



U.S. Department of Energy
Energy Efficiency and Renewable Energy

HIGH PERFORMANCE HVAC SYSTEMS FOR SCHOOLS

ENERGY SMART/HIGH PERFORMANCE
SCHOOLS SEMINAR Richmond, VA
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AGENDA

- Definition of a high-performance HVAC system
- Conventional HVAC systems and their weaknesses
- Some green HVAC strategies
- Dual-path systems
- Advanced HVAC Systems



CHARACTERISTICS OF A HIGH PERFORMANCE HVAC SYSTEM

World-class energy efficiency

Good indoor air quality

Tight temperature and humidity control

Quiet

Minimizes ozone depletion

Easy to maintain

Cost-effective and easy to build

Easy to maintain



PAST FOCUS OF ENERGY CONSERVATION EFFORTS

Improved envelope design and construction

Improved equipment efficiencies

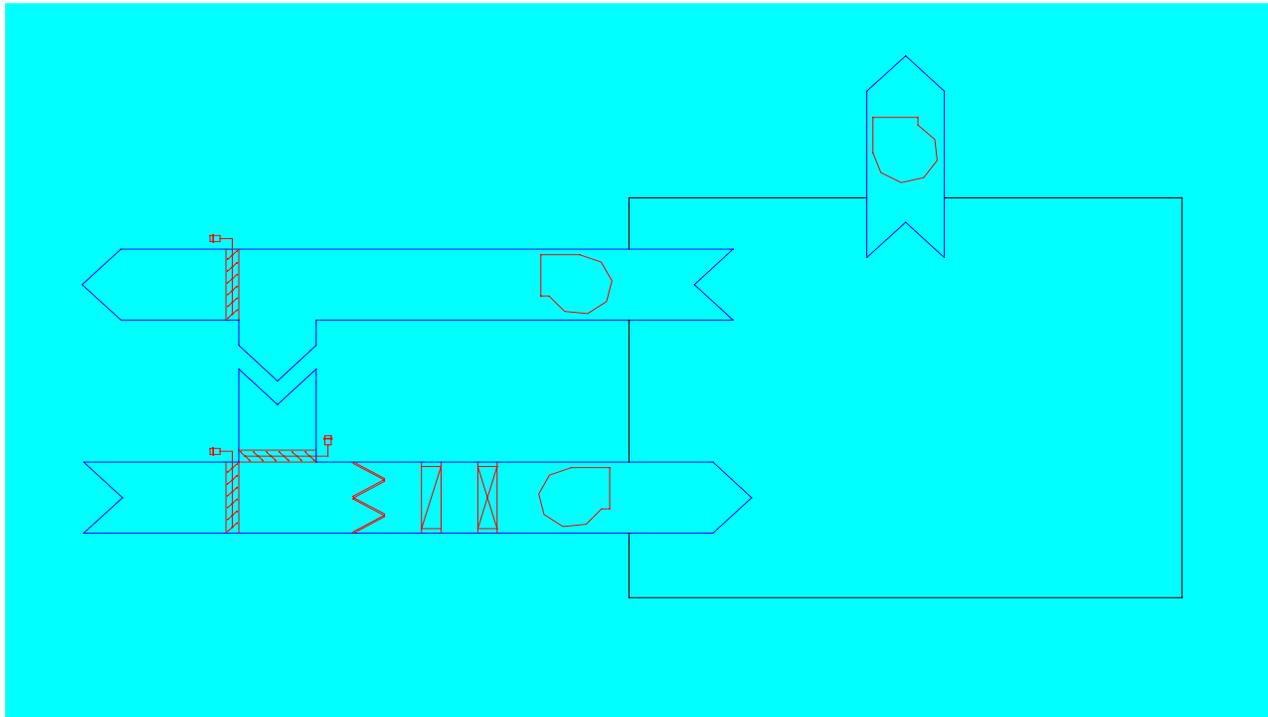
Little change in HVAC system strategies

Reduction of ventilation (when you could get away with it)



IDENTIFYING OPPORTUNITIES

- The Typical HVAC System





TYPICAL HVAC SYSTEM WEAKNESSES

Re-circulation concentrates internal contaminants

Inadequate filtration

Terminal reheat to control temperature and humidity

The process is predicated on using energy intensive
boilers & chillers

Most common approaches are NOISY



LIMITATIONS OF STANDARD HVAC SYSTEMS

Mixing/Re-circulation Compromises IAQ

- Ventilation is subordinated to temperature control
- Over or under ventilation of individual spaces
- Cycle of concentration of contaminants
- VAV reduces ability to introduce air into spaces



LIMITATIONS OF STANDARD HVAC SYSTEMS

Thermodynamically inefficient

- Employ most inefficient processes to provide heating and cooling on large systems
 - ◆ Burn expensive, non-renewable fuel for heat
 - ◆ Excessive use of refrigeration
 - ◆ Require reheat for tempering & humidity control



LIMITATIONS OF STANDARD HVAC SYSTEMS

Noisy

- ANSI has just adopted Std. S12-2002, requires less than 35 dBA in classrooms from HVAC eqpt.
- most unit ventilators, fan coil units, rooftop units and cabinet ground source heat pump units cannot meet this and comply with Code for ventilation for schools and other high occupancy buildings e.g. schools



WHAT DOES “GREEN” MEAN TO HVAC?

“Green” is avoiding the need for that “high efficiency” boiler or chiller

A high efficiency system with low efficiency equipment beats a low efficiency system with high efficiency equipment every time

The big money for HVAC energy savings is in better system designs



“GREEN” STRATEGIES

Dual Path Ventilation – Separation of ventilation from heating and cooling processes permits elimination of terminal reheat and effective management of ventilation.

Energy Recovery – Recycling heating/cooling energy permits ventilation air to be introduced into spaces at low thermodynamic cost.



“GREEN” STRATEGIES

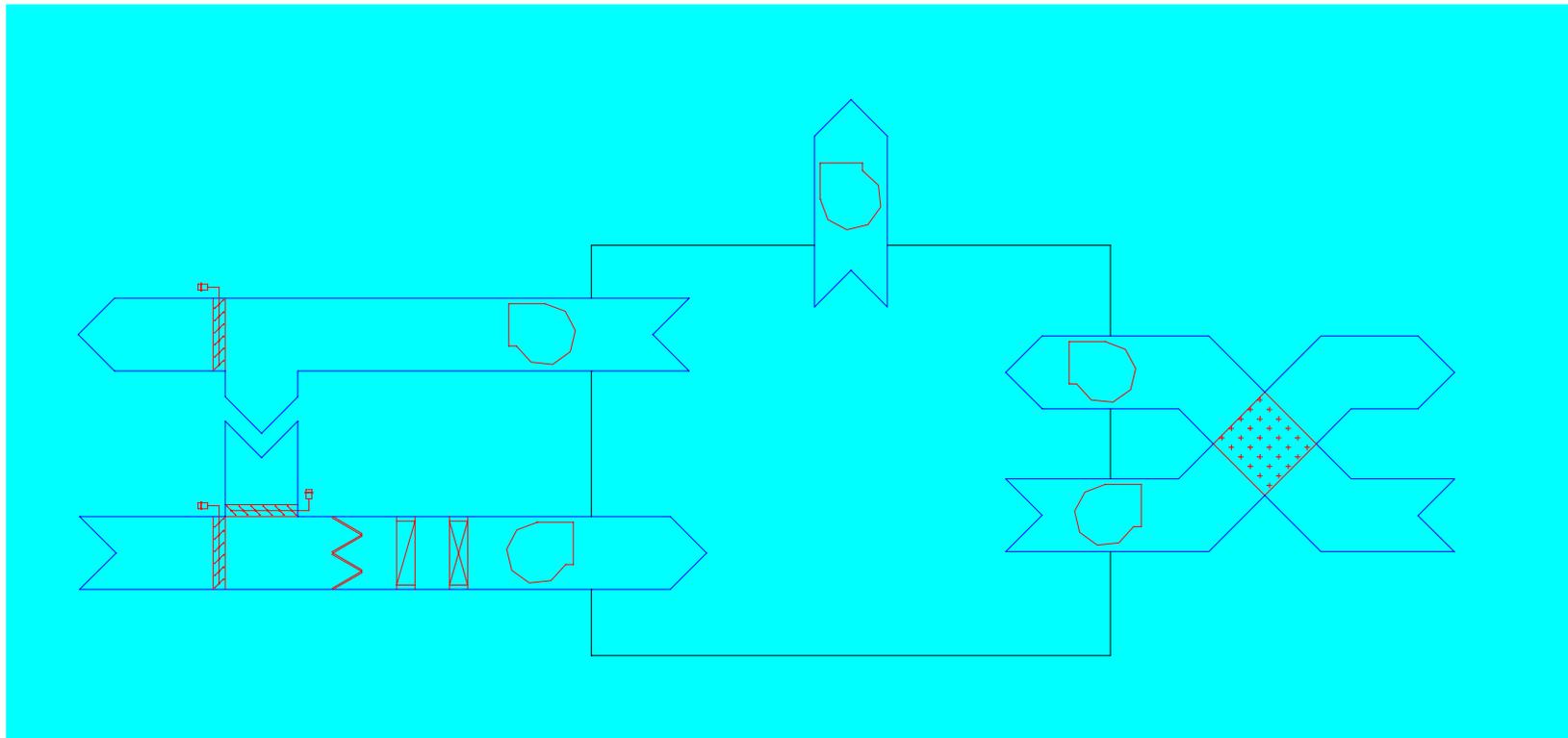
Evaporative Cooling and Humidification – Evaporative processes permit the avoidance of most cooling and humidification energy and are applicable in all environments.

Displacement Ventilation – Permits small, 100% outside air systems to replace much larger systems and greatly reduced energy use.

Thermal Storage – Properly employed, thermal storage can sharply reduce both the quantity and cost of heating and cooling energy use



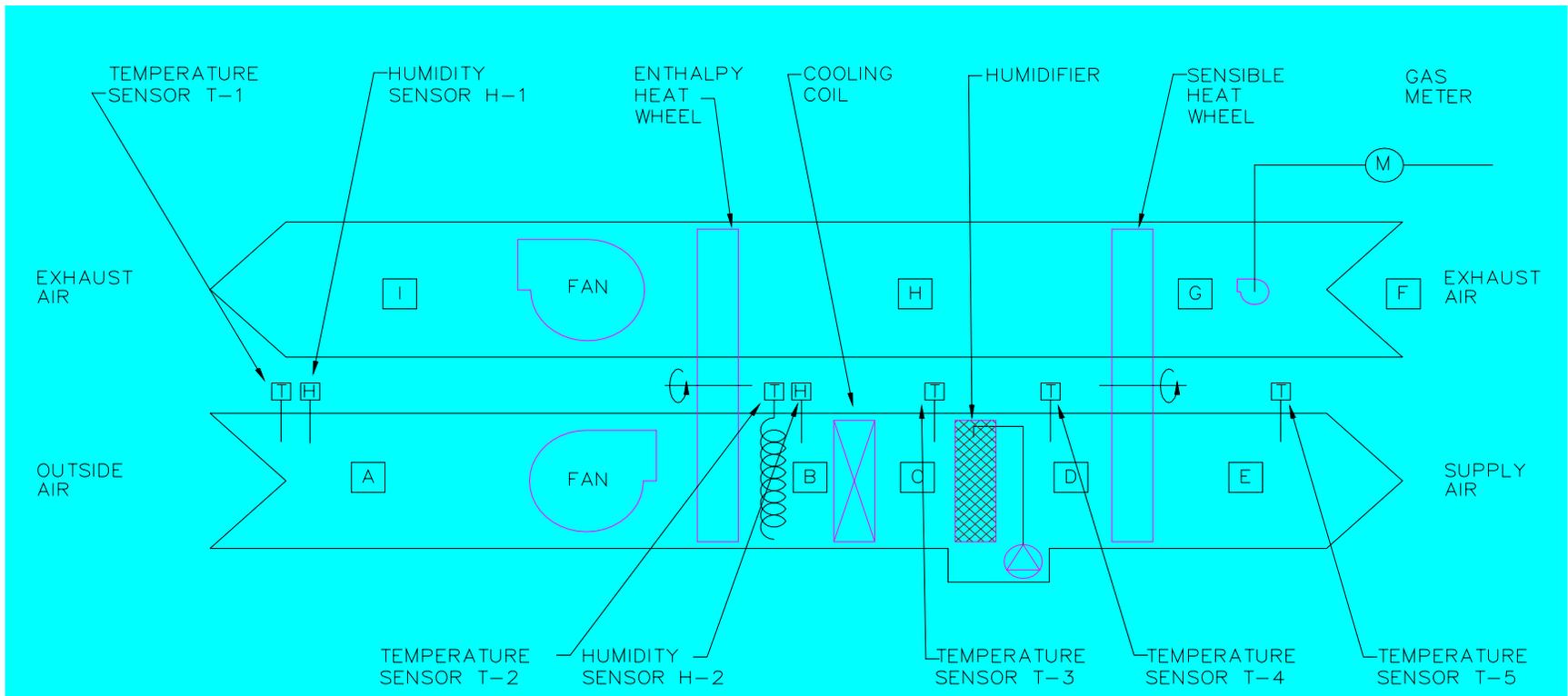
ALTERNATIVE SOLUTIONS





ALTERNATIVE SOLUTIONS

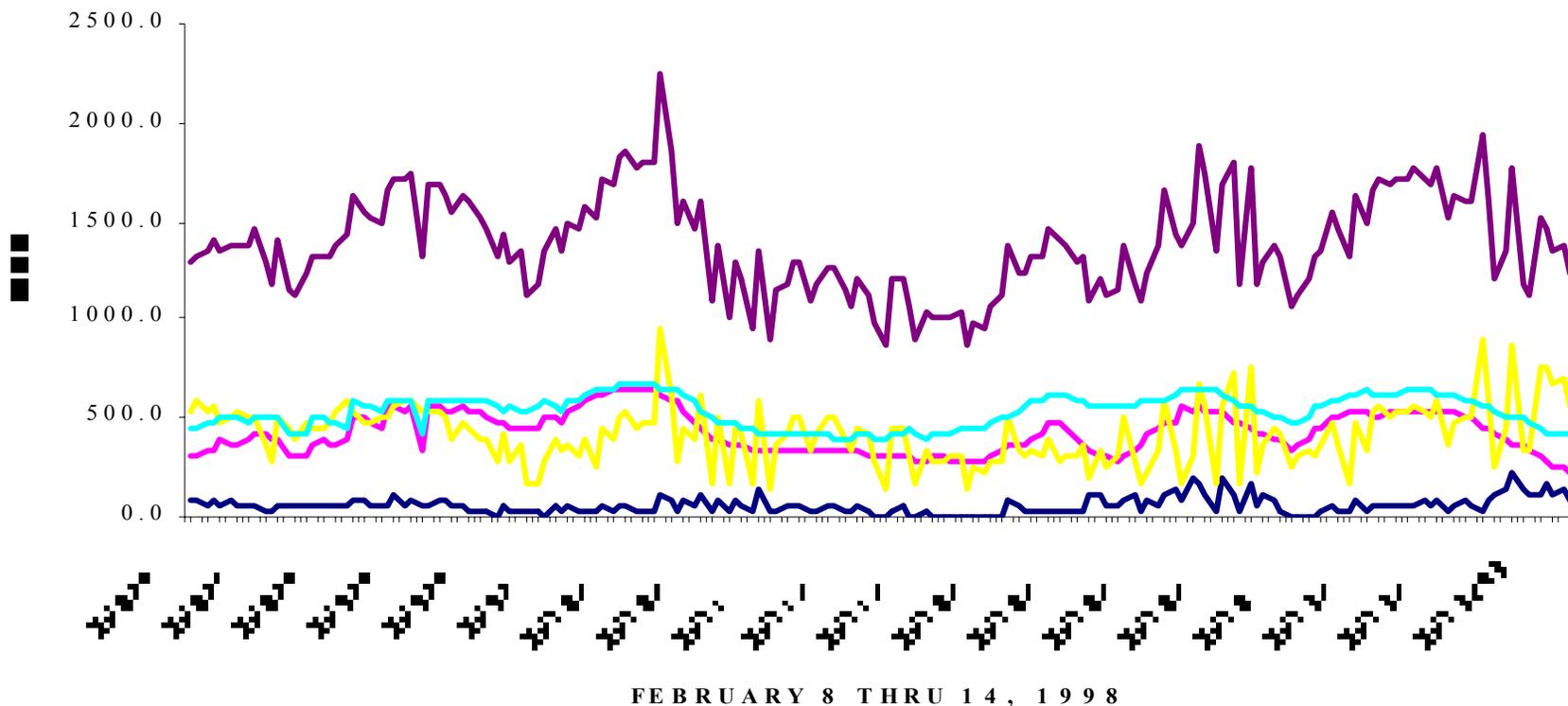
- Direct-Fired, Evaporatively Assisted
- Double Heat Wheel





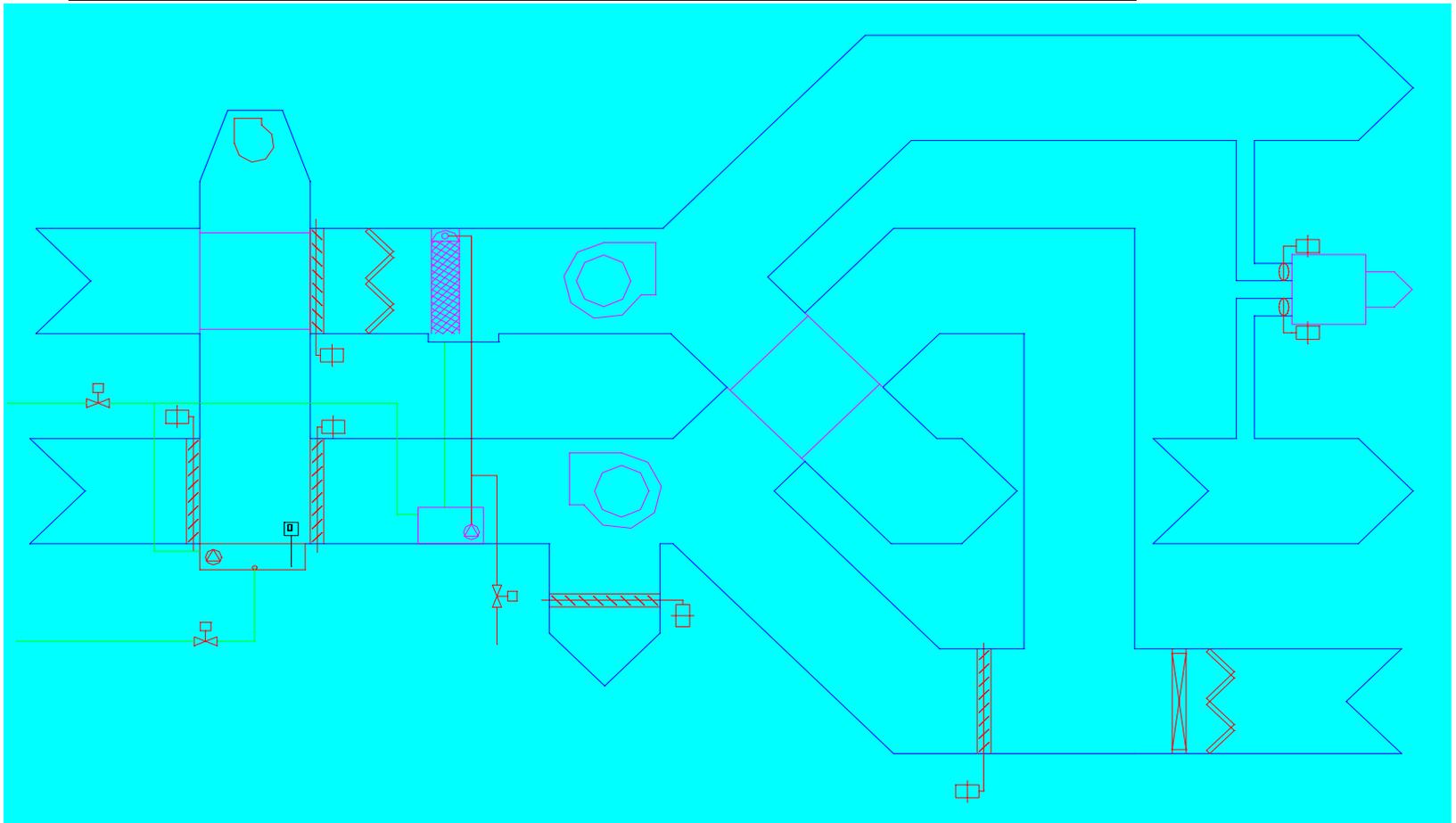
INDEPENDENT PRINTING ENERGY USE

HEATING ENERGY USE





ADVANCED SOLUTIONS: THE REGENERATIVE DOUBLE DUCT

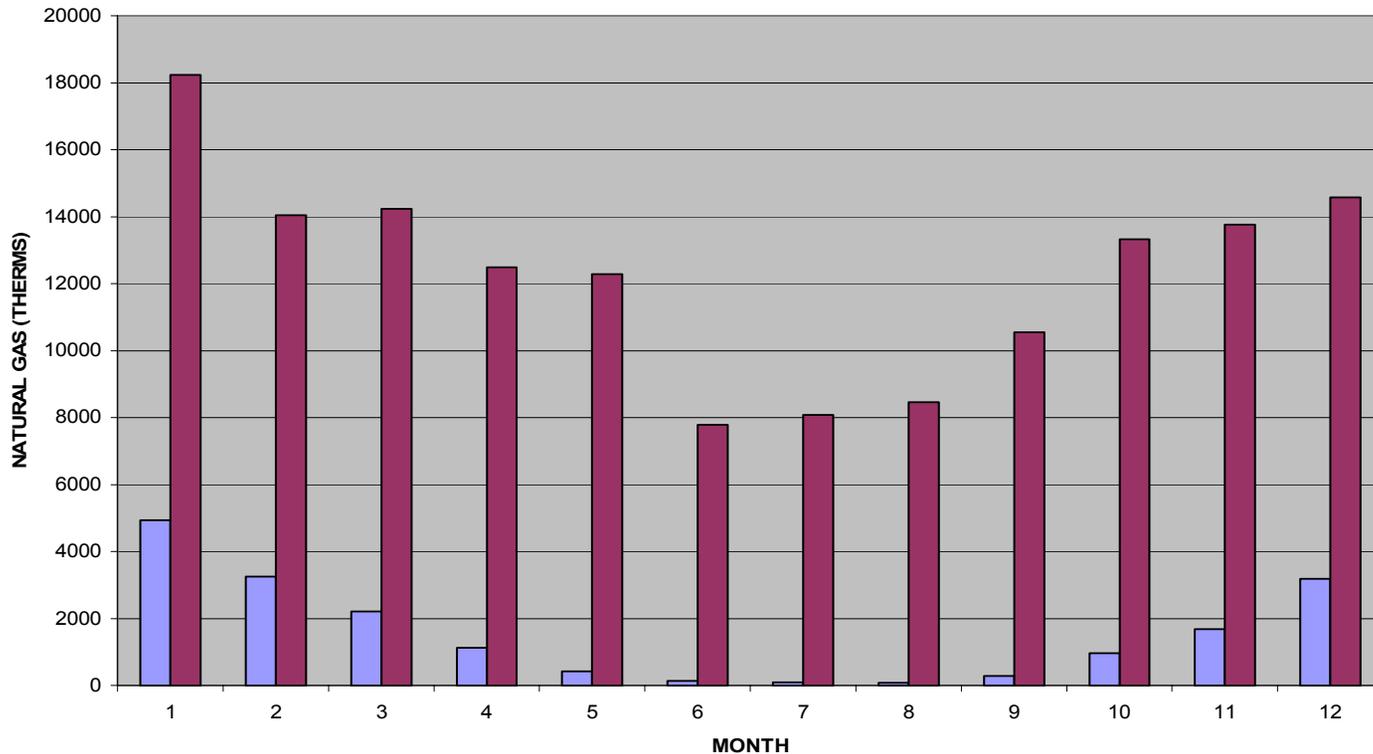




CLINTONVILLE HS RDD

PROJECTED NATURAL GAS USE

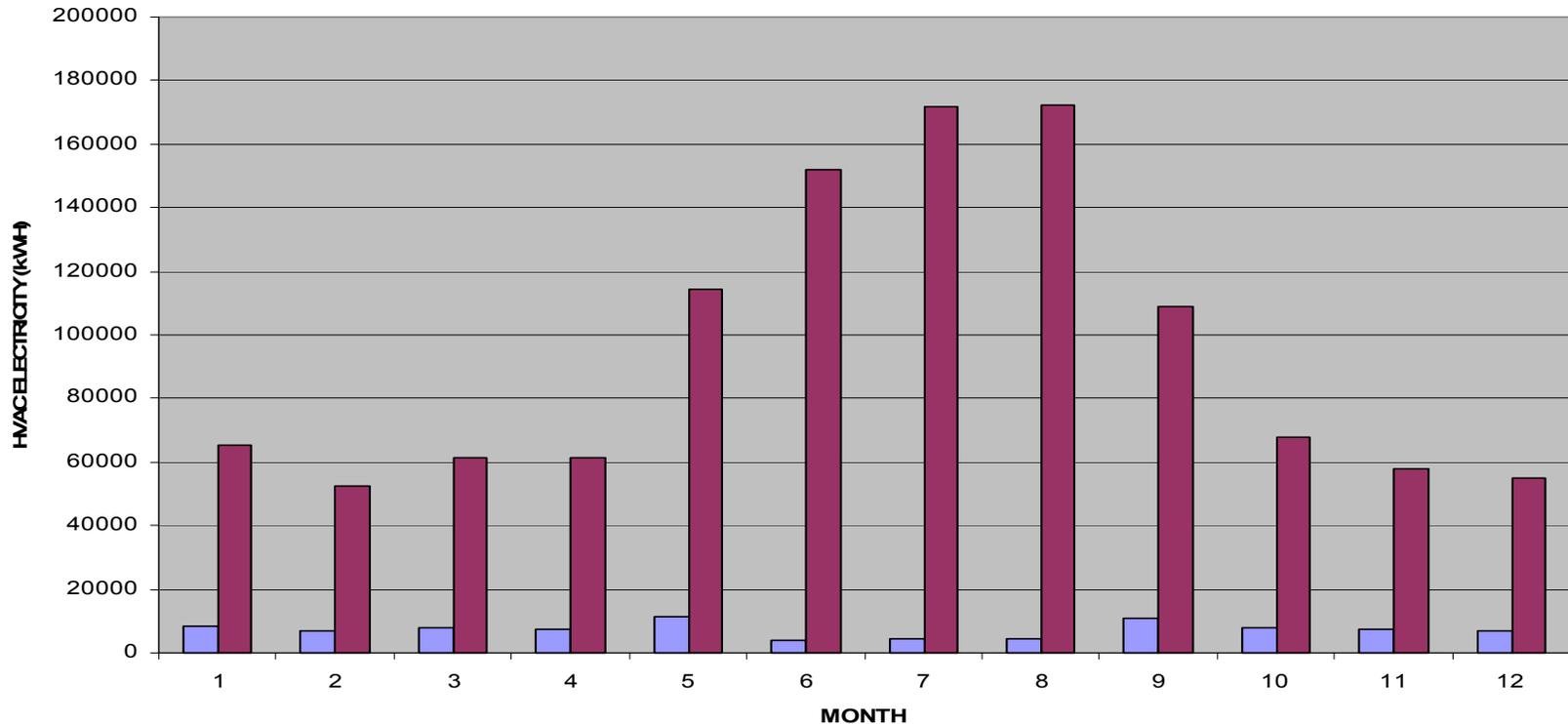
CLINTONVILLE HIGH SCHOOL





CLINTONVILLE HS PROJECTED HVAC ELECTRICAL ENERGY USE

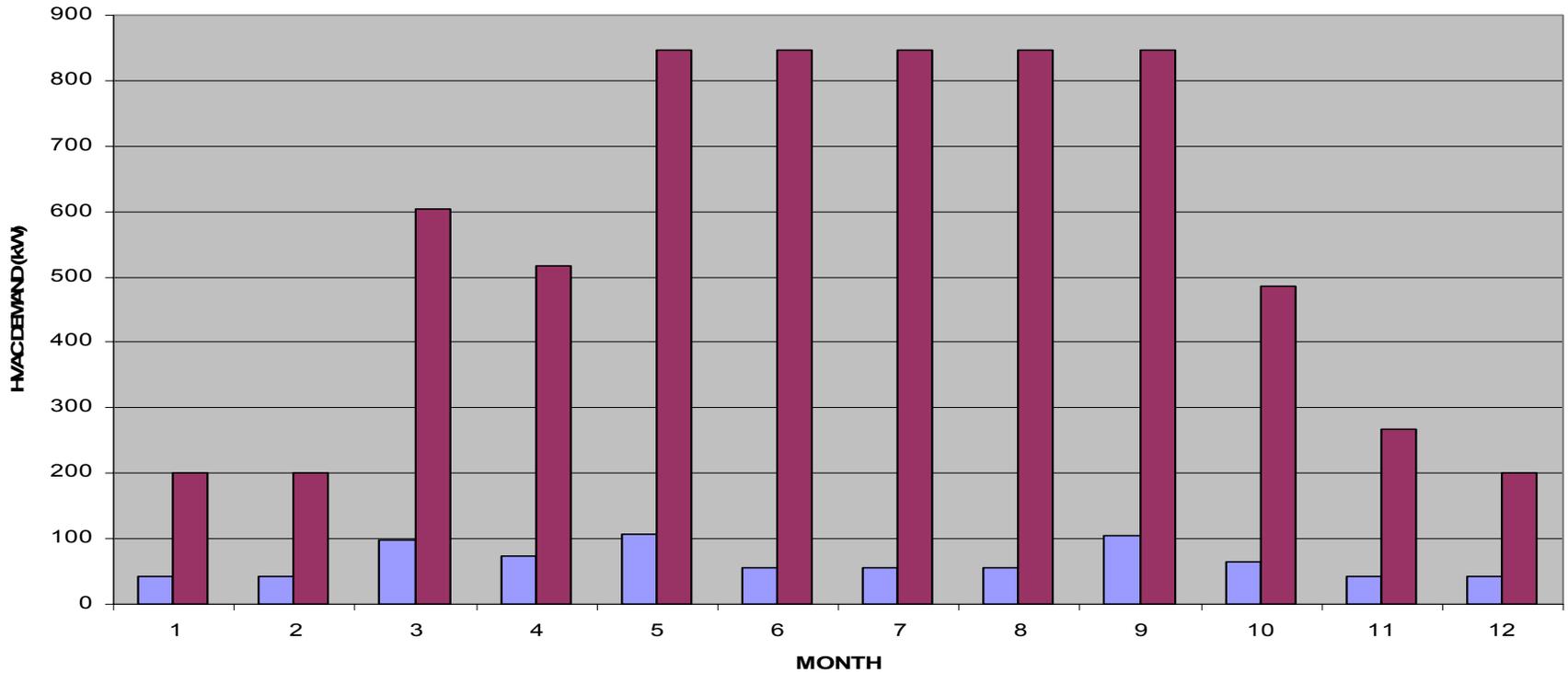
CLINTONVILLE HIGH SCHOOL





CLINTONVILLE HS RDD HVAC ELECTRIC DEMAND

CLINTONVILLE HIGH SCHOOL





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WAUSAU WEST HIGH SCHOOL Wausau, Wisconsin





WAUSAU WEST HS





WAUSAU WEST HS

Area (SF):	275,000
System Types:	Regenerative Double-Duct
Primary Heating Plant Reduction:	60%
Primary Cooling Plant Reduction:	92%
Gross Energy Use Reductions:	
• Natural Gas	38%
• Electricity (kWh)	27.8%
• Electrical Demand	25%
Gross Energy Cost Reductions:	29.3%



WAUSAU WEST HS

Air Quality:	9/98	12/99
•CO2 (Average ppm)	1433	742



INSTALLED CHILLER CAPACITIES

- Typical NJ School
- Wausau West HS
- Clintonville HS
- Howell, NJ ES
- Howell, NJ MS

Note: Howell ES and MS include ~25% future expansion capacity, 100% redundancy

- 250 SF/Ton
- 2,360 SF/Ton
- 1,400 SF/Ton
- 875 SF/Ton
- 1,100 SF/Ton



ENERGY CONSERVATION POTENTIAL

- Potential varies with the structure, local climate, functions supported, and the type of HVAC systems to be compared against.
- Truly “green” systems should be able to provide anywhere from 50% to 97% reductions in energy use with current technologies without compromising the indoor environment.
- It is possible to install properly designed “green” systems at costs equal to, or less than conventional designs.



RDD NEW CONSTRUCTION COSTS

(ALL IN MIDWEST)

- HVAC Costs
 - \$10-\$13/SF (new)
 - \$14-\$15/SF (retrofit)
- Electrical Costs
 - \$6-9/SF (new)



NEW HOWELL, NJ ELEMENTARY SCHOOLS (2)

\$131/SF (\$138/SF budgeted)

70,000 SF

100% O.A. ventilation

2 x 40 ton chillers

50 kW solar PV array (provides

6-7% of total energy)

LEED Silver expected





NEW HOWELL, NJ MIDDLE SCHOOL

\$112/SF (\$141/SF budgeted)

115,000 SF

100% O.A. ventilation

15 KBTU/SF/Yr. for HVAC

2 x 50 ton chillers

LEED Silver expected





BENEFITS OF REGENERATIVE DOUBLE-DUCT SYSTEM

- Superior indoor air quality (100% O.A.)
- Greatly reduced energy consumption (50 - 97%)
- Reduced heating plant size and costs
- Cooling plant size and cost reduction
- Easy to construct and maintain
- Competitive or lower construction costs
- Quiet (under 30 dBA and NC in classrooms)



CONCLUSIONS

- Standard HVAC system strategies are not meeting our needs
- Classical HVAC designs are the problem
 - they are based on energy-intensive processes
 - re-circulation compromises indoor air quality
 - reliance on ventilation reduction is the primary cause of IAQ problems
 - they put IAQ & energy conservation at odds
- Higher performance solutions are possible and they are very cost-competitive



Parting Thoughts

- “The sweetness of low price is quickly forgotten when you have to deal with the bitterness of low quality”.
- author unknown
- “The important thing is not to stop questioning.”
- Albert Einstein



Parting Thoughts

“ The achievement of excellence requires great effort, much planning, and even more time. But, in the long run, mediocrity costs more, drains your energy, and wastes even more time than it takes to do things right (in the first place)” .

- Norman Lamm



Q&A