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Charting a Course to Energy Independence

Providence, RI
August 9-12, 2009

3 Big Hits in Laboratories

and how emerging technologies is addressing them

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FEMP

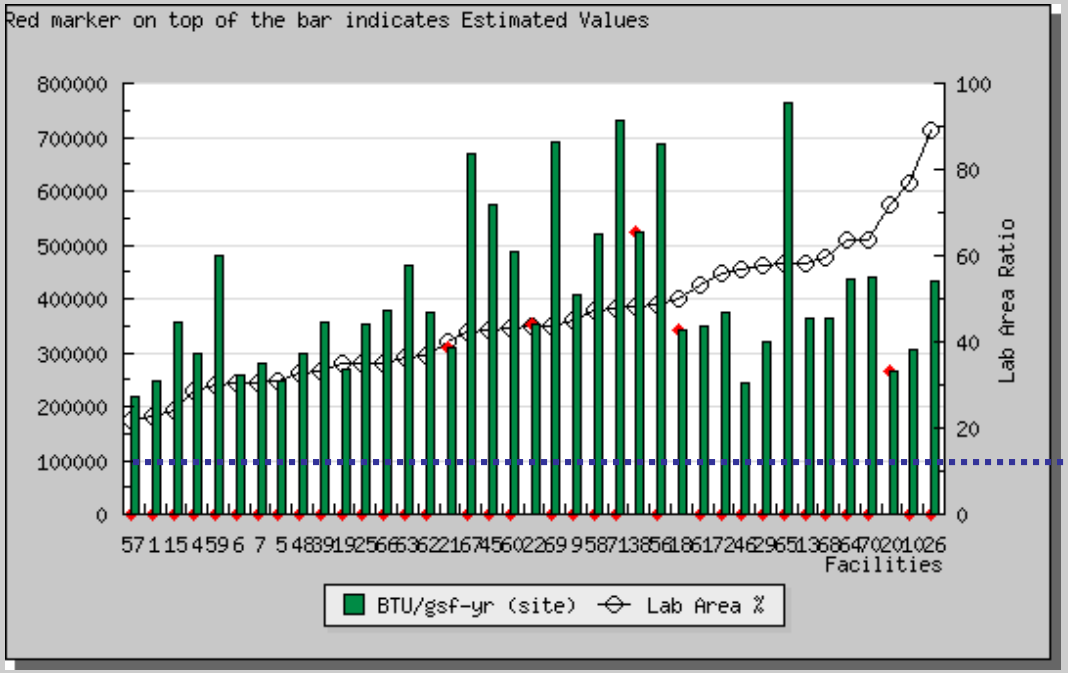
LABS FOR THE 21ST CENTURY

BERKELEY LAB

GSA

Lab Energy Intensity

3 to 8 times as energy intensive as office buildings



Typical Office Building

Total Site Energy Use Intensity BTU/sf-yr for various laboratories in the Labs21 Benchmarking Database

Why Sustainability for Labs?

- **Laboratories are very energy intensive**
  - 3 to 8 times as energy intensive as office buildings
- **Substantial efficiency opportunities**
  - 30%-50% savings over standard practice
- **Triple bottom line**
  - Reduce life cycle costs
  - Improve workplace quality and safety
  - Reduce environmental impact

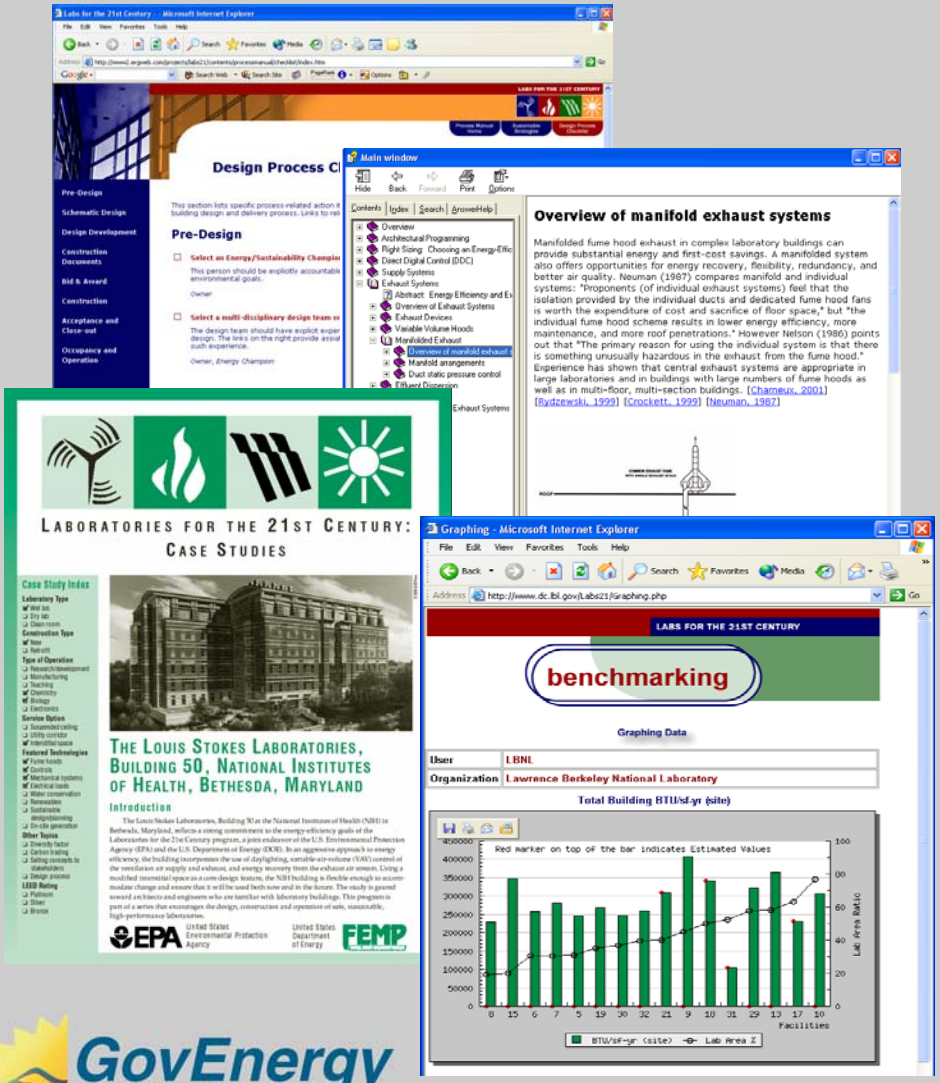
Labs21 Program

- Funded by the DOE Federal Energy Management Program and EPA Facilities Management and Services Division to improve the environmental performance of U.S. laboratories
  - Optimize whole building efficiency on a life-cycle basis
  - Assure occupant safety
  - Minimize overall environmental impacts

Labs21 Program Components

- Partnership Program
  - Draws together lab owners and designers committed to implementing high performance lab design.
- Training Program
  - Includes annual technical conference, training workshops, and other peer-to-peer opportunities.
- Tool Kit for Sustainable Design
  - Resources for owners, designers, and operators

Labs21 Toolkit



- *Core information resources*
  - Design Guide
  - Case Studies
  - Energy Benchmarking
  - Best Practice Guides
  - Technical Bulletins
- *Design process tools*
  - Env. Performance Criteria
  - Design Intent Tool
  - Labs21 Process Manual

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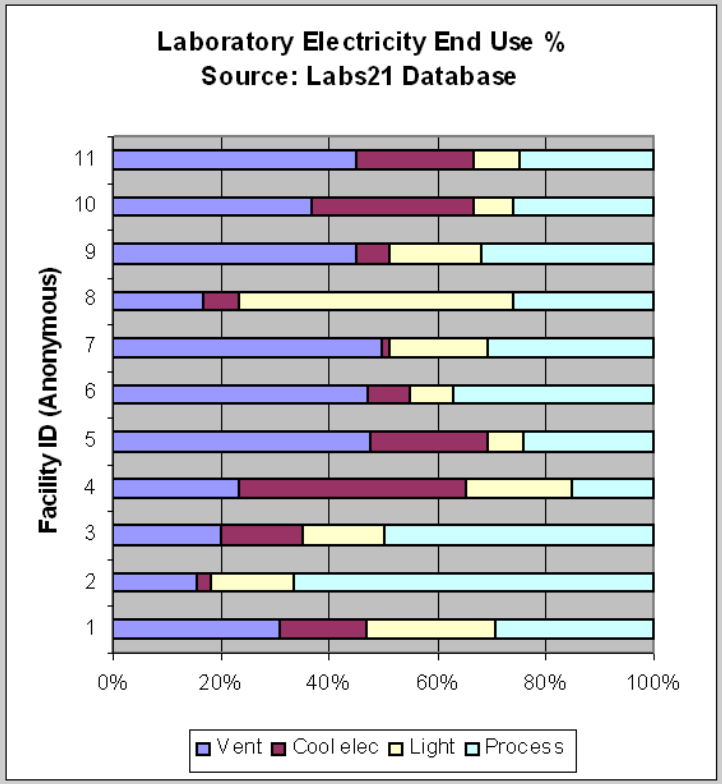
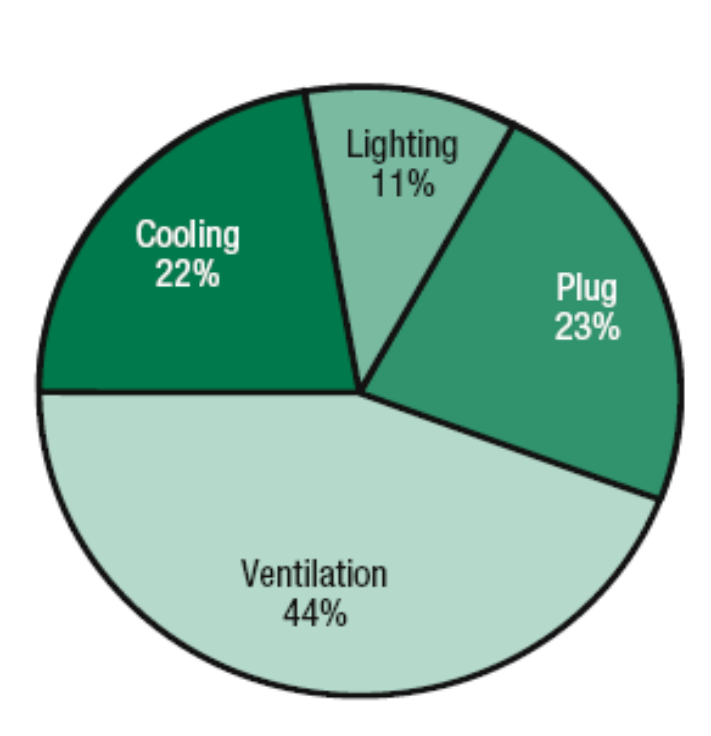
Lab Energy Use is Dominated by HVAC



- Ventilation is the largest component of energy consumption in most labs
  - % varies by lab type and location
- In some labs, 10-20% savings in ventilation is equivalent to total lighting energy use

Three BIG HITS

1. Scrutinize the air changes: Optimize ventilation rates
2. Tame the hoods: Compare options
3. Just say no to re-heat: Minimize simultaneous heating and cooling



Annual electricity use in Louis Stokes Laboratory, National Institutes of Health , Bethesda, MD

#1 Scrutinize the Air Changes

Air change rates have large peak and total cost impact

- Don't assume air changes are driven by thermal loads
- What do you use as minimum air change rate (ACR)?
  - Why? Why? Why?
- When is ten or more air changes safe and six air changes (or less) not?

Scrutinize the Air Changes

- Options to consider
  - cfm/sqft rather than ACR
  - Panic switch concept
  - Cascading air from clean to dirty
  - Setback ACR when lab is unoccupied
  - Control Banding (one rate doesn't fit all)
  - Modeling and simulation for optimization
  - **Emerging Tech: Demand controlled ventilation (based on monitoring of hazards and odors**
- Ventilation effectiveness is more dependent on lab and HVAC design than air change rates (ACR)
- High ACR can have a negative impact on containment devices

Centralized Demand Control Ventilation (CDCV)

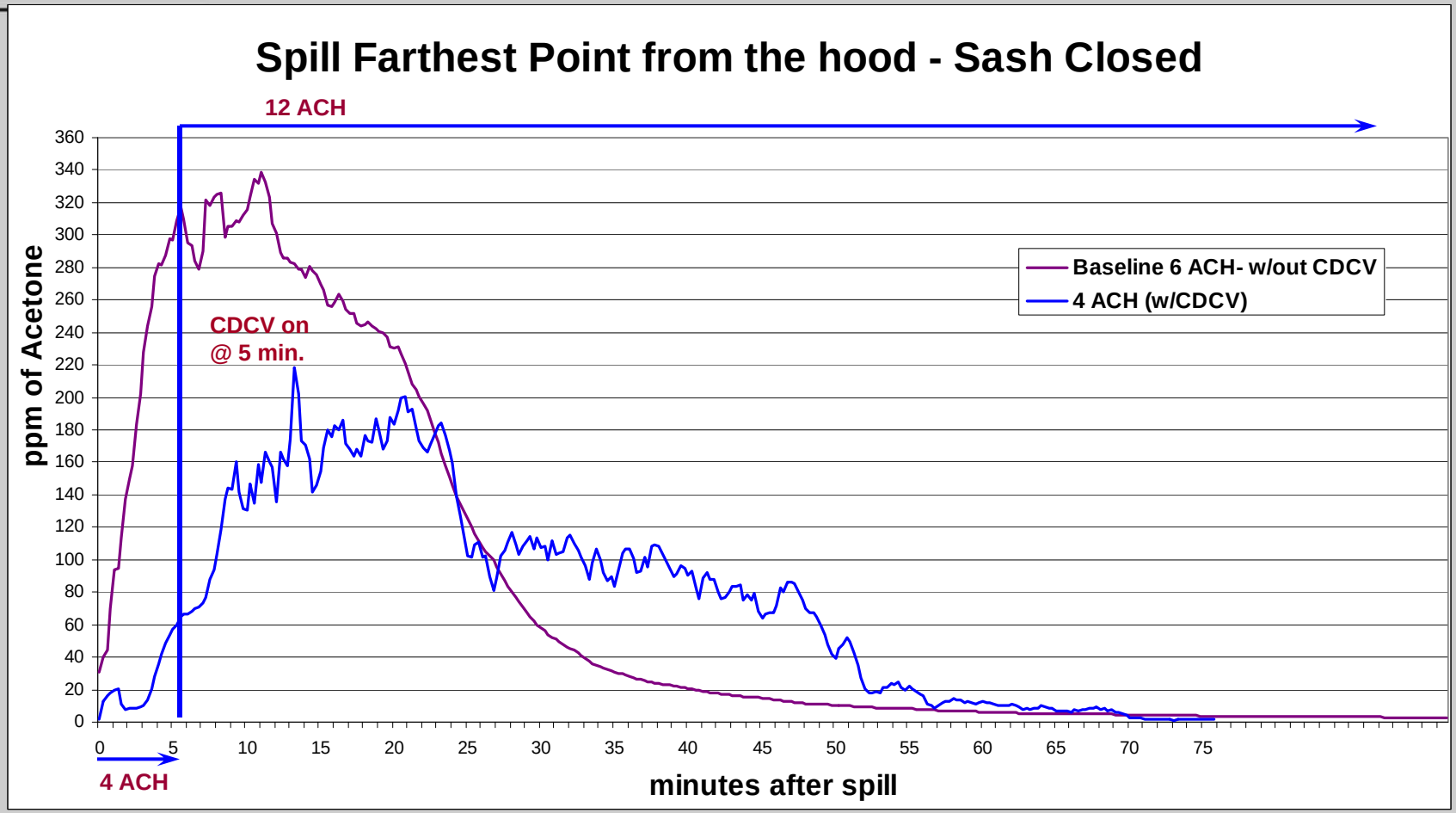
CDCV Testing at UC Irvine

Farthest point from the hood

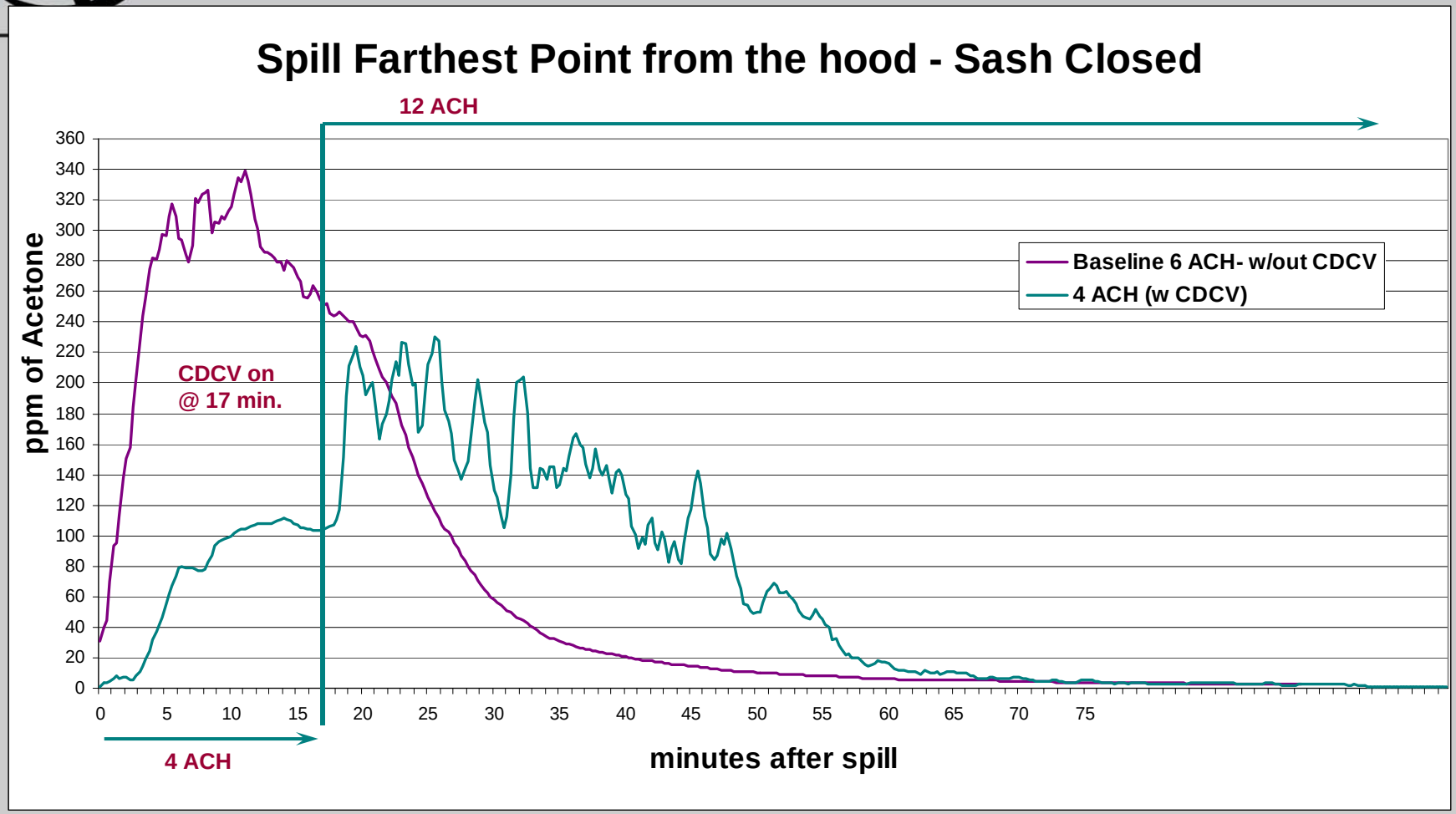
In front of the hood

Benchtop

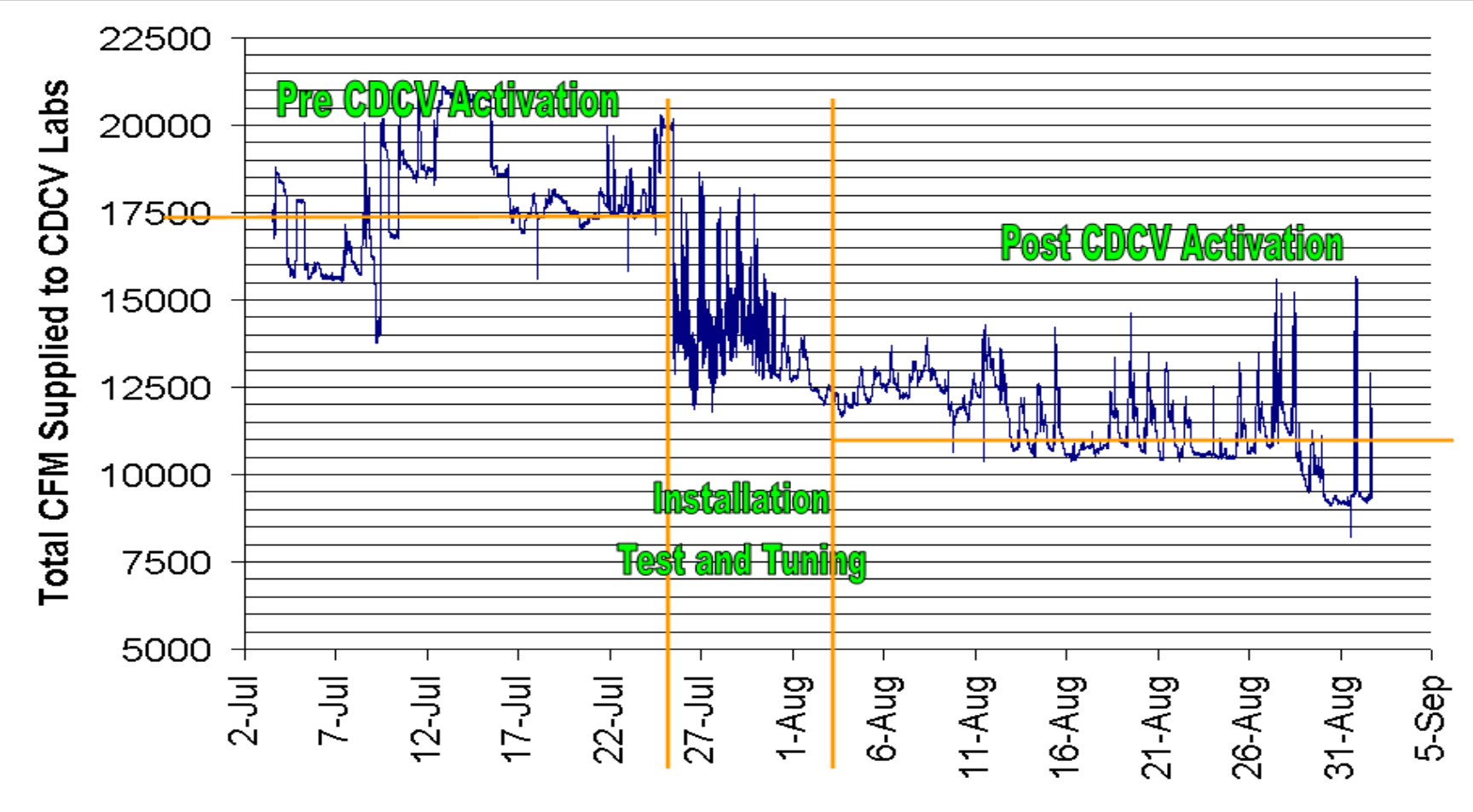
Air Contaminant Monitoring Results:



Air Contaminant Monitoring Results:

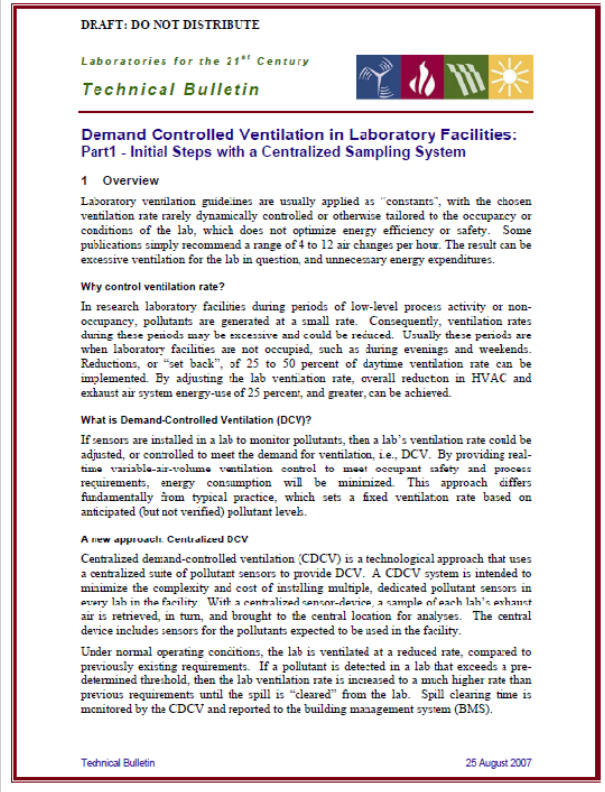


Croul Hall CFM / Air Change Rate



CDCV Conclusions:

- **Responsive to spills**
  - **Effective for sensing acetone levels**
- **Lowers peak concentration in open areas**
- **Polling time could result in delay in detecting spill**
- **No significant difference in clearance time**
- **Labs21 Tech Bulletin in development**



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Laboratories for the 21st Century

Technical Bulletin

Demand Controlled Ventilation in Laboratory Facilities: Part1 - Initial Steps with a Centralized Sampling System

1 Overview

Laboratory ventilation guidelines are usually applied as "constants", with the chosen ventilation rate rarely dynamically controlled or otherwise tailored to the occupancy or conditions of the lab, which does not optimize energy efficiency or safety. Some publications simply recommend a range of 4 to 12 air changes per hour. The result can be excessive ventilation for the lab in question, and unnecessary energy expenditures.

Why control ventilation rate?

In research laboratory facilities during periods of low-level process activity or non-occupancy, pollutants are generated at a small rate. Consequently, ventilation rates during these periods may be excessive and could be reduced. Usually these periods are when laboratory facilities are not occupied, such as during evenings and weekends. Reductions, or "set back", of 25 to 50 percent of daytime ventilation rate can be implemented. By adjusting the lab ventilation rate, overall reduction in HVAC and exhaust air system energy-use of 25 percent, and greater, can be achieved.

What is Demand-Controlled Ventilation (DCV)?

If sensors are installed in a lab to monitor pollutants, then a lab's ventilation rate could be adjusted, or controlled to meet the demand for ventilation, i.e., DCV. By providing real-time variable-air-volume ventilation control to meet occupant safety and process requirements, energy consumption will be minimized. This approach differs fundamentally from typical practice, which sets a fixed ventilation rate based on anticipated (but not verified) pollutant levels.

A new approach: Centralized DCV

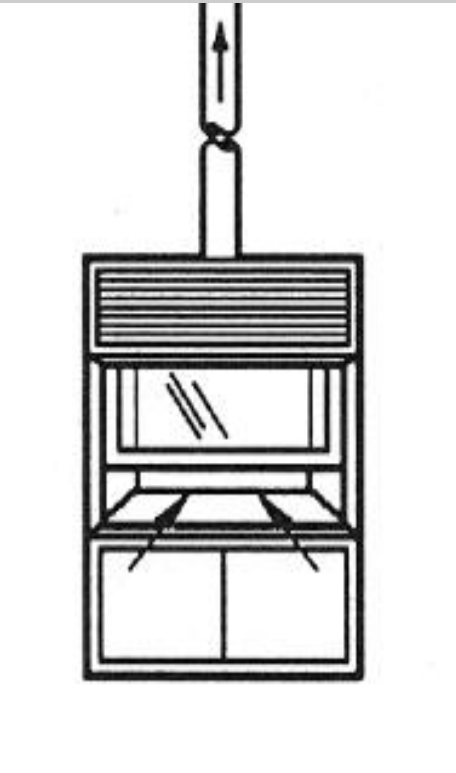
Centralized demand-controlled ventilation (CDCV) is a technological approach that uses a centralized suite of pollutant sensors to provide DCV. A CDCV system is intended to minimize the complexity and cost of installing multiple, dedicated pollutant sensors in every lab in the facility. With a centralized sensor-device, a sample of each lab's exhaust air is retrieved, in turn, and brought to the central location for analyses. The central device includes sensors for the pollutants expected to be used in the facility.

Under normal operating conditions, the lab is ventilated at a reduced rate, compared to previously existing requirements. If a pollutant is detected in a lab that exceeds a pre-determined threshold, then the lab ventilation rate is increased to a much higher rate than previous requirements until the spill is "cleared" from the lab. Spill clearing time is monitored by the CDCV and reported to the building management system (BMS).

Technical Bulletin 25 August 2007

#2 Tame the Hoods

Fume hood Energy Consumption



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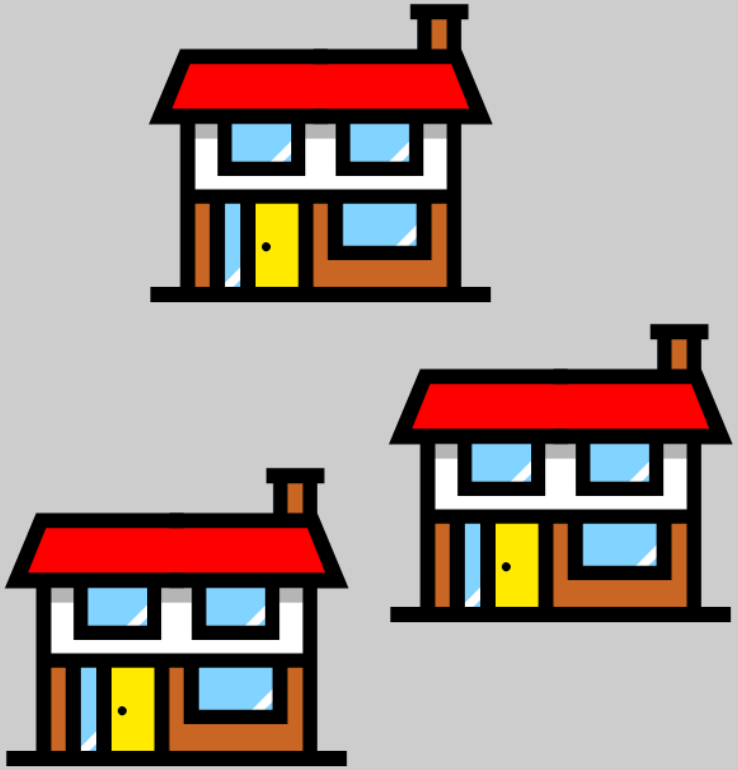
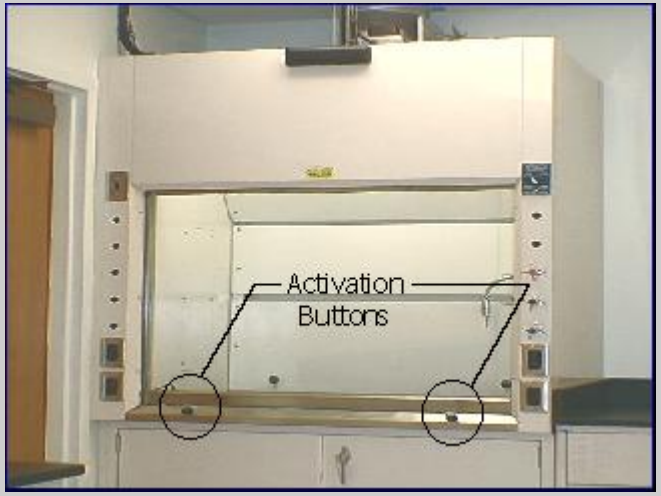


Tame the Hoods

1. Reduce the number and size of hoods
2. Restrict the sash opening
3. Use Two “speeds” occupied and un-occupied
4. Use variable air volume (VAV)
5. Consider high performance hoods
6. Say no to Auxiliary Air hoods
7. **Emerging tech: Auto sash closure**

Automatic Sash Closure System



The New-Tech Automatic Sash Positioning System

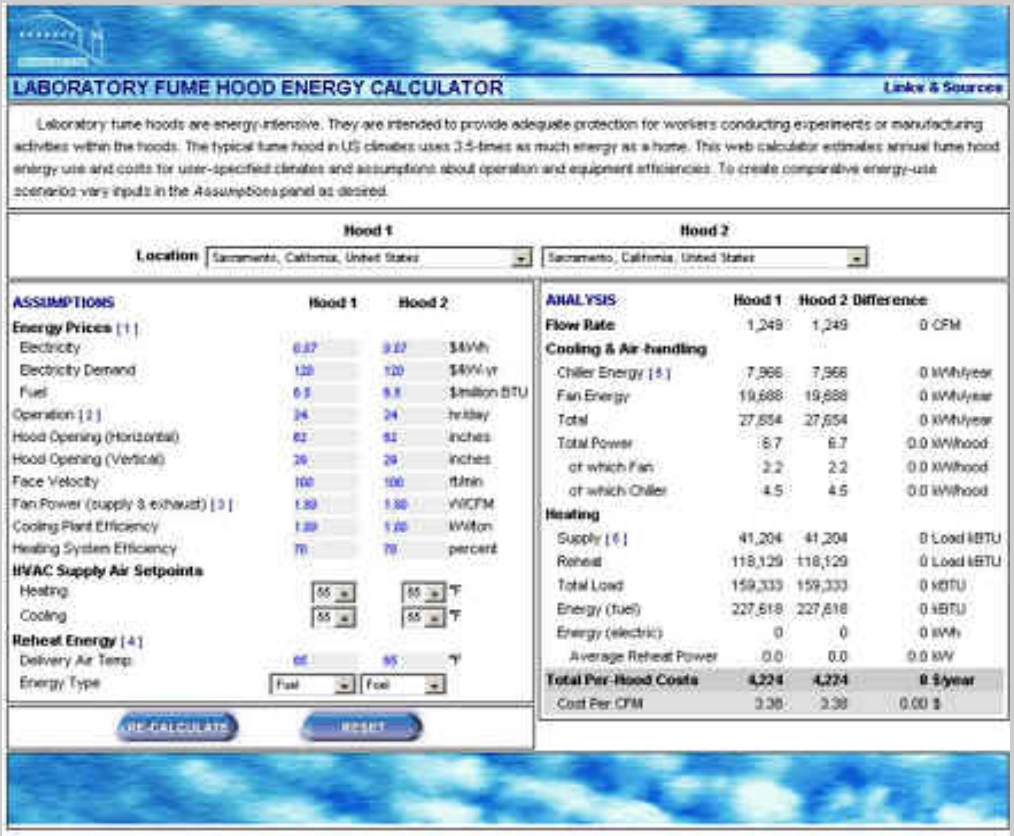
“Typical” savings per cfm

Configuration	Hood #1			Hood #2		
	Therms	KWh	$	Therms	KWh	$
Electric Cooled						
Commercial PG&E rates (.10/kWh, 1.30/therm)	**1.9**	**9.2**	**$3.44**	**2.0**	**13**	**3.90**

“Typical” annual savings per hood

Configuration	Hood #1 (6 ft. Hood)		Hood #2 (5 ft. Hood)	
	CFM	$	CFM	$
1. Base (“Typical”)	**533**	**$1834**	**293**	**$1143**
2. Hood driven load (all savings captured)	**533**	**$1834**	**433**	**$1689**
3. Remove sash stops and assume CAV (or open VAV) - most energy intensive scenario	**1333**	**$4586**	**866**	**$3377**

Fume hood savings calculator



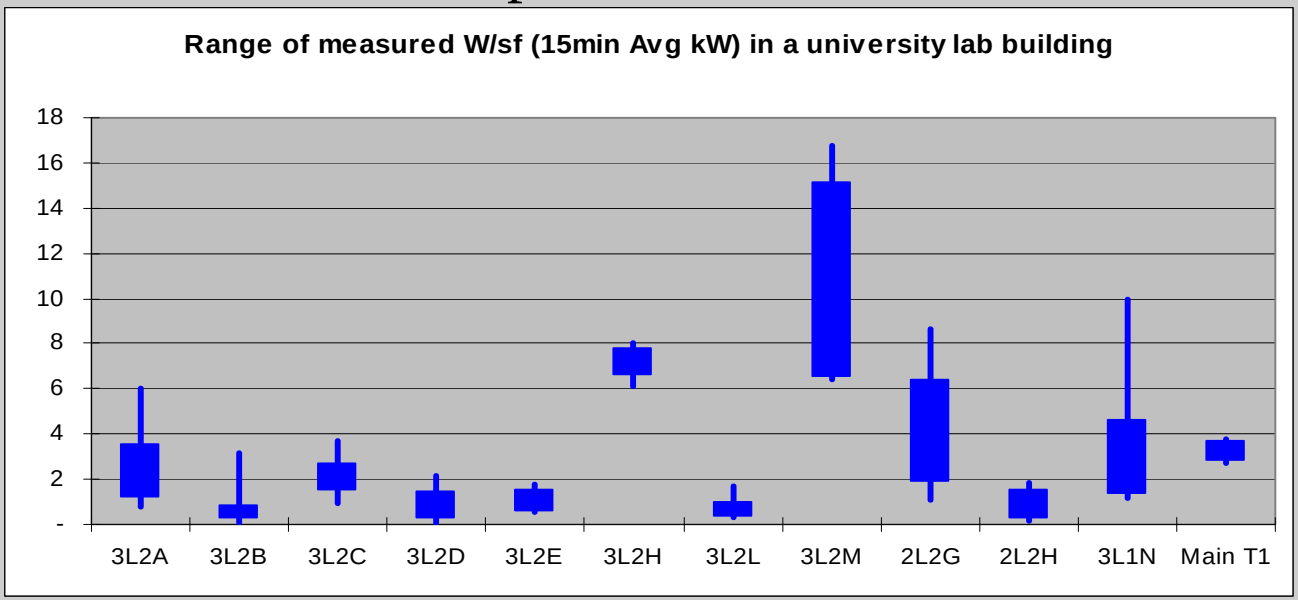
Calculator web site:

http://fumehoodcalculator.lbl.gov/

Use calculator to test energy and cost impacts of improving component efficiencies (e.g. fans or space conditioning equipment), modifying face velocities, and varying energy prices. Supply air set points can be varied, as can the type of reheat energy. Several hundred weather locations around the world are available. The calculator allows for an instantaneous comparison of two scenarios.

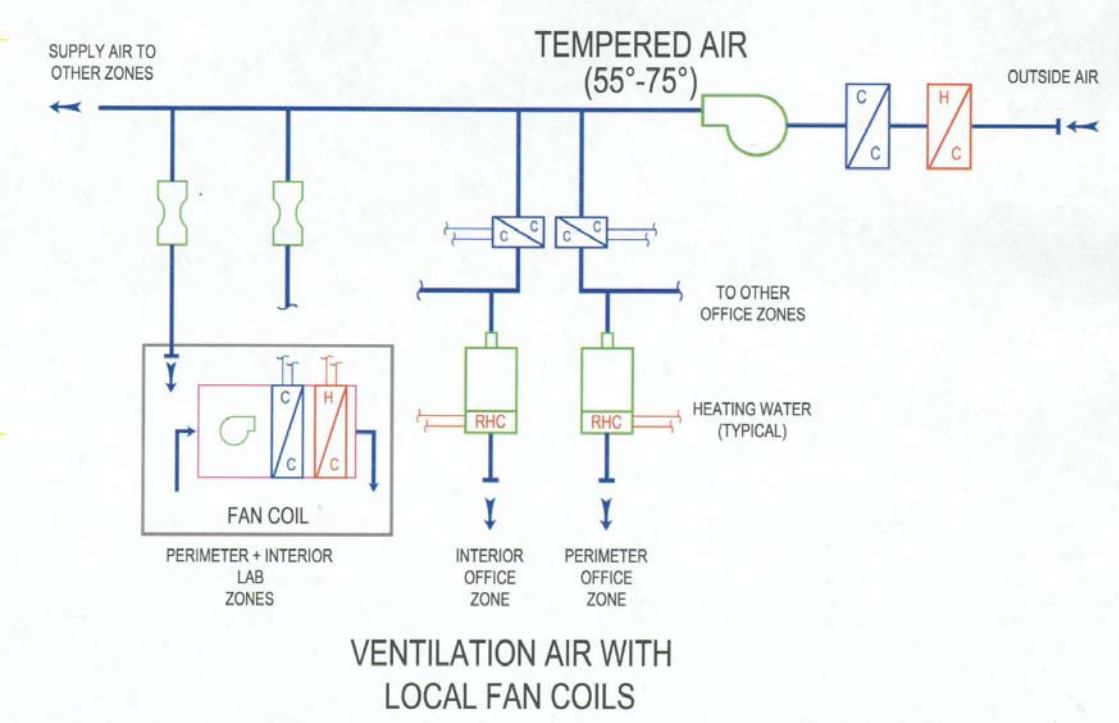
#3 Just Say No to Reheat

- Reheat (simultaneous heating and cooling) causes major energy use in labs
  - High-load areas require lower supply air temperature, so reheat occurs in other spaces

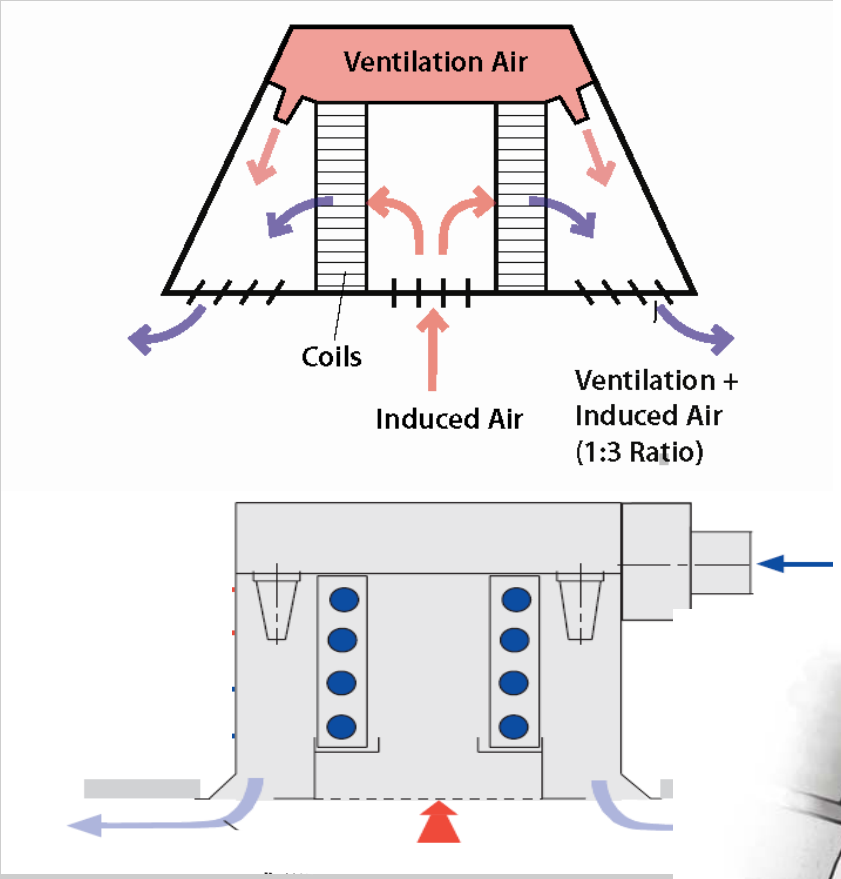


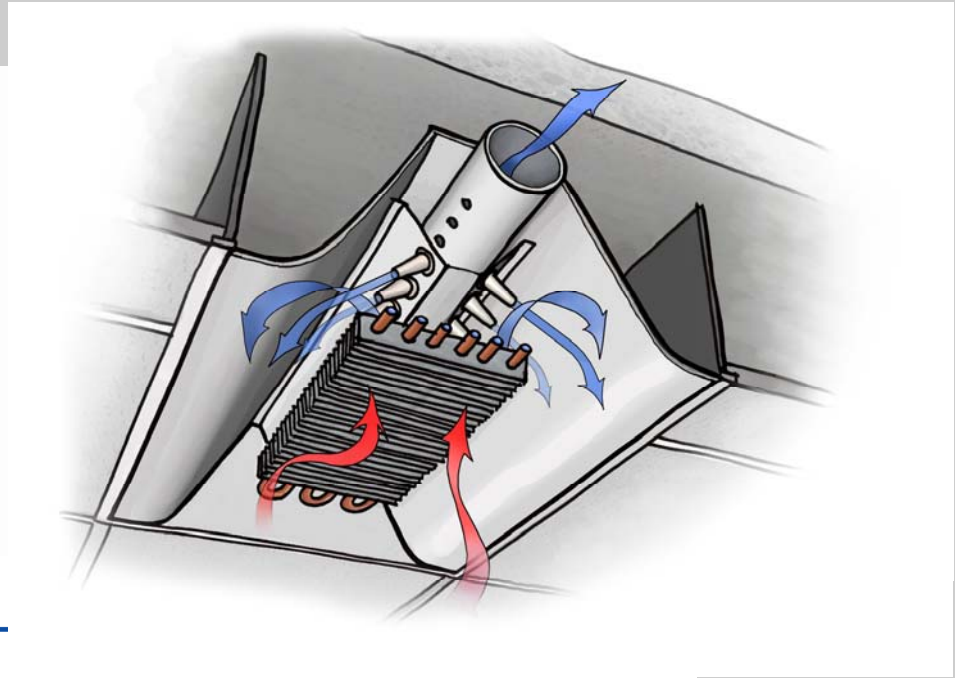
System Alternatives to Minimize Reheat

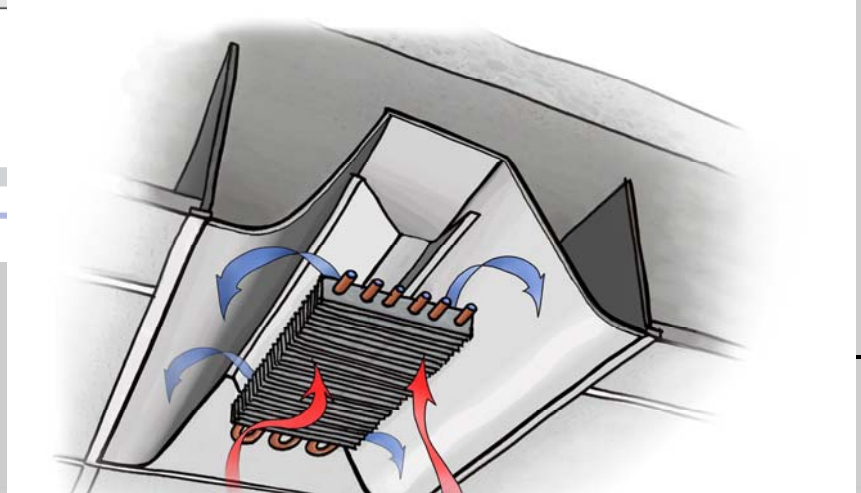
- Dual-duct systems
- Ventilation air with zone coils
- Ventilation air with fan coils
- Ventilation air with radiant cooling
- **Emerging Tech: Ventilation air with inductive cooling (Cool Beams)**



Inductive Cooling Units

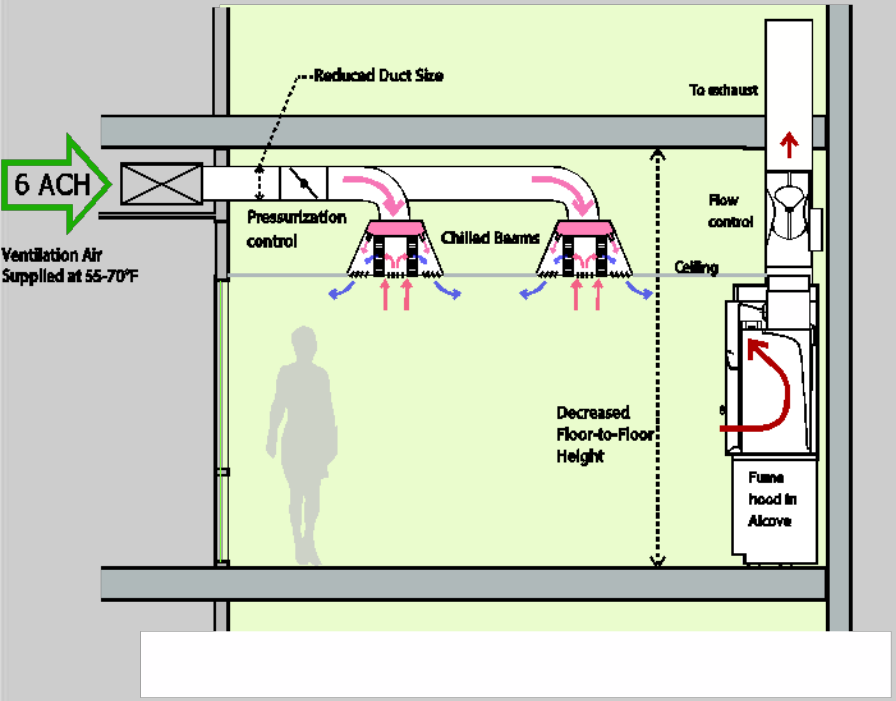




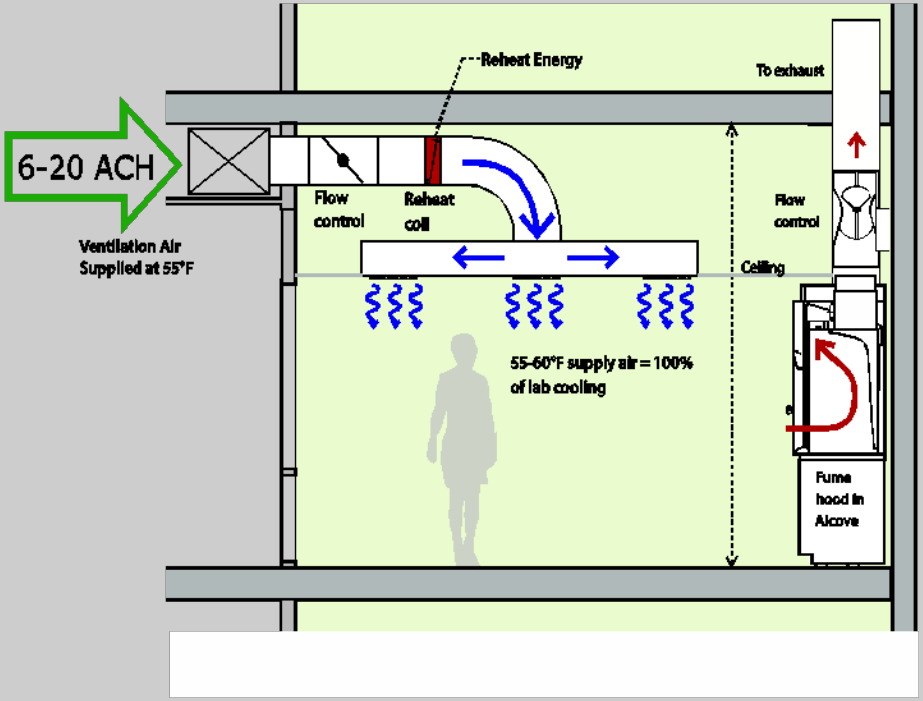


Chilled Beam vs. VAV Reheat

Chilled Beam System



VAV-Reheat System



Chilled Beams are Gaining in Popularity

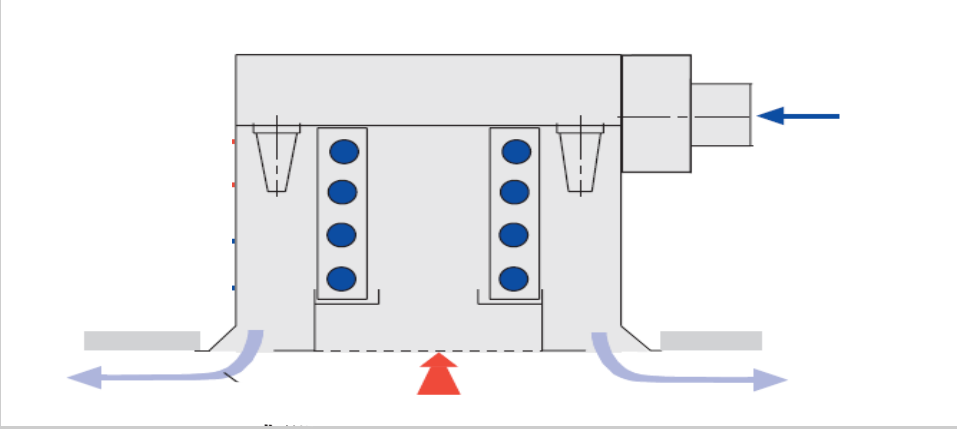
- Some notable projects with chilled beams
  - Tahoe Center for Environmental Sciences LEED Platinum
  - Vanderbuilt University
  - Energy and Environment Building, Stanford University
  - Cal Poly 175,000 sf Science Building
  - UC Davis VetMed3B & Health Services
  - UC Santa Cruz Biomed Building

Slide courtesy of Rumsey Engineers, Inc.

Inductive cooling applications

Concern about condensation

- Concern persists
- No documented cases of condensation
- Horizontal Coils versus Vertical Coils



Slide courtesy of Rumsey Engineers, Inc.

In Labs -

Chilled Beams work best when placed perpendicular to fume hood

Chilled Beam – Tahoe Center for Environmental Sciences.

Slide courtesy of Rumsey Engineers, Inc.

Best Energy Savings when use with Water Side Economizer or Free Cooling

Slide courtesy of Rumsey Engineers, Inc.

Lessons Learned

- Costs are high due to contractor inexperience
- Mounting details have an enormous impact on costs
- Energy savings hinge on using water side economizer
- So far, condensation is not an issue
- Significant savings are being realized on AHUs, ducting and exhaust fans
- Overall cost is typically slightly higher compared to conventional
  - Contractor experience and competition of suppliers should make chilled beams systems cost neutral soon

Slide courtesy of Rumsey Engineers, Inc.

Labs21 Best Practice Guide Available

Laboratories for the 21st Century: Best Practice Guide

Chilled Beams in Laboratories: Key Strategies to Ensure Effective Design, Construction, and Operation

Introduction

Laboratories commonly use far more energy than typical office buildings, primarily due to the intensive ventilation required to address environmental, health, and safety concerns. As a result, facility designers and engineers are constantly seeking new ways to reduce energy consumption while maintaining performance. Active chilled beam systems are gaining in popularity among laboratory designers because these systems allow ventilation requirements to be decoupled from sensible heating and cooling loads. This decoupling eliminates the need for reheat coils for temperature control and reduces the fan energy required to maintain comfort.

Chilled beam systems are prevalent in European commercial office buildings but have not yet been widely applied in the U.S. Such systems offer many compelling benefits, including high cooling capacities, excellent performance, and dramatic energy savings for little or no additional costs over conventional systems

The guide presents best practice strategies for designing, constructing, operating, and maintaining chilled beam systems in laboratories and is divided into the following sections:

- **Overview** describes how such beams work and their benefits in a laboratory setting, and presents three case studies.
- **Designing Chilled Beam Systems** discusses sizing a system, the controls and integration required, and the challenges of modeling such systems.
- **Construction** examines system costs, how to hang chilled beams, and code compliance.
- **Commissioning, Operations, and Maintenance** summarizes how to commission, operate, and maintain chilled beam systems.
- **Appendix A** contains a case study of the chilled beam system installed at the Tahoe Center for Environmental Sciences laboratory, which is also a Labs21 partner project.

This guide is one in a series created by the Laboratories for the 21st Century (Labs21) program, a joint program of the U.S. Environmental Protection Agency and U.S. Department of Energy (DOE). Geared towards architects, engineers, and facilities managers, these guides provide information about technologies and practices to use in designing, constructing, and operating safe, sustainable, high-performance laboratories.

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Main Labs21 web site:

http://www.labs21century.gov

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