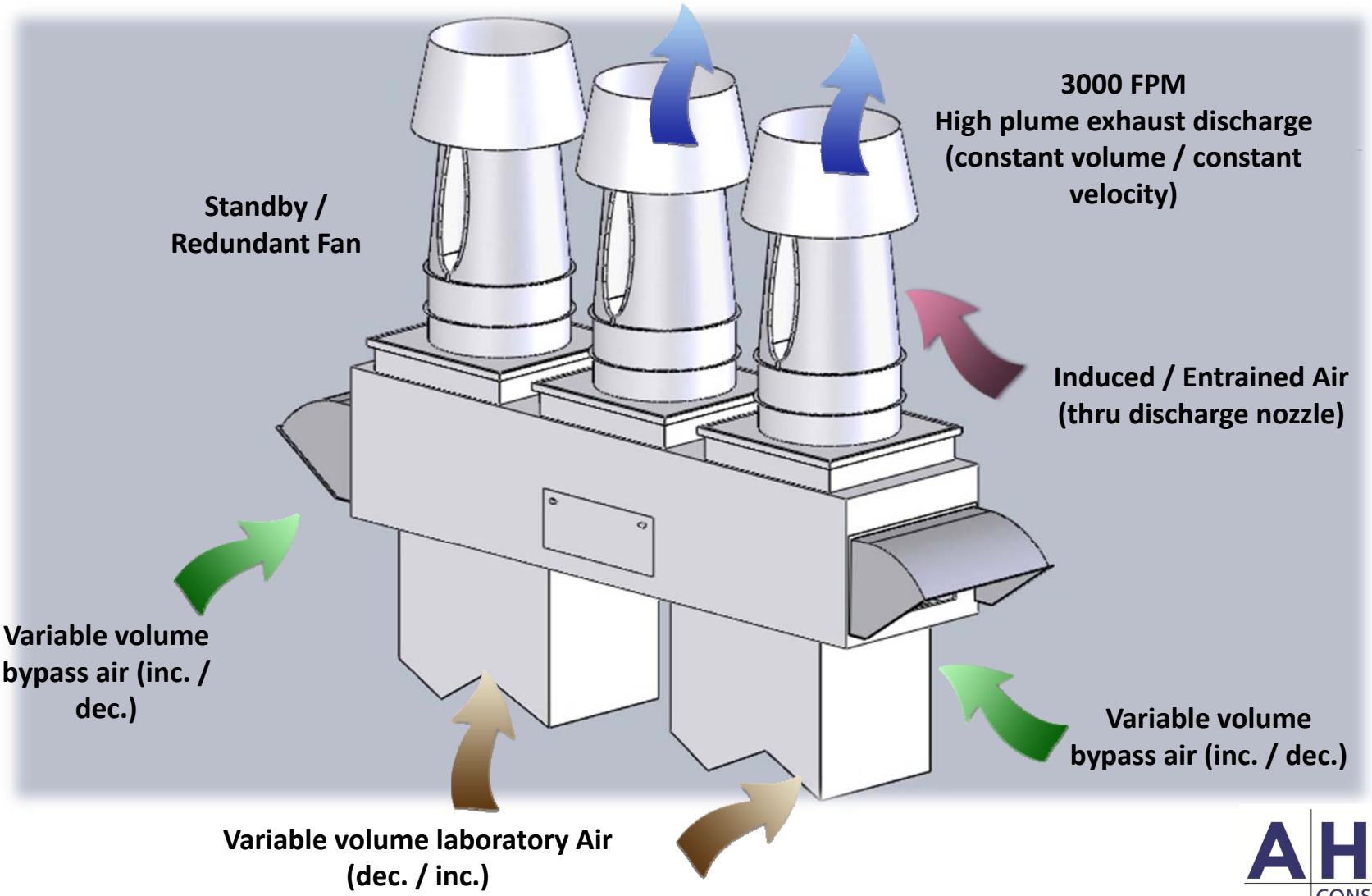
Fans: Two Operating, One Standby



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New Plenum and Roof Fans

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Fan Room After!

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Energy Recovery

Simple Definition: Extracting energy from the exhaust air being discharged from the building and using this energy to pre-treat the incoming outdoor supply air

Energy Recovery Required by Energy Code:

- System greater than 5,000 CFM
- 70% or more outdoor supply air

Two Most Common Energy Recovery Approaches:

- Enthalpy Wheel: more effective, but small cross-contamination potential
- Glycol Run-Around Loop: less effective; needs pumping energy; needs frost prevention control; no cross-contamination
- Both methods require added fan energy to overcome wheel/coil resistance

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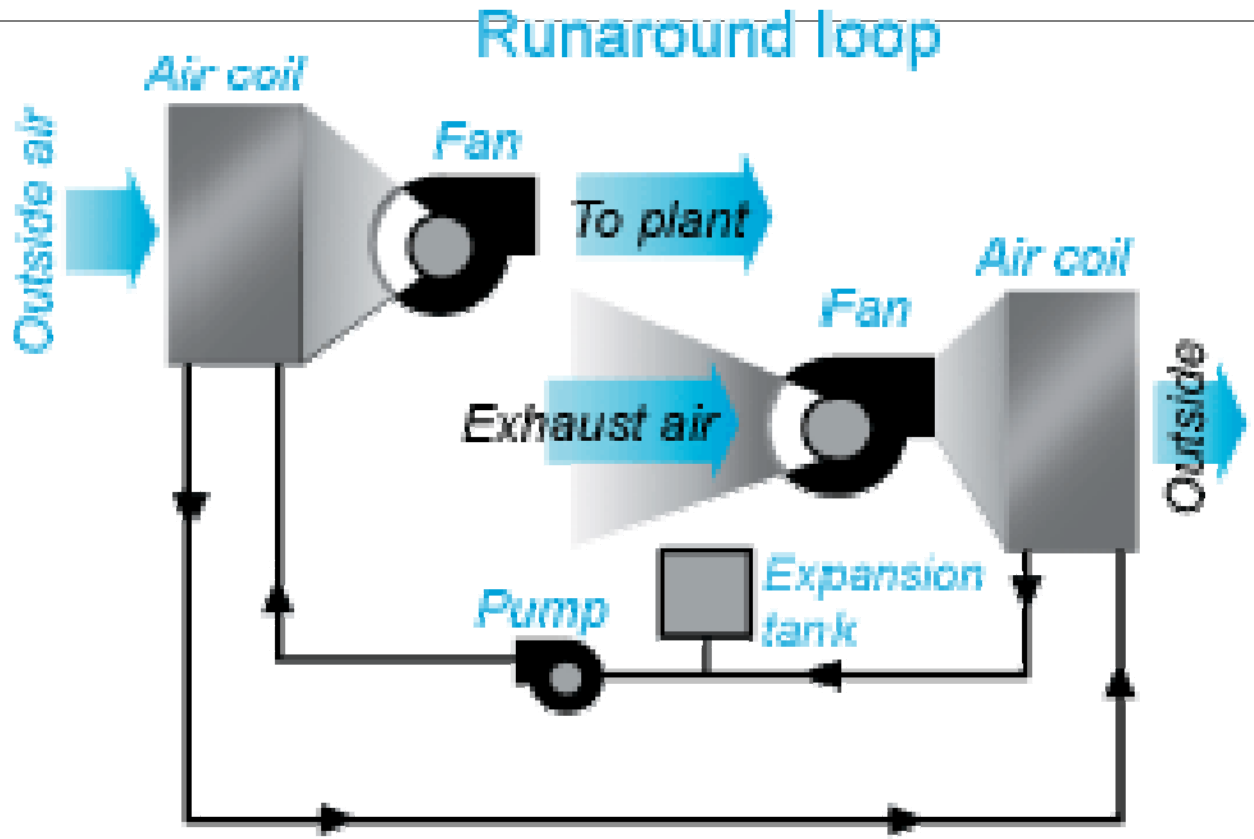
Glycol Run Around Loop



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Air Handling Units

Existing AHU: Constant volume units, beyond normal expected life, standard efficiency motors, belt drive fans

New VAV AHU: premium efficient motors, VFD's, direct drive fans, new MERV 13 filters, and new DDC controls

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Air Handling Units

2nd Floor Existing CV AHU & 4th Floor New VAV AHU

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Energy Modeling

eQUEST Model: match bldg. geometry, construction, systems, schedules, & utility rates.

"Tune" model to adjust inputs so output matches (within a reasonable +/-) the actual usage.

Change specific elements of model to match proposed changes, in order to see what the impact will be (pos. / neg.)

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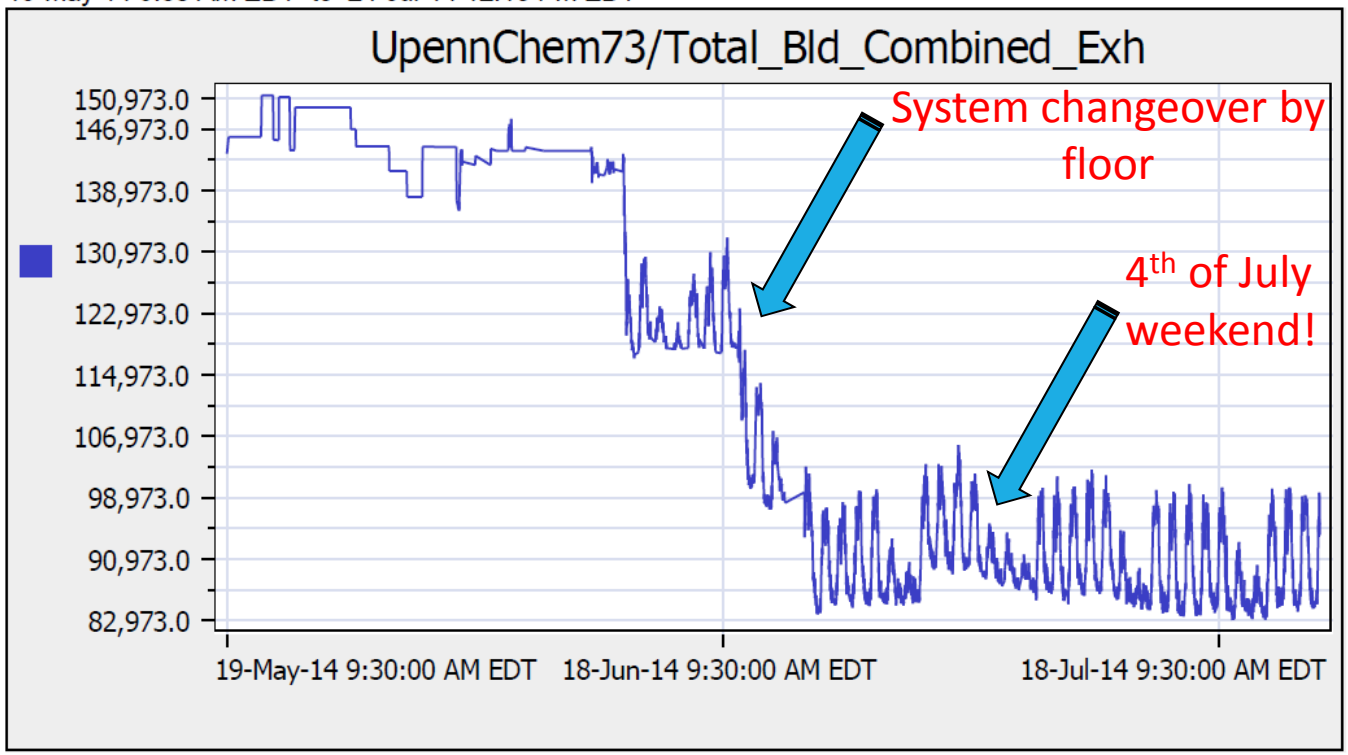
CV - VAV Total Exhaust - Monitoring

history:UpennChem73/Total_Bld_Combined_Exh

19-May-14 9:30 AM EDT to 24-Jul-14 12:18 PM EDT



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Annual Energy Usage

Model Predicted Energy Savings:

- 24% Electric
- 51% Steam
- 40.99% Overall energy usage

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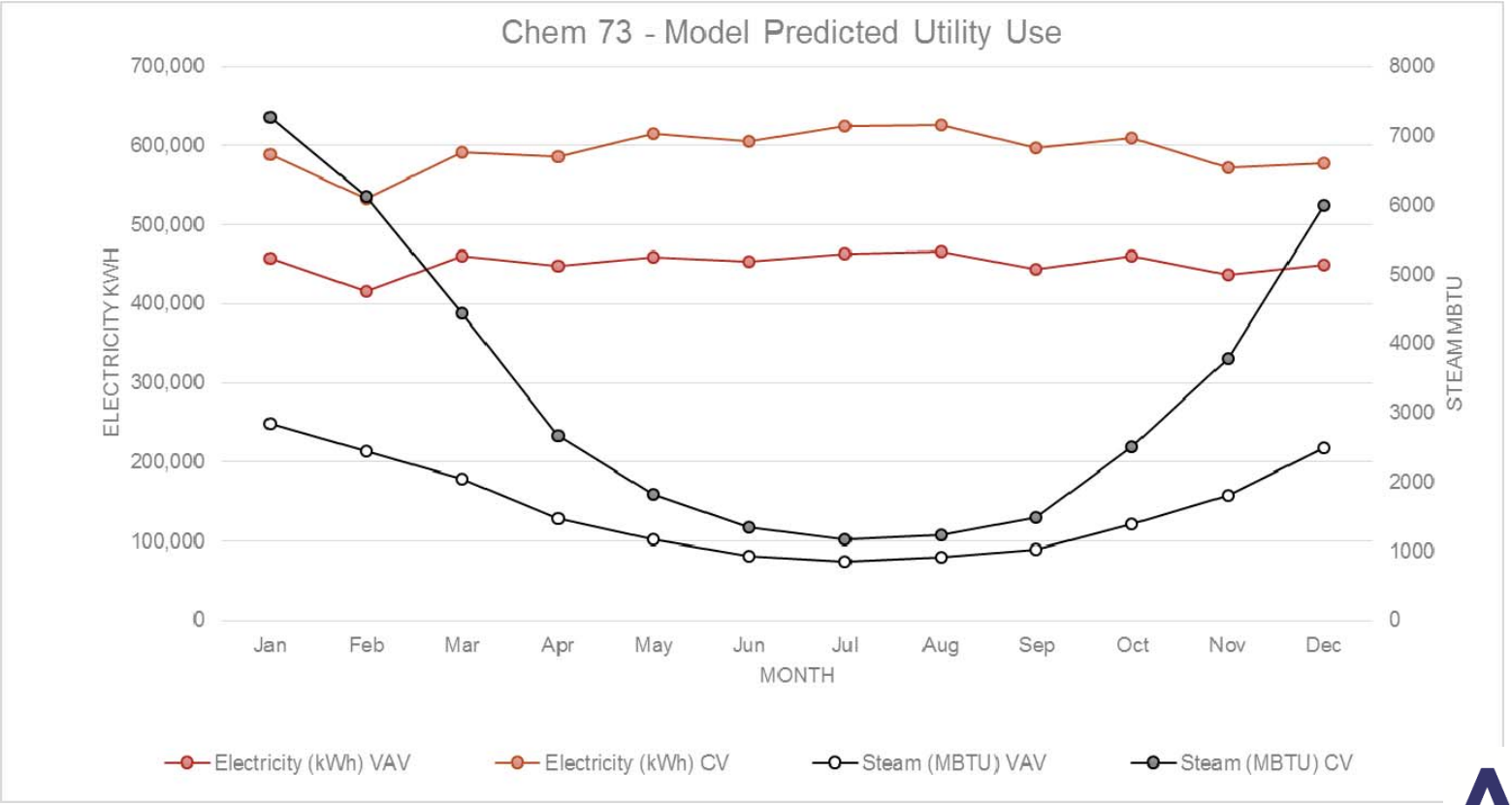
Modeled Energy Usage

Before (CV) and After (VAV)



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Endowment Return Comparison

Think about it this way…..

Year	MIT	Harvard	Yale
2007	22.1%	23.0%	28.0%
2008	3.2%	8.6%	4.5%
2009	-17.1%	-27.3%	-24.6%
2010	10.2%	11.0%	8.9%
2011	17.9%	21.4%	21.9%
2012	8.0%	-0.1%	4.7%
2013	11.1%	11.3%	12.5%
2014	19.2%	15.4%	20.2%
Average	**9.3%**	**7.9%**	**9.5%**
(source: Boston	Globe, 6/18/15)		

ROI Comparison

Harvard Average: 7.9%
MIT Average: 9.3%
Yale Average: 9.5%

Simple Payback = 8.78 years

= 11.4% EVERY YEAR ***GUARANTEED***

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Summary Benefits to Owners

Reduces Annual Operating Costs

- 37.6% energy savings annually
- New VAV system
  - ~ 85,000 CFM (Off Peak)
  - ~ 105,000 CFM (Peak)
- Savings started before construction was completed!

Reduces Carbon Footprint/Emissions

- 87% of Carbon Produced from Campus Buildings (remainder = vehicles)
- Lab Buildings are the largest contributors at 37% of total

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Summary Benefits to Owners

- **VAV Systems Respond to Space Occupancy Changes vs. CV running Full Out 24/7**
  - Extremely Tight Environmental Space Condition Control (+/- ¼◦ F in Laser Lab)
  - Significantly reduces hot/cold calls
- **Reduces Ongoing Maintenance**
  - Eliminate problematic pneumatic controls and inefficient air compressors
  - Reduce fan belt replacement & unit down time
- **Engineering – 2 years to Plan and Design (Oversight and reviews) - 12 month Construction project**

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The Three Takeaways…

1. **Yes they Can! -** Opportunities exist for system improvements and modifications for energy savings without replacing everything AND they CAN be modified while occupied!

2. **Not Anymore!..** Relatively speaking of course...Research spaces don't have to be the energy hogs they once were.

3. **Invest in energy savings! Think differently...**Consider ROI instead of simple payback in the context of building ownership timeline; consider the cost of money; a 20 year simple payback is 5% ROI…

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Questions?… Thank you for your TIME!

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