ASHRAE – CHICAGO 2006

Demand Side Ventilation Control For Green Laboratory Buildings

THE CHALLENGE – Demand Ventilation In Labs

Why we have not done this to date:

- Safety of Occupants Primary
- Belief in High Air Changes /Hour (ACH) as a Dilution Strategy for Poor Lab Practices
- Limited Confidence in Distributed Sensing Capability & Calibration

Trends in Laboratories

- Fume hood densities are much lower
  - More computation & lessened chemical quantities
  - Increased amount of life sciences labs
- Thermal loads have peaked & are dropping
  - Plug loads down from energy efficient equip.
  - Higher efficiency lighting & more day lighting
- Energy costs are soaring >>> LEED labs
- VAV Fume Hood Control has gained wide acceptance

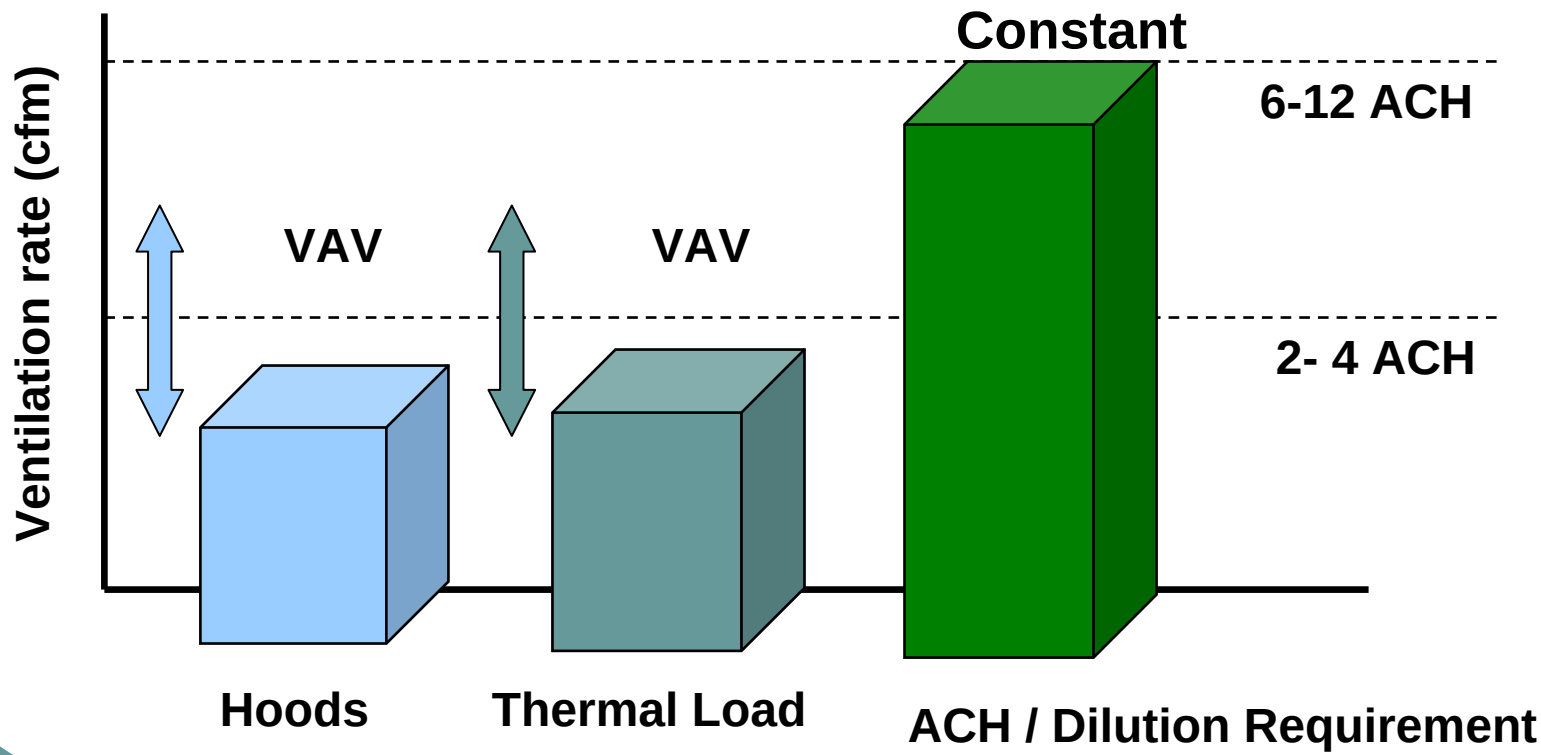
Yet Requirements Stay The Same

- Minimum air changes still fixed at 6 to 12 ACH
- Need still exists for dilution ventilation in labs
  - Dilute vapors from a spill when lab is unoccupied
  - Dilute vapors & gases caused by poor lab practices
    - Working outside the hood
    - Improper storage of chemicals
    - No localized exhaust for instruments
    - “Overworking” & overcrowding of hoods
- Dilution: a backup to containment
  - 3 to 10X reduction vs. $1000^{+}X$

Fortunately, for most labs, room air is often “clean”

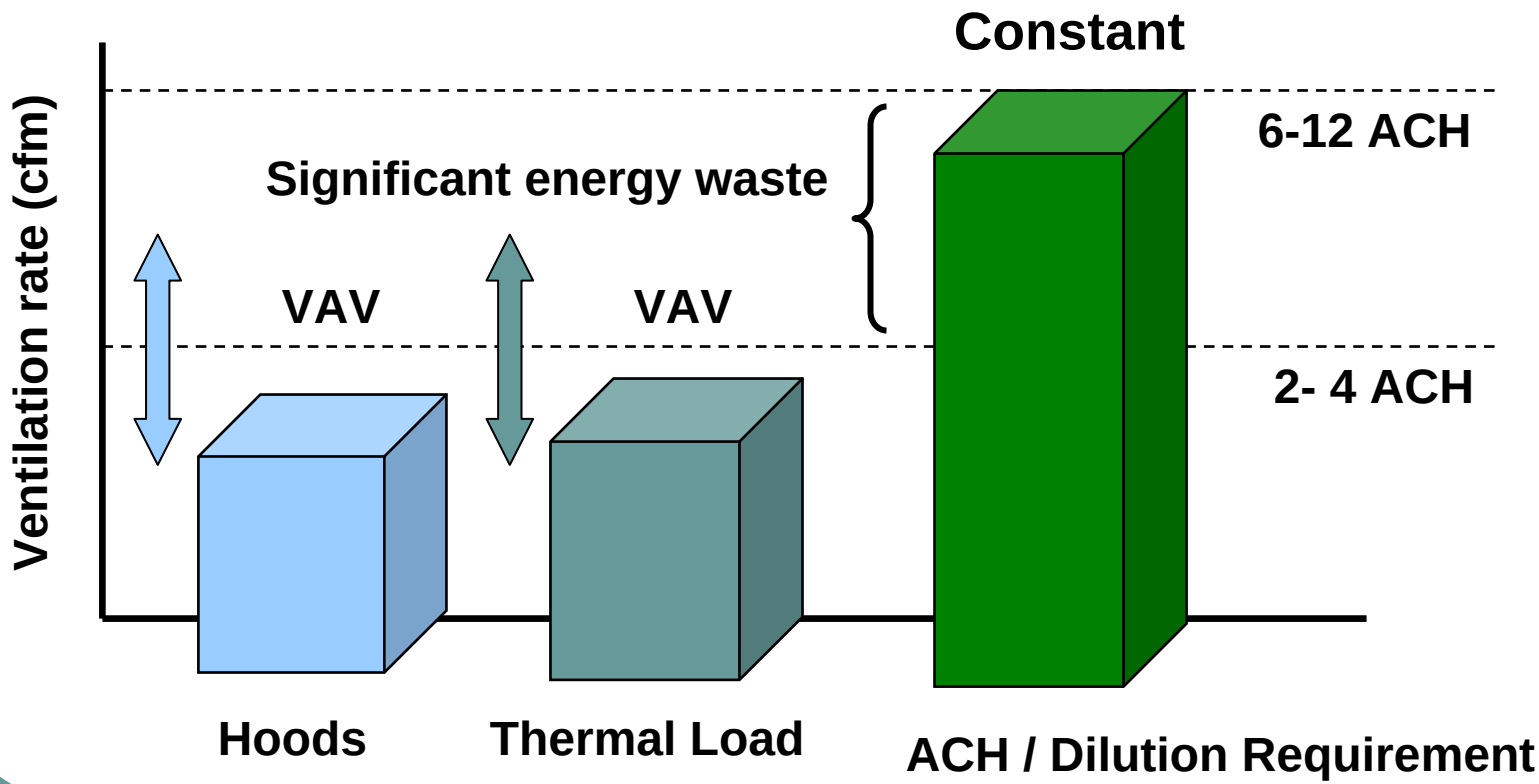
Current Drivers of Lab Airflow

- Hood & thermal airflows are reduced & vary for peaks
- Due to higher “dilution” req. it is typically the driver



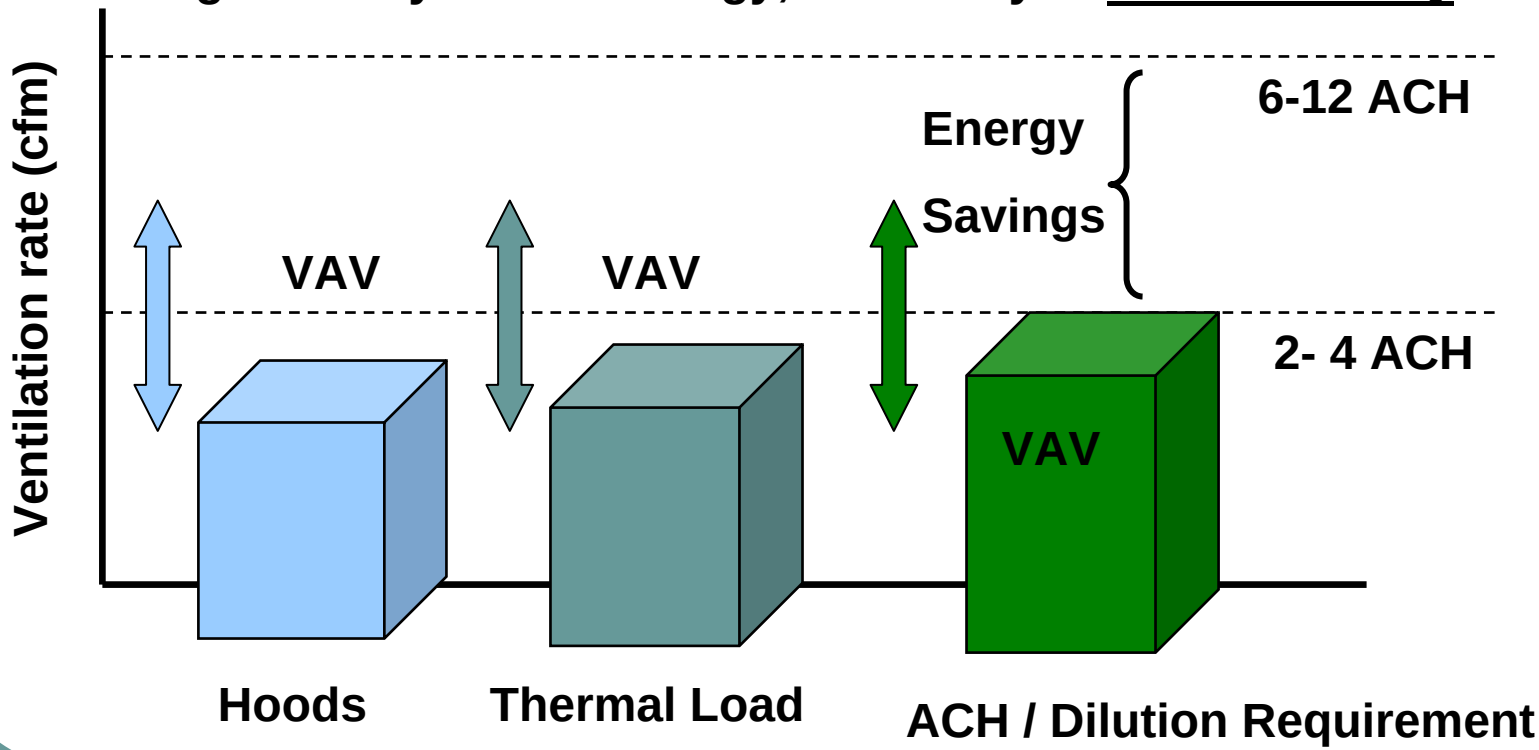
Problem: Dilution Wastes Energy

- Base ACH's increases avg. & peak airflows
  - Impacts fan energy, reheat, & outside air heating & cooling



Solution: Vary Dilution to Save Energy

- **Lab DCV: Next generation lab airflow control concept:**
  - **Apply VAV control, not to 1 or 2, but all 3 lab air requirements**
  - **Significantly reduce energy, find a way to <u>increase safety</u>**

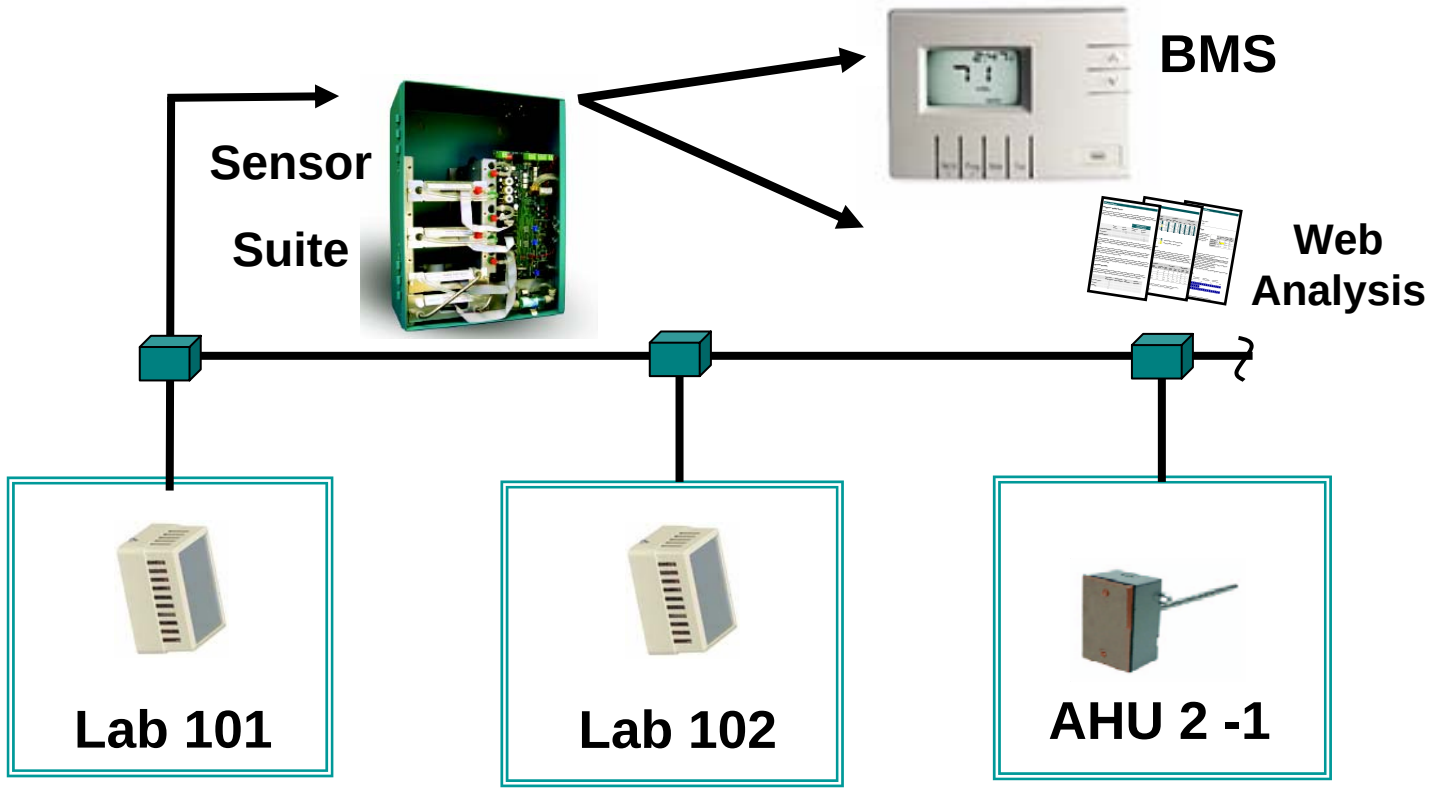


Lab Demand Controlled Ventilation (DCV)

- Varies dilution / min ACH's by sensing lab IEQ
  - If lab air is clean, dilution airflow can be reduced
  - Yet greater lab dilution is provided when needed by sensing or manual over ride
- Most lab controls can vary min ACH levels
- Critical piece: Sensing of IEQ parameters:
  - Lab TVOC's, particles, Air PH, RH, CO, & CO2
- Barriers to date: Cost & practicality
  - Sensor cost
  - Long term reliability
  - Calibration of Distributed Sensors

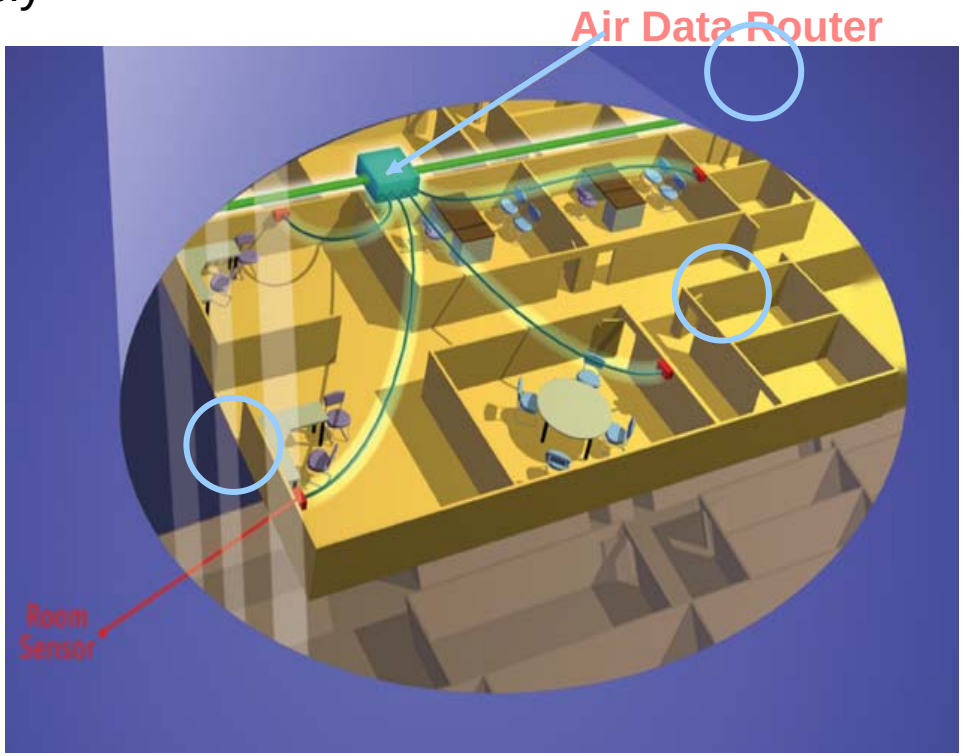
A New Approach to Sensing Lab Air:
Multiplexed Air Packets – Central Sensor Suite

- Route multiplexed air samples to central sensor suite
  - Integrated into BMS & lab controls for monitoring & control
  - Includes web based expert system analysis



Multiplexed Facility Monitoring Components

- A *Room or Duct Sensor* collects local lab air packet sample, routing it to a sensor suite for central air packet evaluation, dynamically and continuously



Lab Quality Sensed Parameters

- Air Cleanliness
  - Total Volatile Organic Compounds – PID
  - Air Acidity (PH)
  - Particles – laser based particle counter
  - Carbon Monoxide (CO)
- Lab Specific
  - Ammonia
  - Differential Static pressure
  - Formaldehyde
  - Chemical & Biological agents
- Comfort &Ventilation
  - Temperature
  - Humidity – Chilled Mirror Hygrometer
  - Carbon Dioxide (CO2)

Central Sensor Suite Benefits

- Better Sensing:
  - Extremely high relative accuracy
    - Same sensor checks many locations
  - Drastically reduced calibration costs
    - Calibrate one higher quality sensor vs. many low cost sensors
  - Very Cost Effective
    - Cost of measuring parameters amortized over many locations
      - A $2,500 particle counter sensor used at 25 areas: $100/location
- Better Knowledge of Actual lab conditions:
  - Expert system can process vast amounts of data
  - Real time analysis reports: Third party & independent

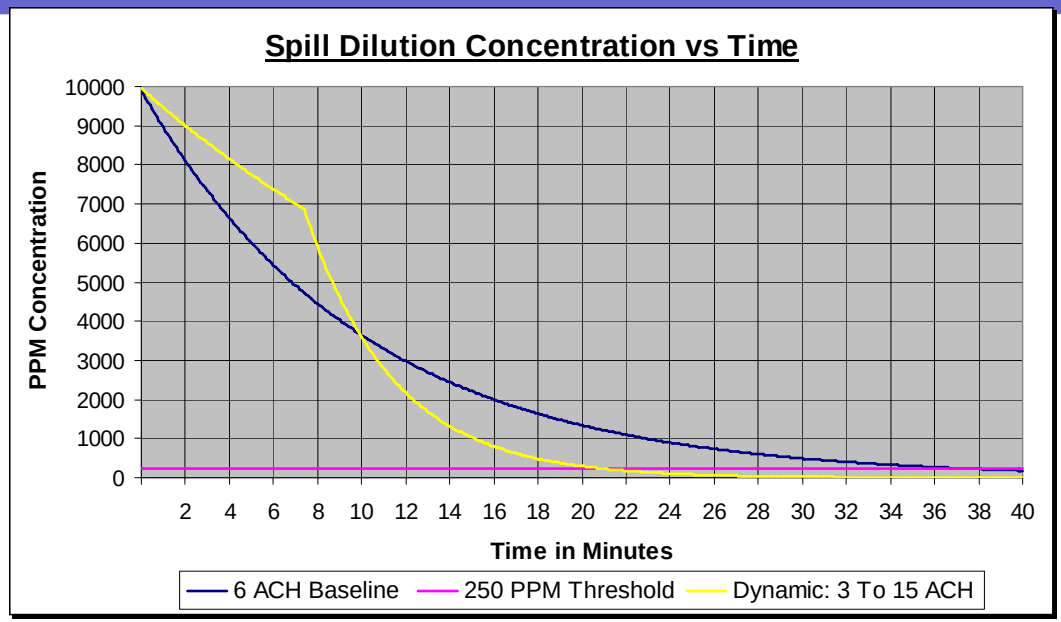
LAB IEQ Monitoring Increases Lab Safety

- Validates the safe operation of a lab
  - Detect improper bench use of chemicals
  - Detect poorly containing fume hoods
  - Spills, fires, & rogue reactions rapidly sensed
  - Check lab pressurization, T & RH
- Allows for safer lab airflow control
  - Increased hood capture from reduced drafts
    - Drops room flows when dilution not needed
  - Greater dilution provided for spills, leaks, etc.
    - 12 to 15 ACH's can be provided automatically
- Sources of leaks & emissions can be found
  - With fact based data, source controls can be used

Actual Lab IEQ Case Study

- Major University laboratory facility
- 15 laboratories monitored continuously for 10 mo.
- Ventilation rate set to 12 ACH per university IH group
- Result
  - Two recorded “incidents” of elevated TVOC levels in several laboratories totaling 4-5 hours (0.07% of total hours)
  - 99.93% of the time, these labs could have been operated at lower airflow rates
- Cause
  - Workers using fume hoods during scheduled hood maintenance periods
- Solution
  - Better internal communication between maintenance and occupants – No further incidents

Safety Impact of Dynamic Control of Dilution



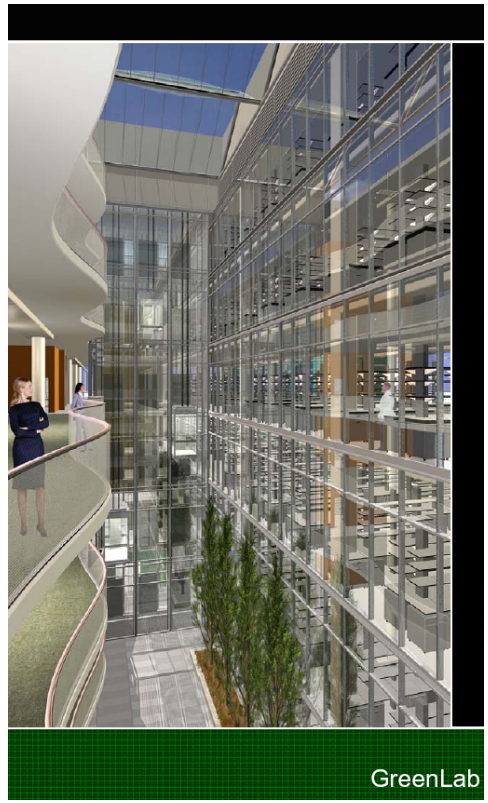
- 1.5 L spill of acetone in 200 sq ft lab room: 10,000 PPM
- Dynamic control reaches 1/3rd TLV (250 PPM) in 21 vs. 36 min
- After 1 hour Dynamic control has dropped level to 14 PPB
  - After 1 hour, 6 ACH system is at 25 PPM or 1785 times higher

Dynamic Dilution Ventilation Control (Lab DLV)

- There is no need to dilute clean air w/ clean air
  - PID, Acid gas sensor, particle counter, etc sense air
    - Hundreds of compounds are detected below TLV threshold
    - Small number of compounds that are not are fairly dangerous
      - These materials most likely should not be used in a fume hood
    - Additional specialty gas sensors can also be used if desired
- Set min dilution levels per OSHA or as desired
  - For high concern: 4 ACH occupied & 2 ACH unocc.
    - OSHA guidelines have a minimum at 4 ACH (range of 4 to 12)
  - For less severe applications, use 2 ACH as minimum
    - ASHRAE fresh air min for science lab is .18 cfm/sq ft or 1.2 ACH
    - Appropriate for life sciences & less critical lab and support areas
- Set max dilution level at 12 to 16 ACH for safest purge

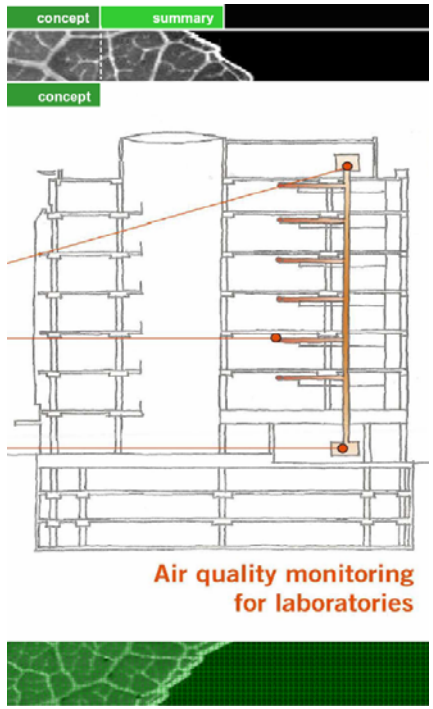
Lab DCV Case Study: GreenLab - Seattle

- Project Facts:
  - 215,000 sq ft mixed use building
    - 75,000 sq. ft lab area
    - 75,000 sq. ft. office
    - 25,000 sq. ft optional vivarium
    - Virtual Project
  - Project team:
    - Owner –
    - Architect –
    - Mechanical Eng.-
    - Contractor-
  - **<u>Design based on Lab DCV</u>**



Lab DCV Case Study: GreenLab - Seattle

- Lab DCV analysis assumptions:
  - Lab area: 4 to 16 ACH vs. a fixed 9 ACH
  - Vivarium: 8 to 16 ACH vs. a fixed 15 ACH
- Gross first cost savings: $1,025,000
  - Net savings after system cost: $650,000
  - $13.68/sq. ft gross or $8.68/sq. ft net for lab
- Total bldg energy cut by $250,000/yr.
  - Reduced total bldg's utility bill by 20%
  - ROI: 1.5 yr energy payback



"Single greatest energy savings measure of the project"

Multiplexed Facility Monitoring Summary

- A building wide sensing infrastructure
- Cost effectively implements Lab DCV
- For new or existing facilities
- Key Benefits:
  - Greater lab safety
  - Reduced lab first costs
  - Increased energy efficiency

Laboratory airflow can now be controlled by the single most important parameter: Lab Environmental Quality