

# Energy and Indoor Air Quality (IAQ) in Schools

NARUC Winter Meetings

Energy Resources & the Environment Committee

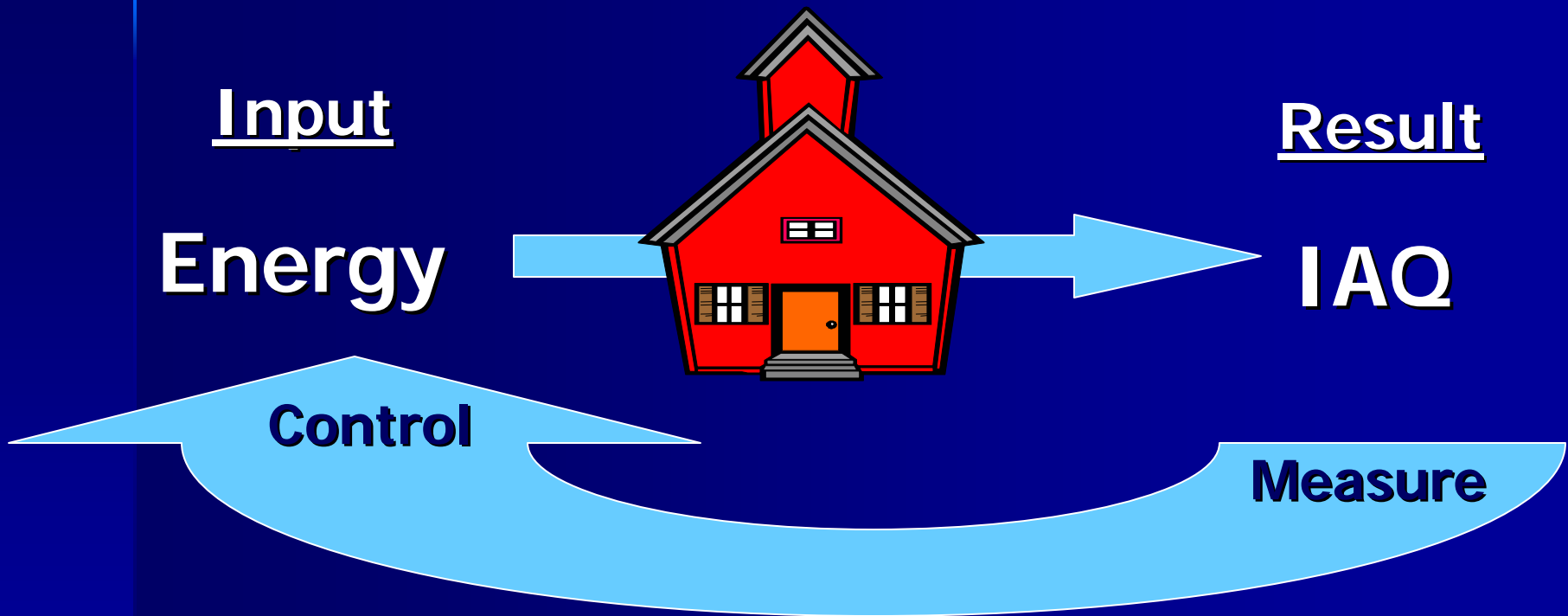
Washington, DC

February 15, 2005

*Schulte Associates LLC*

*Altec Energy Systems, Inc.*

# Energy and Indoor Air Quality (IAQ)



*You cannot manage  
what you do not measure*

# A Different Perspective

## Outdoor Environment

*More energy  
production is*  
**BAD**

## Indoor Environment

*More energy  
use can be*  
**GOOD**

# IAQ Monitoring Focus

Annual  
\$ per  
Square  
Foot

Energy  
**\$2**

Total  
Investment  
in  
Student  
Education  
**\$45\***

\*National average @ 200 sq ft per student

A map of the United States with 27 states highlighted in light blue. The highlighted states are: Alaska, Washington, Oregon, California, Nevada, Idaho, Utah, Arizona, New Mexico, Texas, Oklahoma, Kansas, Nebraska, South Dakota, North Dakota, Minnesota, Iowa, Missouri, Arkansas, Louisiana, Mississippi, Alabama, Georgia, Florida, South Carolina, North Carolina, Virginia, West Virginia, Maryland, Delaware, Pennsylvania, New Jersey, New York, Connecticut, Rhode Island, Massachusetts, Vermont, New Hampshire, and Maine. A blue banner with white text is overlaid on the map.

*27 states are now considering IAQ legislation  
for schools and public buildings*

# Overview

- IAQ and energy projects
- IAQ results
- Energy conservation results
- Lessons learned

# Two Programs in MN Schools

- SAMPLE<sup>2</sup> – Schools Air Monitoring Project for Learning and Energy Efficiency
- LCMR – Legislative Commission on MN Resources

***Now continuously monitoring IAQ in more than 110 Minnesota K-12 classrooms***

# Our Project Team

- IAQ Experts
  - Sebesta Blomberg & Associates
  - Grimsrud & Associates
- Energy Experts
  - ALTEC Energy Systems
- IAQ Monitoring Services
  - PureChoice, Inc.
- Project Developer and Manager
  - Schulte Associates LLC

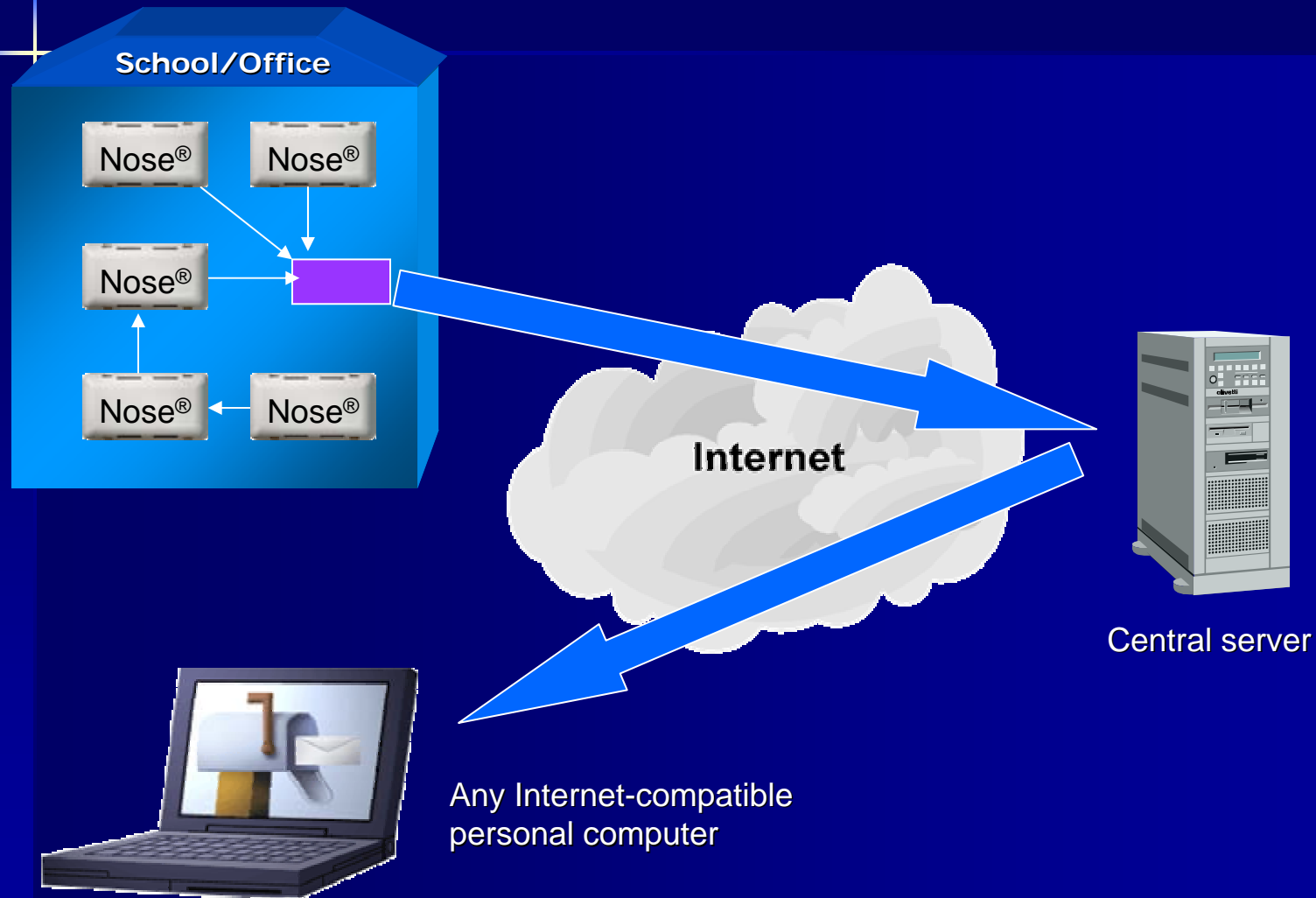


# IAQ Monitoring: Old Way



- Handheld Instrument
- “Snapshot” Measurements

# Continuous Indoor Air Monitoring



# Parameters Monitored

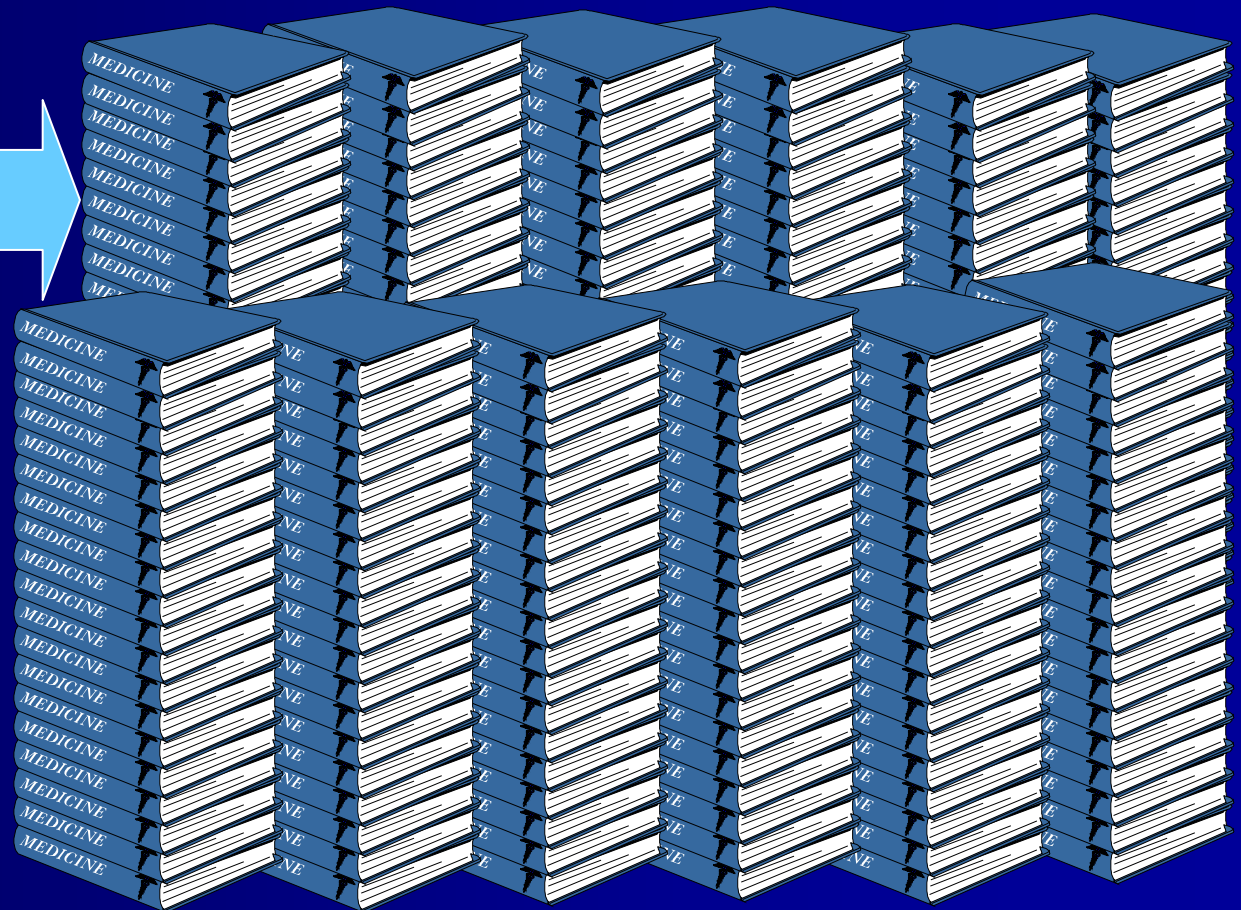
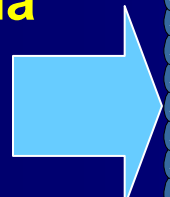
- Temperature
- Relative humidity (RH)
- Carbon dioxide (CO<sub>2</sub>)
- Carbon monoxide (CO)
- Odors and gases (TVOCs)



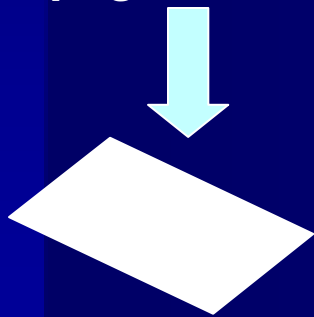
# Expanding our Understanding

## An analogy for one classroom

In one month, we collect **12 encyclopedia sets of IAQ data**



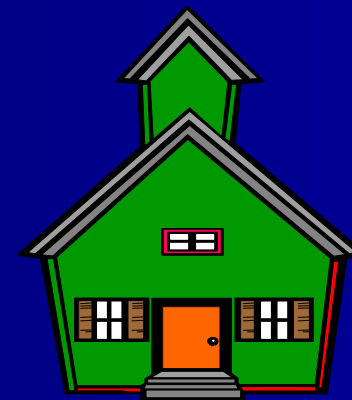
*If a snapshot reading of five IAQ parameters with a handheld instrument is one “page” of data*



# SAMPLE<sup>2</sup>

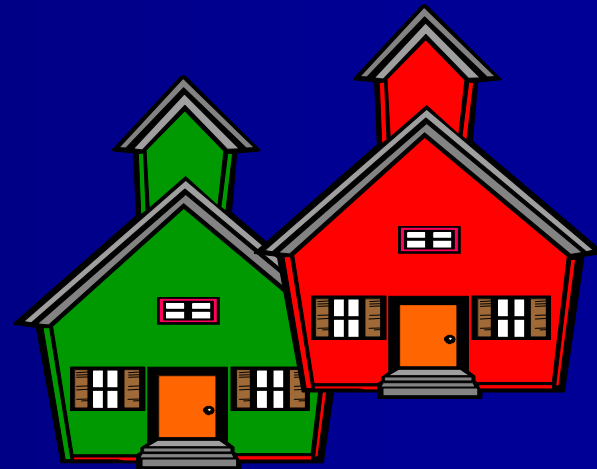


- Three K-12 Schools
- Eight or more Noses<sup>®</sup> per school
- Sponsored by Minnesota Power
- One-year study
  - Started November 2002
  - Completed March 2004
- Targets:
  - Energy conservation (primary)
  - IAQ Improvement (secondary)

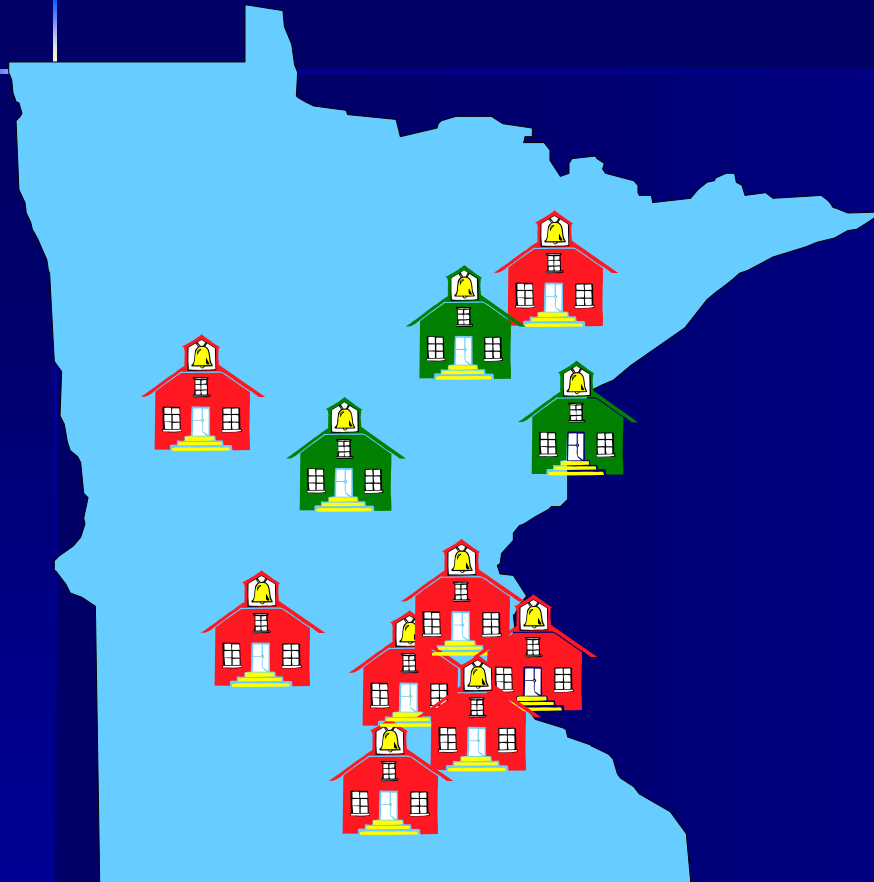


# LCMR – Legislative Commission on Minnesota Resources Program

- 8 Minnesota K-12 Schools
- Eight or more Noses<sup>®</sup> per school (85 rooms)
- Funded by MN legislature
  - MN Environmental and Natural Resources Trust Fund
- One-year study
  - Started September 2003
  - Completion December 2004
- Targets:
  - IAQ Improvement (primary)
  - Energy conservation (secondary)



# 11 Participating Schools



- Chisholm Senior High School
- Countryside Elementary (Edina)
- Duluth Senior High School
- Fergus Falls Middle School
- Hibbing High Schools
- Highland Catholic School (St. Paul)
- Lindbergh Elementary (Little Falls)
- Mankato East High School
- Orchard Lake Elementary (Lakeville)
- Renville County West High School
- St. Anthony Village Middle/High School

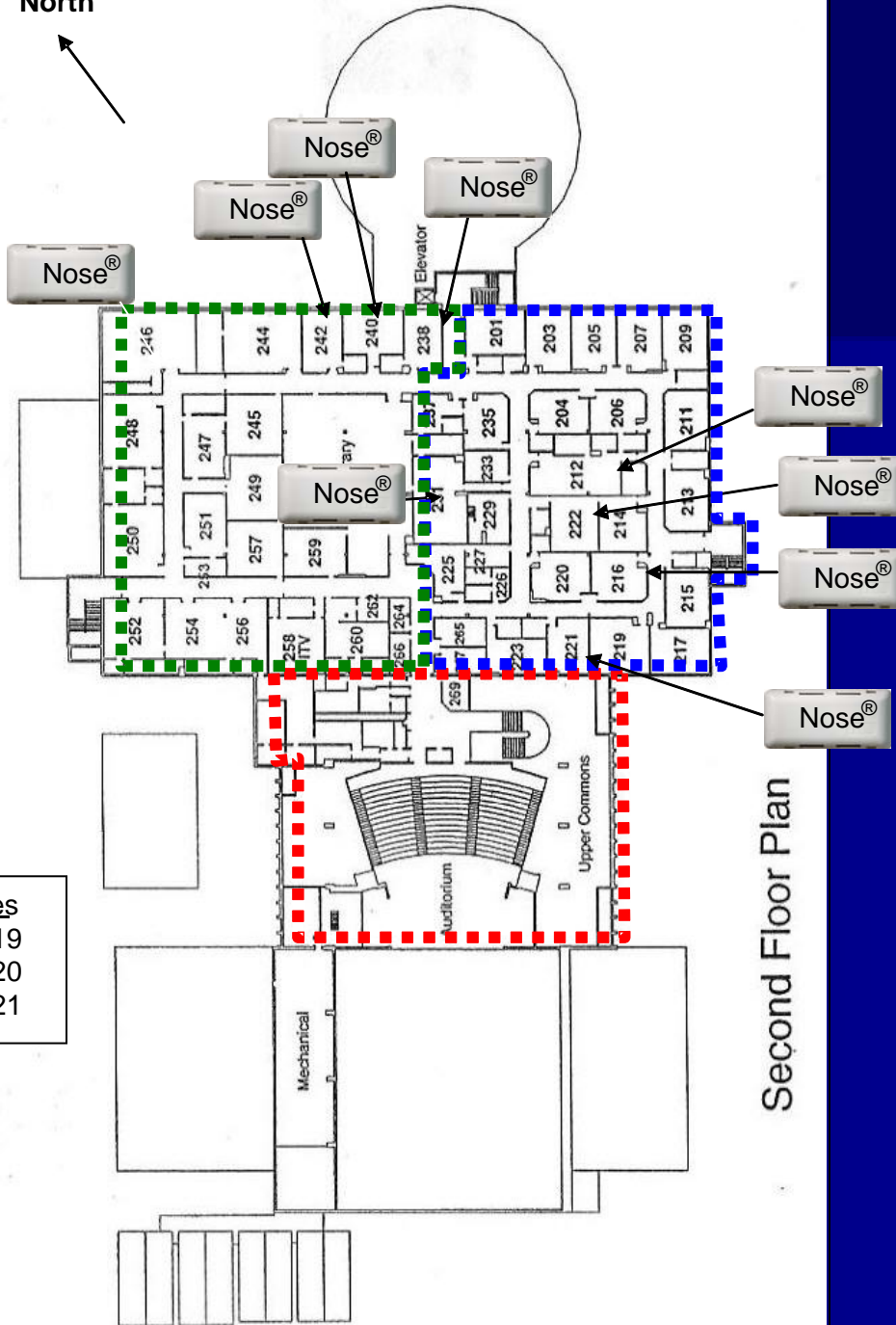


= SAMPLE<sup>2</sup> School



= LCMR School

North



HVAC Zones	
Green	Zone #19
Blue	Zone #20
Red	Zone #21

Second Floor Plan

# Typical Monitoring Layout

Location of Noses<sup>®</sup> at Duluth Central High School

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# ASHRAE Standard 62: Two Approaches to Ventilation

## Traditional Design Approach

**15 CFM**  
*of fresh outside air*  
*per occupant,*  
*or more\**

## Operational Approach

**1,000 ppm**  
*of carbon dioxide (CO<sub>2</sub>),*  
*or less\**

\*Subject to presence of non-occupant sources of air contaminants.  
(Standard 62 Addendum N)

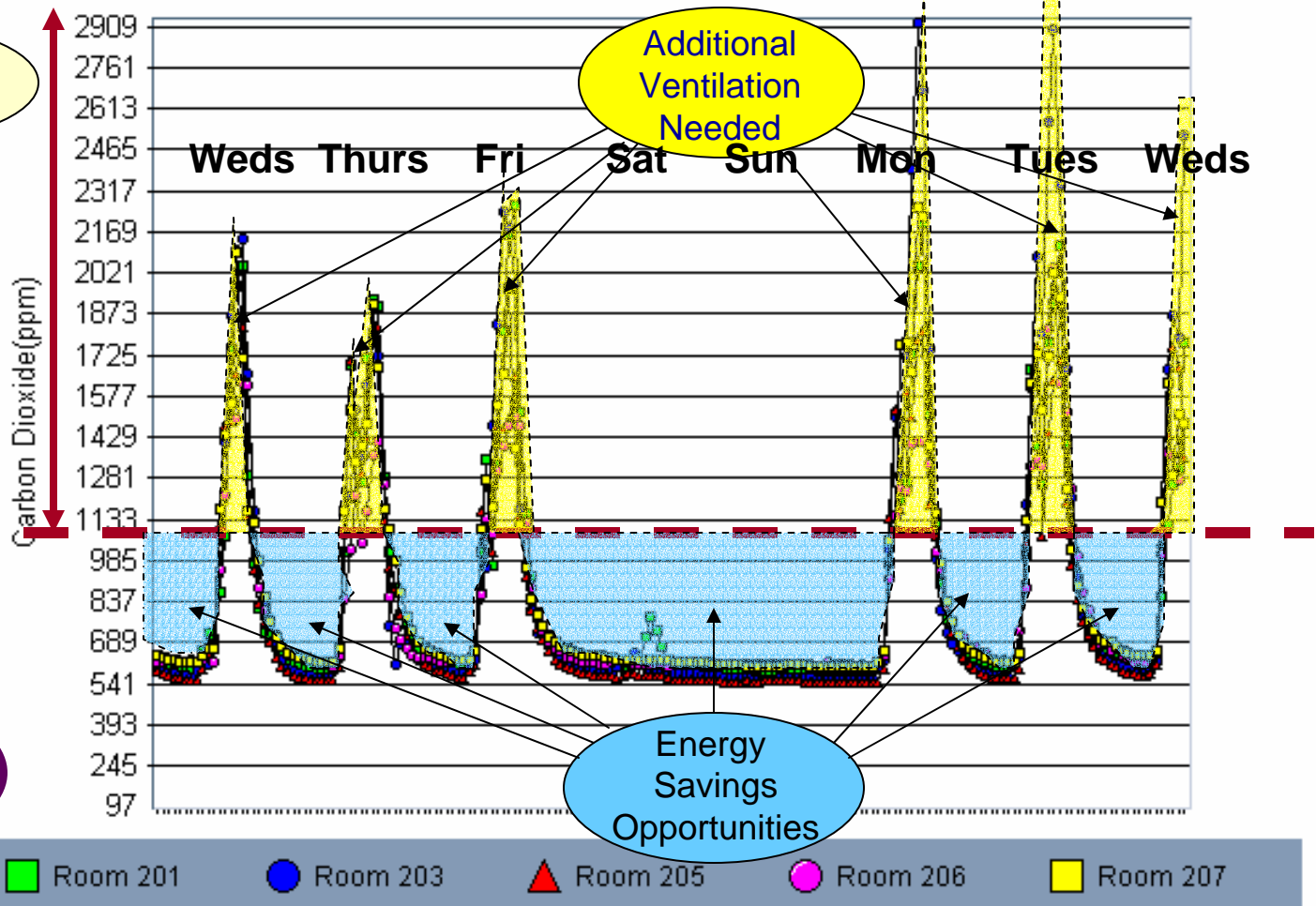
# Ventilation Assessment

Real Elementary - Week Carbon Dioxide (2/27/02-3/6/02)

High CO<sub>2</sub> Zone

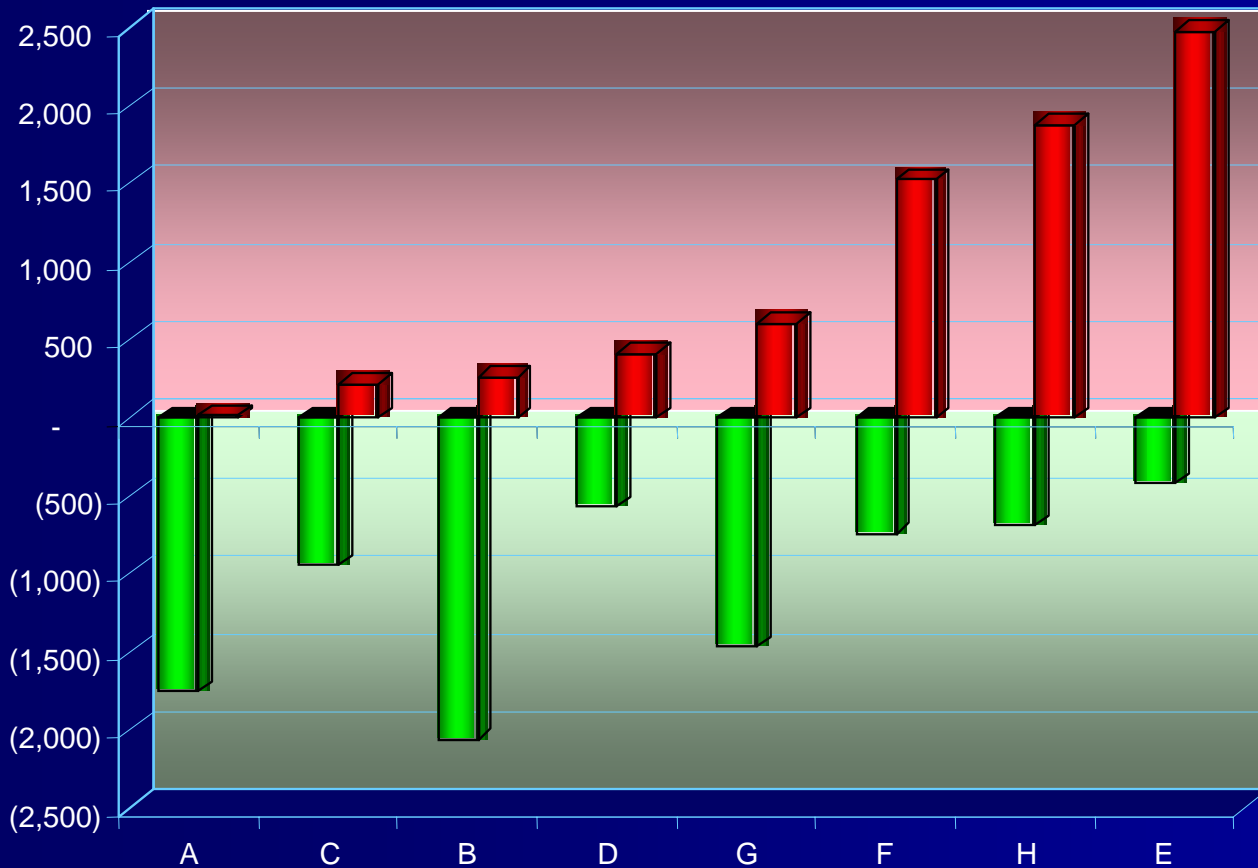
ASHRAE  
Ventilation  
Standard 62

Carbon Dioxide  
Example



# Certifying Ventilation Adequacy in Real Time

ppm-hours of Carbon Dioxide (CO2)



**Poor**  
(more energy needed)

**Adequate**

**Excellent**  
(energy savings opportunity)

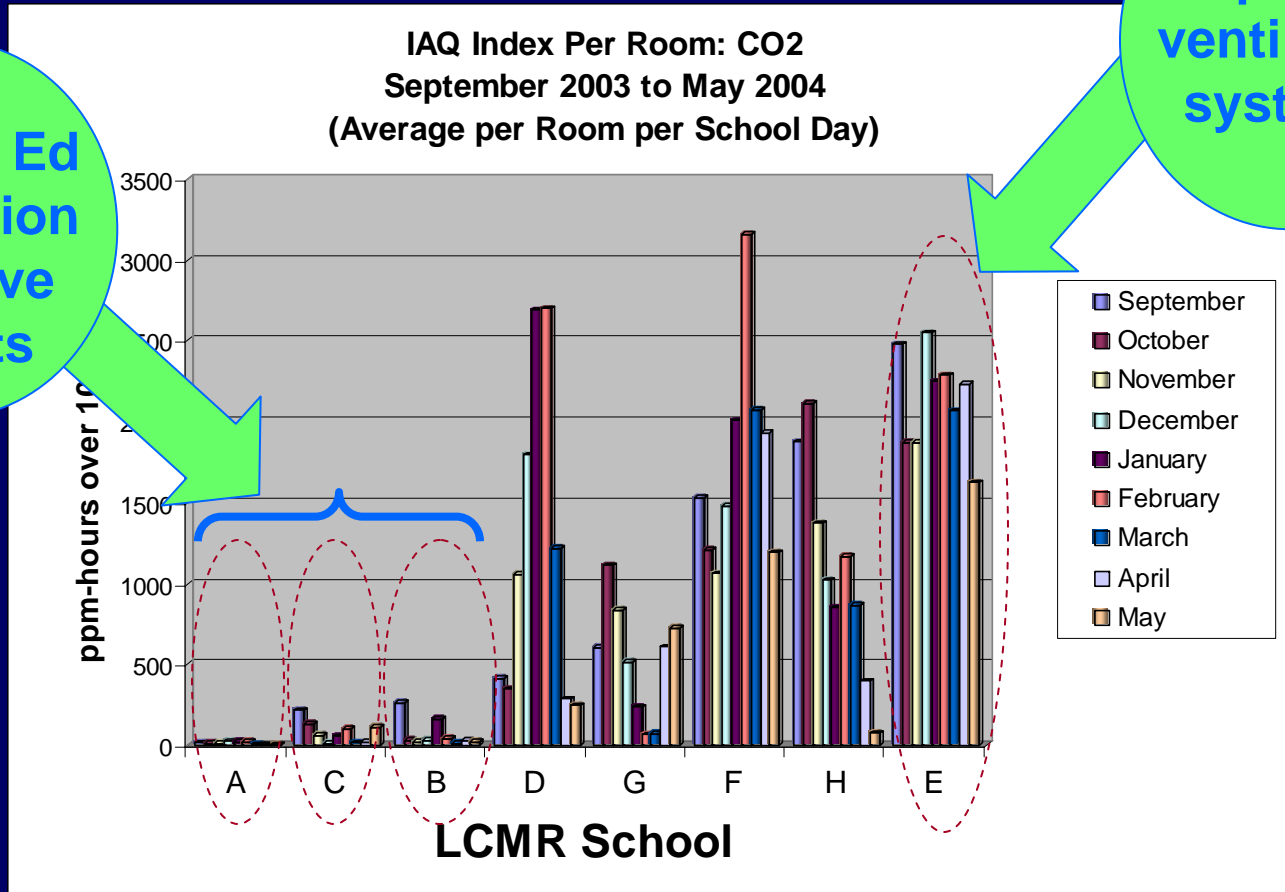
School

■ Above 1000 ppm CO2  
■ Below 800 ppm CO2

# Ventilation Effectiveness: (CO<sub>2</sub> Index)

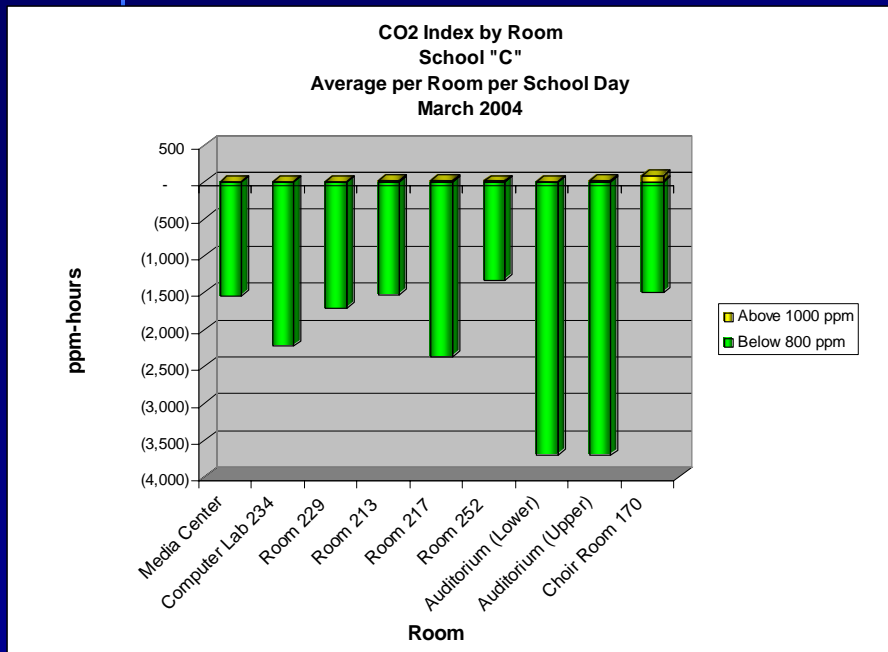
Inoperable  
ventilation  
systems

Dept of Ed  
ventilation  
initiative  
results



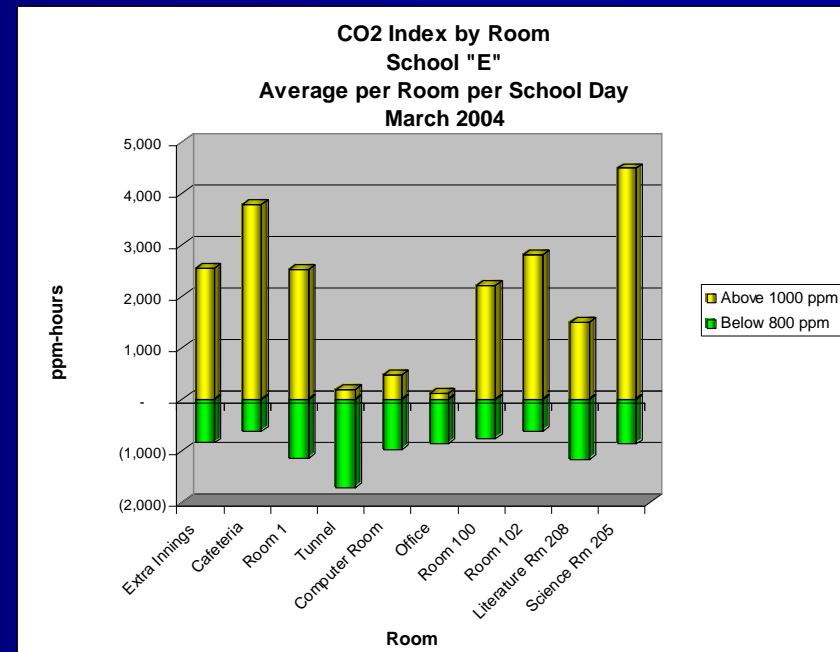
*There was a big difference in ventilation  
adequacy in the participating schools*

# CO<sub>2</sub> Index by School Room



**School "C"**

*Energy savings target*



**School "E"**

*Ventilation improvement target*



# Berkeley Lab

LAWRENCE BERKELEY NATIONAL LABORATORY

- Relationship between IAQ and student absenteeism
  - 10% to 20% increase in absenteeism per 1000 ppm increase in CO<sub>2</sub>
  - Published in "Indoor Air Journal" this year

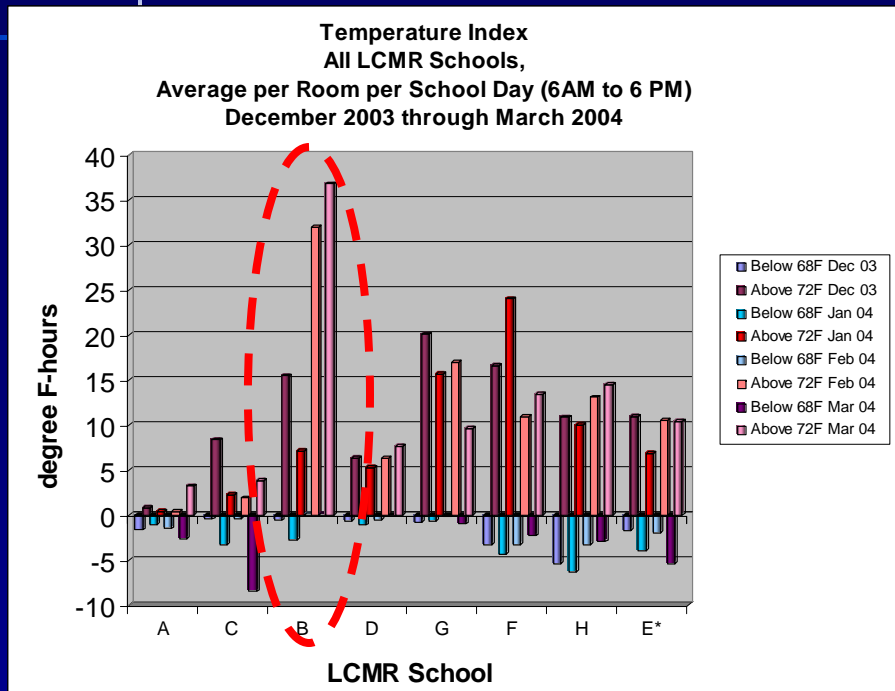
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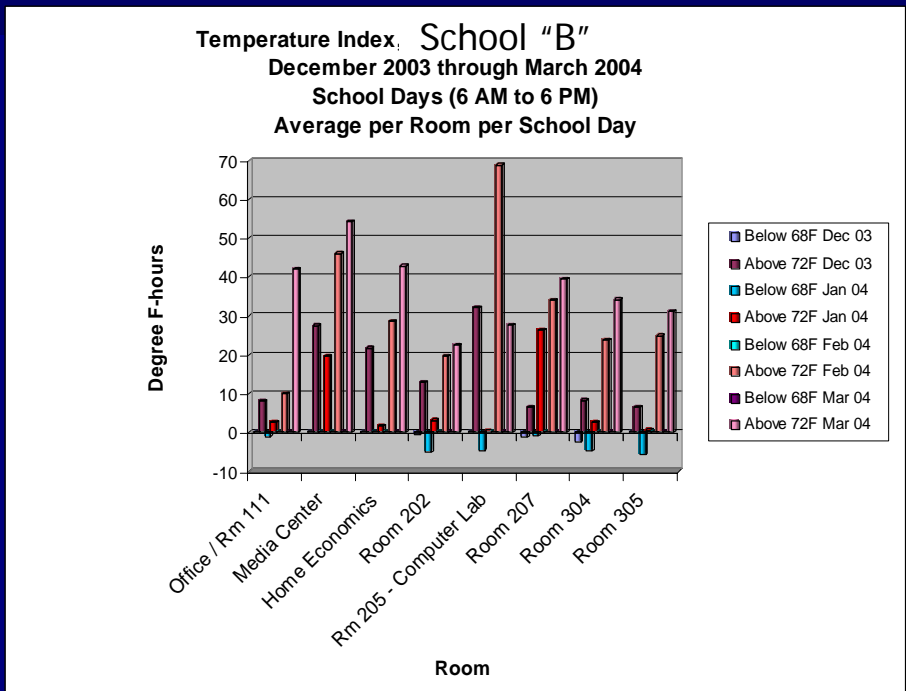
# Three Strategies

- Temperature Management
  - School Nights
  - School Days
  - Weekends & Holidays
- Demand-Controlled Ventilation
- Local Area Network (LAN) -  
Controlled Computer Lab

# Winter Results: Temperature School Days



by School

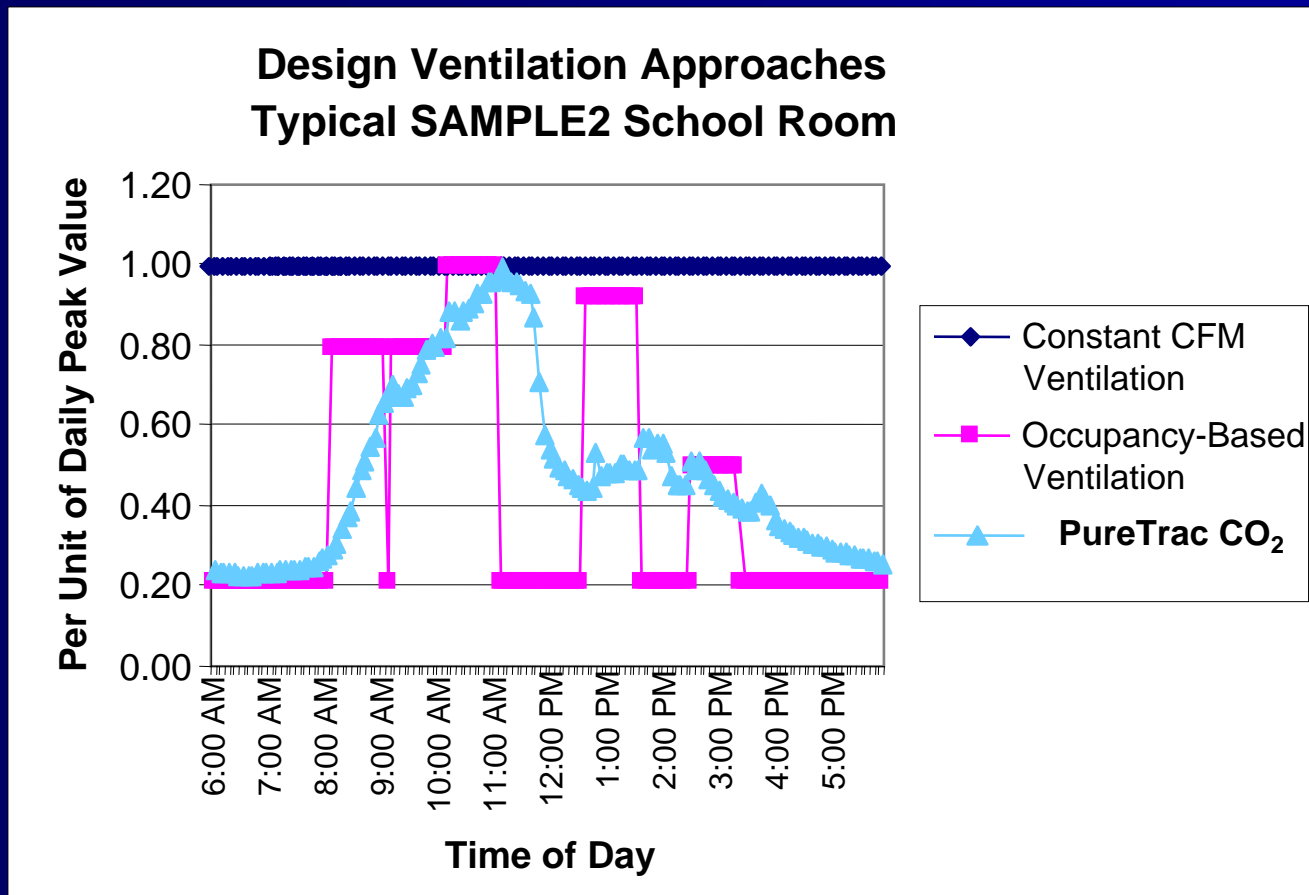


by Room

**School "B" was often the warmest school on school days--by far. Media Center, Office and Home Economics were warmest.**

# Save Energy

## Demand-Controlled Ventilation (DCV)



\* 15 CFM per desk  
\*\* 15 CFM per student occupant

# Potential Energy Impacts Summary (SAMPLE<sup>2</sup> schools)

- Potential annual HVAC energy savings
  - *Starting from current ventilation rate*

*13% to 20%*

- Potential annual HVAC energy penalty
  - *If adopted ASHRAE ventilation standard*

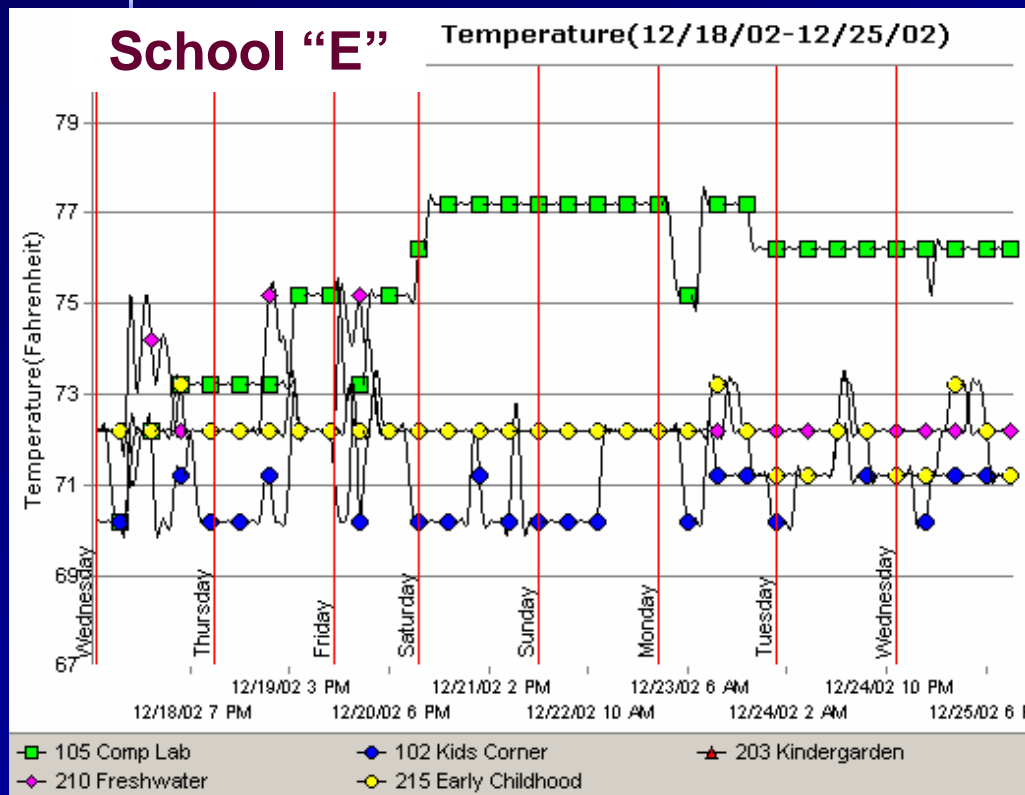
*11% to 13%*

*Difference:*

*24% to 33%*  
*(\$41,000/year)*

# Save Energy

## Computer Lab Energy Management



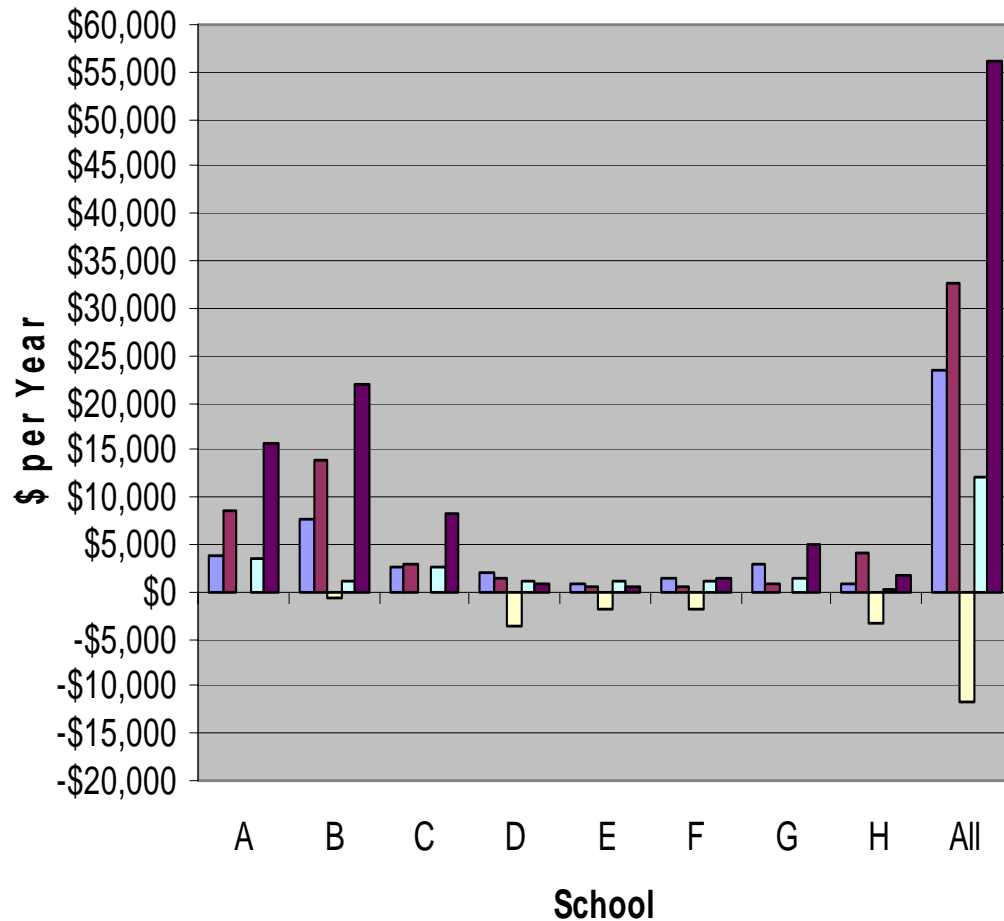
Computer Labs often show higher temperatures

Central LAN Administrator control of PCs

**Available savings:  
\$13.60 per PC-year\*  
(\$400 to \$800/year  
for this school)**

\*@ 5.8 cents/kWh

# Energy Savings Potential: LCMR Results



■ Temperature Management   
 ■ Over Ventilation Savings   
 ■ Under Ventilation Penalty  
■ Computer lab   
 ■ Net Dollar Savings

# Energy Conservation: Results (continued)

- All 11 schools can save energy
  - Even after fixing any ventilation problems
- Schools with the best ventilation have the most energy savings potential
- Total potential savings for all 11 schools is \$75,000/year

# Project Web Site

www.mnk12IAQEnergyuse.org

The screenshot shows a Microsoft Internet Explorer browser window displaying the website for the Indoor Air Quality-Energy Use Study. The browser's address bar shows the URL <http://www.mnk12iaqenergyuse.org/>. The website's main heading is "Indoor Air Quality-Energy Use Study" with the subtitle "...in Minnesota K-12 Schools". Below the heading is a navigation menu with tabs for Home, Plans & Regs, Case Studies, Information, IAQ Reference, Guides, and Forum/Survey. A secondary navigation bar contains links for Project Overview, Participating Schools, Project Participants, and School Snapshots & Details. The main content area features a section titled "Intended Audience" with two paragraphs of text. The first paragraph states that the website was created with school building operators, business managers, and facility managers in mind, designed to help them find information on school IAQ requirements and solutions. The second paragraph describes the website's content, including background information on Minnesota rules and regulations, and tools for understanding heating, ventilation, and air conditioning. A sidebar on the left contains a quote about project results.

At the conclusion of this project it can be said that "Schools are already using project results successfully to improve their IAQ. Often, these improvements can be made relatively inexpensively with operating or maintenance adjustments, once school staffs have actual IAQ data to

### Intended Audience

This Web site was created with school building operators, business managers, and facility managers (buildings and grounds supervisors) in mind. It was designed with their input, so that they can find information on school IAQ requirements, better understand IAQ monitored data and find solutions to problems in one place. During its development many members of the Minnesota Association of School Maintenance Supervisors (MASMS — [www.masms.org](http://www.masms.org)) contributed ideas as to the nature, scope and content needed on the site.

We've attempted to provide a site that contains both reference information and tools. You'll find background information about Minnesota rules and regulations. There are pages and links to help you understand the dynamics of heating, ventilation and air conditioning, and provide information to expand your IAQ knowledge base. Among the tools is one to compare your buildings with other buildings in other school districts. If you're ready to dig in now, go directly our Information, IAQ Reference or Guides pages.

Our goal was to provide useful information and tools to project participants and others so that they can initiate or continue steps to improve the performance of

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# Lessons Learned

- Energy and the indoor environment are closely related
- Recent research indicates there is a link between inadequate school ventilation and student absenteeism
  - If proven, this link could have a profound effect on cost/benefit of energy & IAQ in schools

# Lessons Learned (continued)

- State Departments of Education are moving to improve school ventilation
- Efforts to improve ventilation have big energy cost implications, if done incorrectly
- Schools need help to achieve a better balance between their energy use and indoor air quality (ventilation)

# Lessons Learned (continued)

- Much can be accomplished with no- or low-cost O&M measures
  - If schools have actual IAQ data to target their actions
- State programs could be better coordinated
  - IAQ improvement
  - Energy conservation
- IAQ of multiple schools can be monitored and certified remotely over the Internet

# How You Can Help

- Utility conservation programs
  - Aimed at operating & maintenance improvements (recommissioning); not just capital investments
  - Insist on a better balance between conservation and IAQ
  - Continuous IAQ monitoring as a management tool

## How You Can Help (continued)

- Promote better coordination between state IAQ and energy programs
  - Department of Education: IAQ
  - State Energy Office & Utilities: Energy

Questions?

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