



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

# HIGH PERFORMANCE HVAC SYSTEMS

## Moving Towards Sustainable Energy:

### The Bronx is Going Green

### Hostos Community College

### Bronx, NY

### September 23, 2005

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# TOPICS TO BE DISCUSSED

- ❖ The Message
- ❖ Characteristics of a high-performance HVAC system
- ❖ Conventional HVAC systems and their weaknesses
- ❖ Some green HVAC strategies
- ❖ Dual-path systems
- ❖ Advanced HVAC Systems
- ❖ The Message Again



# THE MESSAGE

- ❖ Vastly more energy efficient HVAC systems are available than what you are used to
- ❖ They don't have to cost more to install, they can, and should cost less than conventional HVAC systems
- ❖ You don't have to trade off IAQ for energy efficiency



# CHARACTERISTICS OF A HIGH PERFORMANCE HVAC SYSTEM

- ❖ World-class energy efficiency
- ❖ Good indoor air quality
- ❖ Precise temperature and humidity control
- ❖ Quiet
- ❖ Minimizes ozone depletion
- ❖ Easy to maintain
- ❖ Cost-effective and easy to build



# PAST FOCUS OF ENERGY CONSERVATION EFFORTS

- ❖ Improved envelope design and construction
- ❖ Improved equipment efficiencies
- ❖ Little change in HVAC system strategies
- ❖ Reduction of ventilation



# ENERGY CONSERVATION

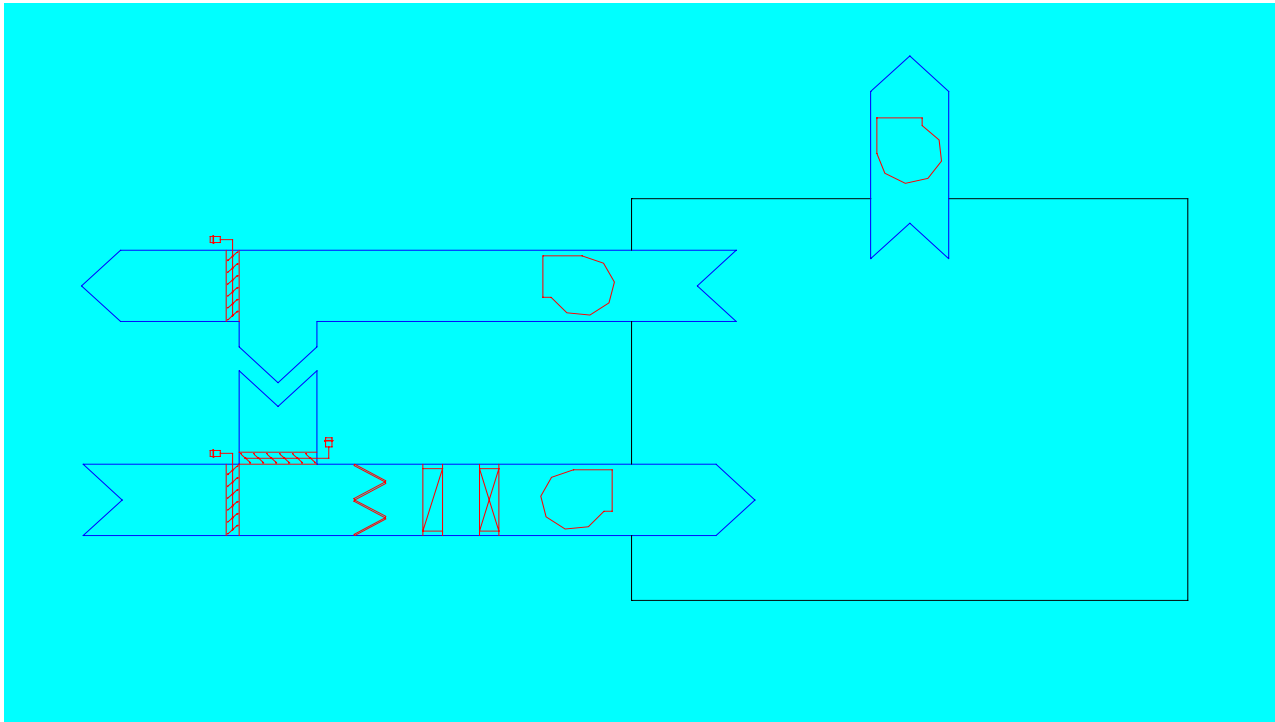
- ❖ World oil production will peak and then decline this decade
- ❖ World oil demand continues to increase, dollar is dropping
- ❖ Old HVAC systems in new bldgs. are 50-year long financial disasters for owners
- ❖ Dramatic reductions of energy use are needed





# IDENTIFYING OPPORTUNITIES

- The Typical HVAC System





## TYPICAL HVAC SYSTEM WEAKNESSES

- ❖ Re-circulation concentrates internal contaminants
- ❖ Inadequate filtration
- ❖ Terminal reheat to control temperature and humidity
- ❖ They use large, energy intensive boilers & chillers
- ❖ That can actually make them expensive to build
- ❖ Most common approaches are NOISY



## 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
- ❖ Energy Recovery – Recycling heating/cooling energy permits ventilation air to be introduced into spaces while minimizing new energy input

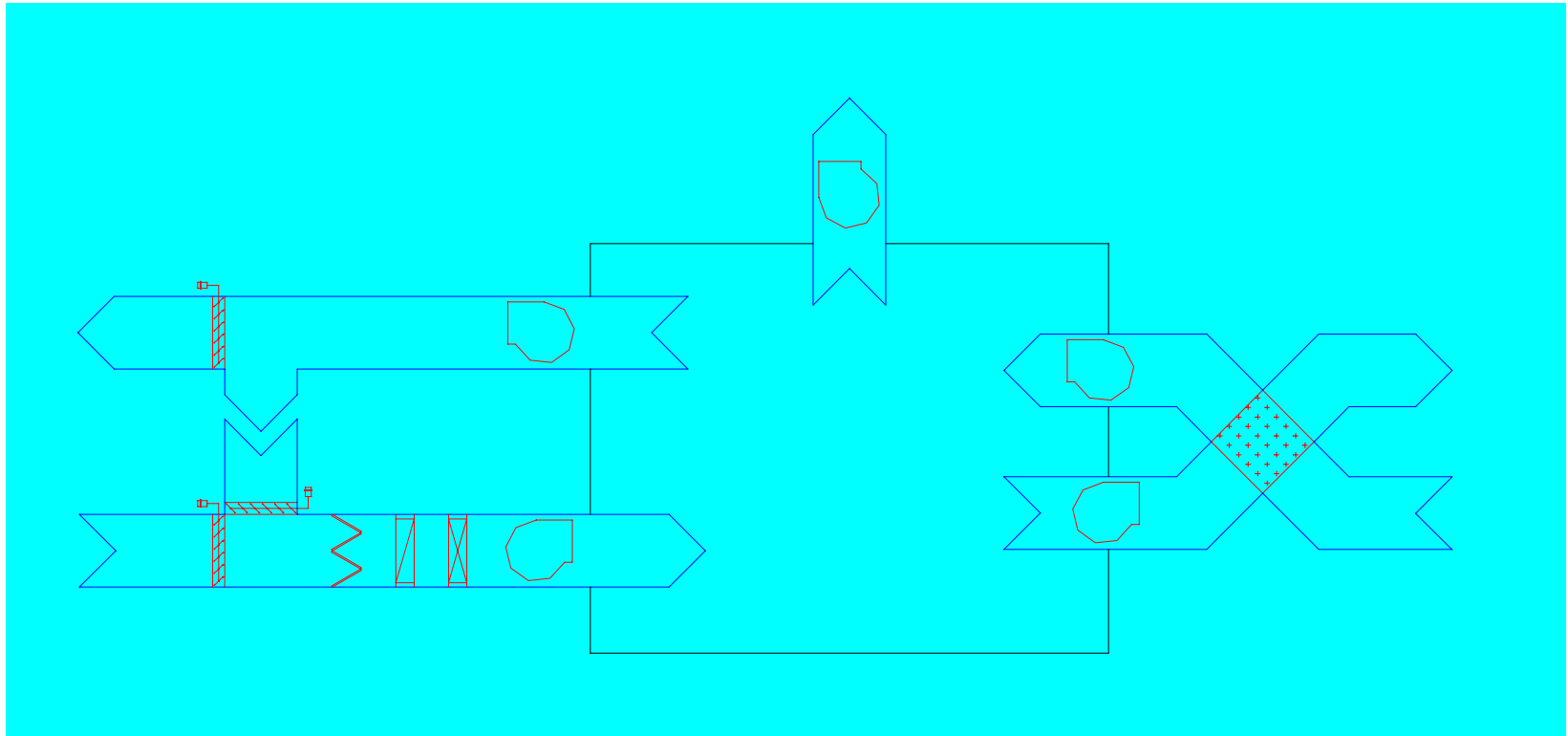


## "GREEN" STRATEGIES

- ❖ Evaporative Cooling and Humidification – Evaporative processes permit the avoidance of most cooling and humidification energy and are applicable in all climates
- ❖ Displacement Ventilation – Permits small, 100% outside air systems to replace much larger systems and greatly reduce energy use
- ❖ Thermal Storage – Properly employed can sharply reduce both the heating and cooling plant size and energy use



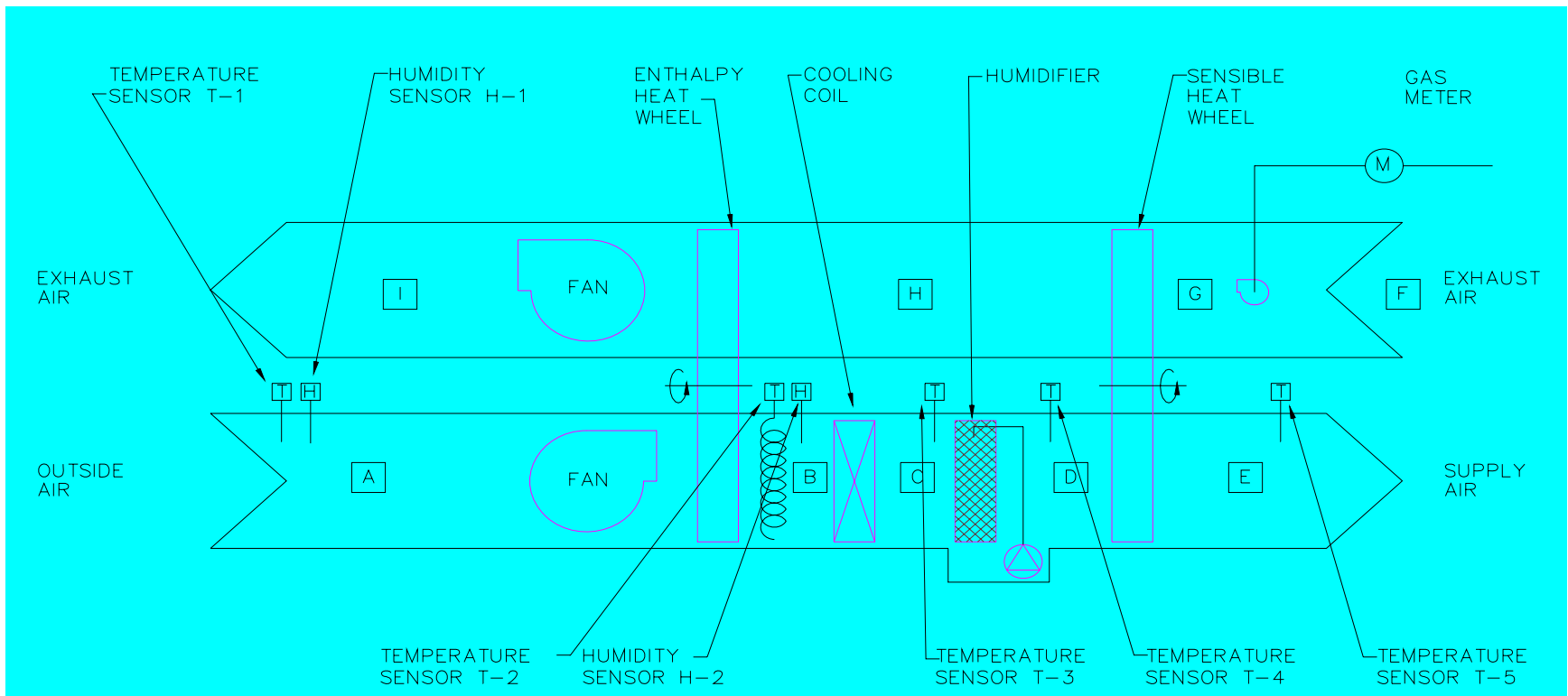
# ALTERNATIVE SOLUTIONS – DUAL PATH SYSTEMS





# ALTERNATIVE SOLUTIONS

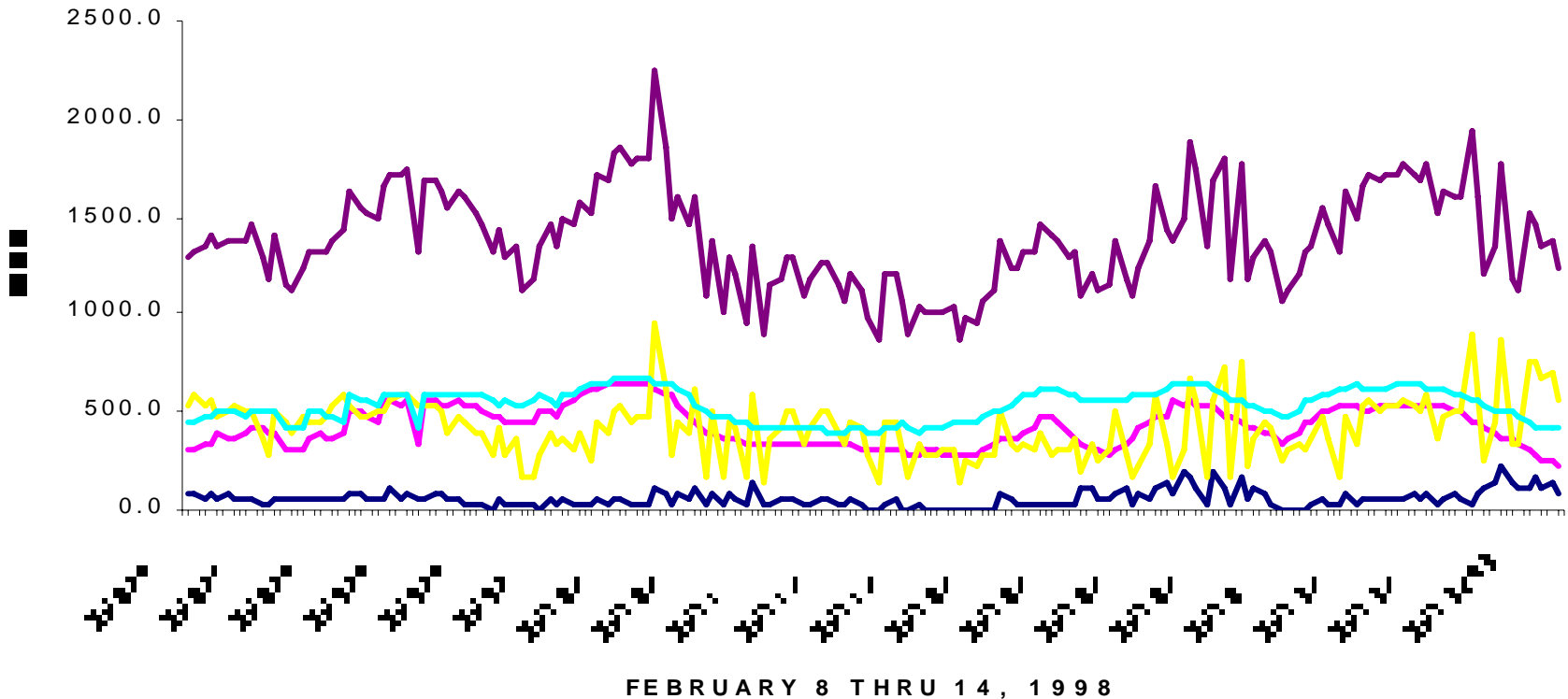
- Direct-Fired, Evaporatively Assisted
- Double Heat Wheel





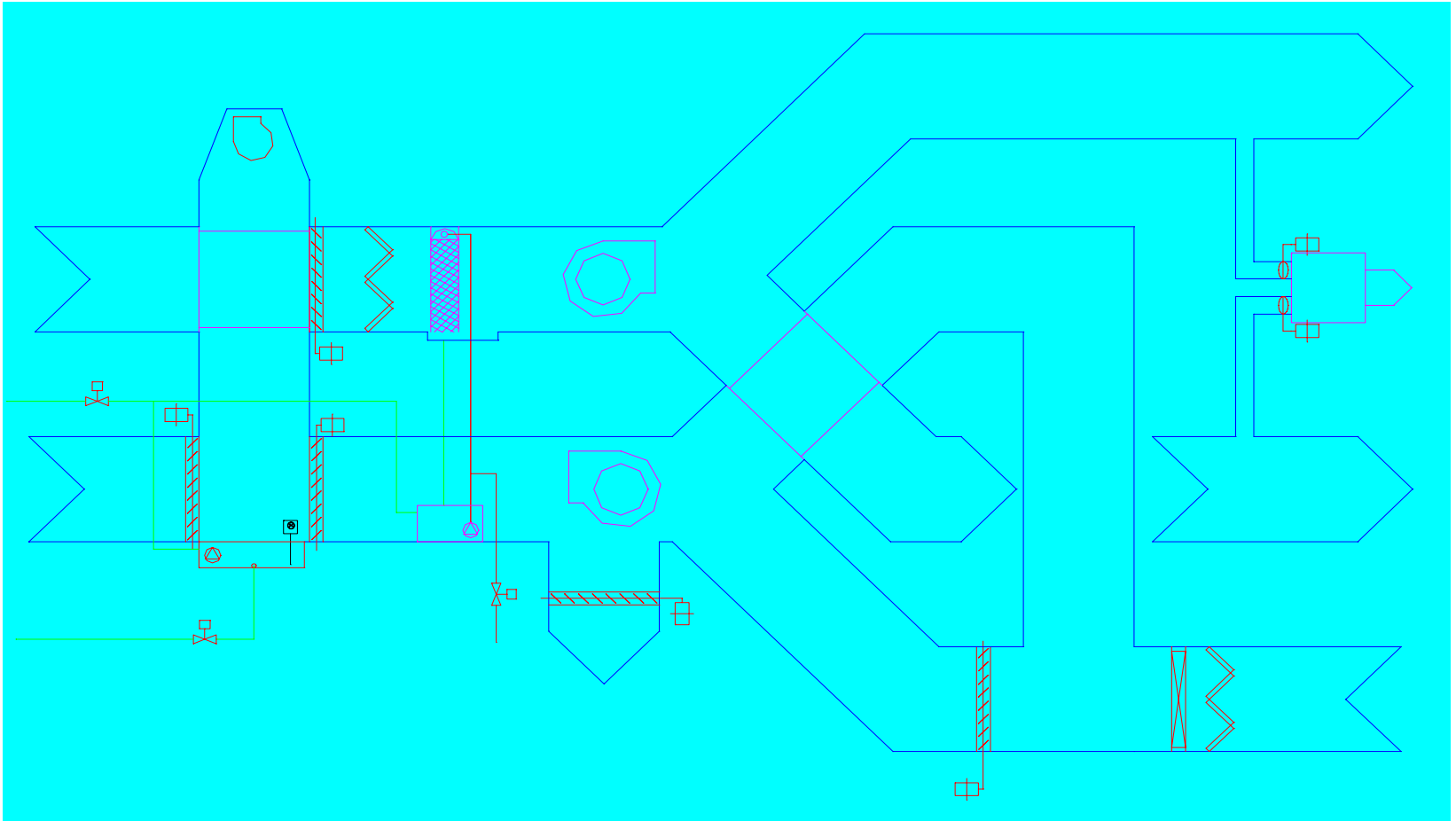
# INDEPENDENT PRINTING ENERGY USE

HEATING ENERGY USE





# ADVANCED SOLUTIONS: THE REGENERATIVE DOUBLE DUCT (RDD)

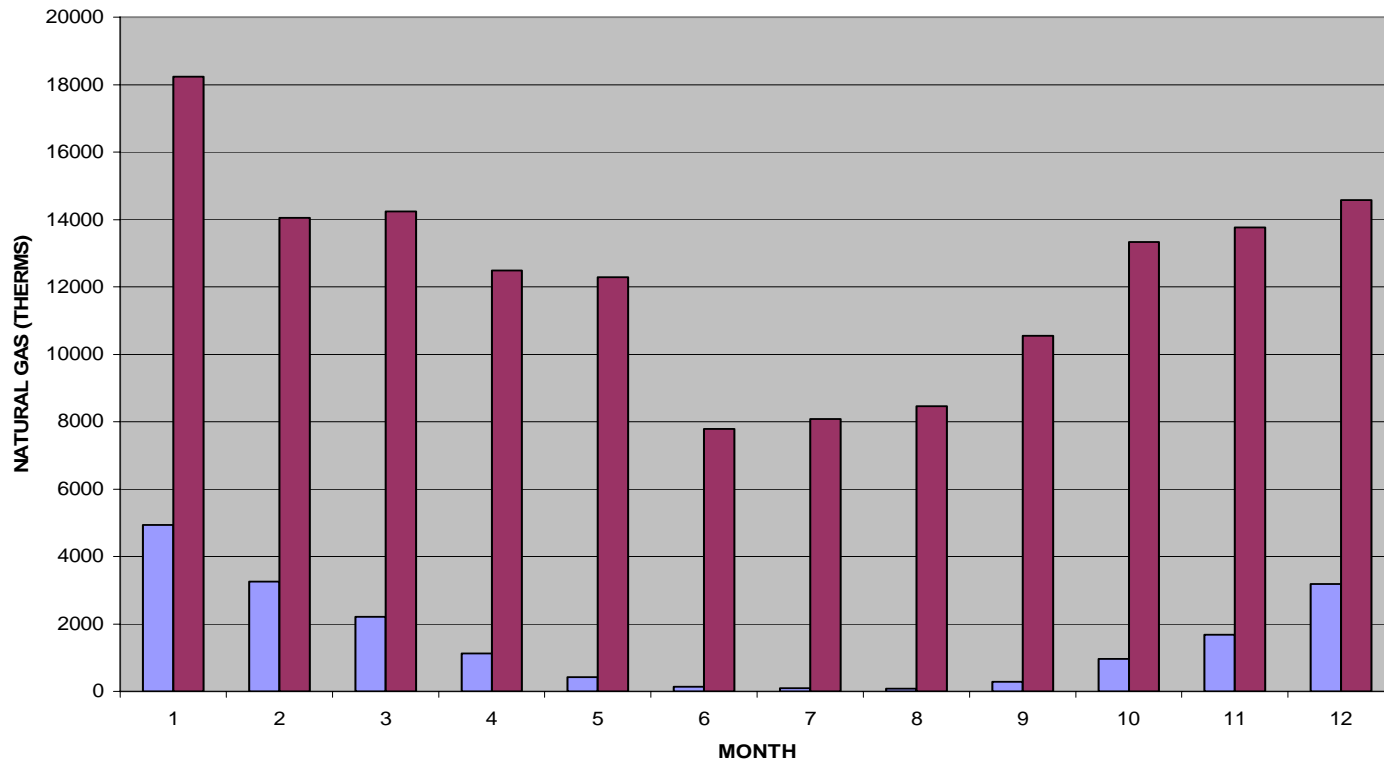




# CLINTONVILLE HS RDD

# PROJECTED NATURAL GAS USE

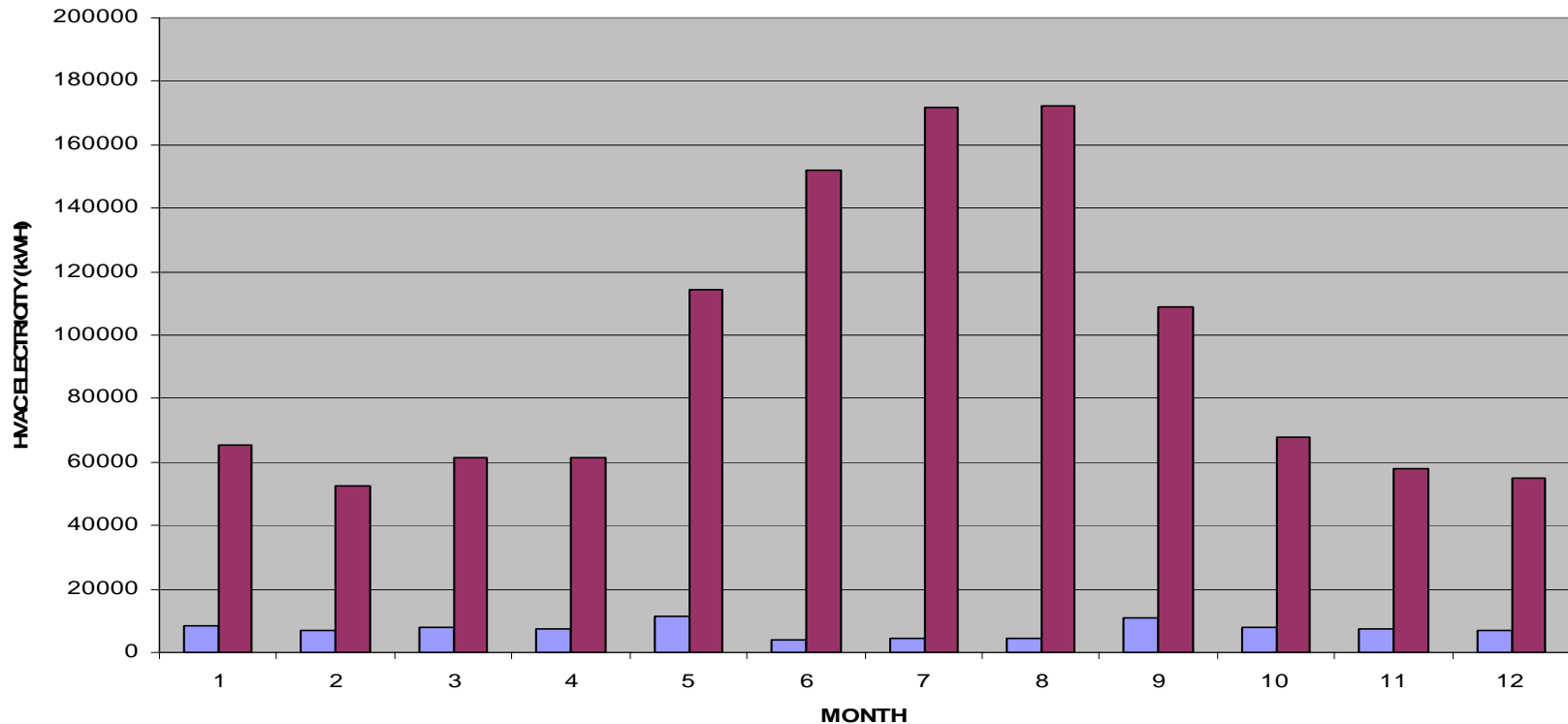
CLINTONVILLE HIGH SCHOOL





# CLINTONVILLE HS PROJECTED HVAC ELECTRICAL ENERGY USE

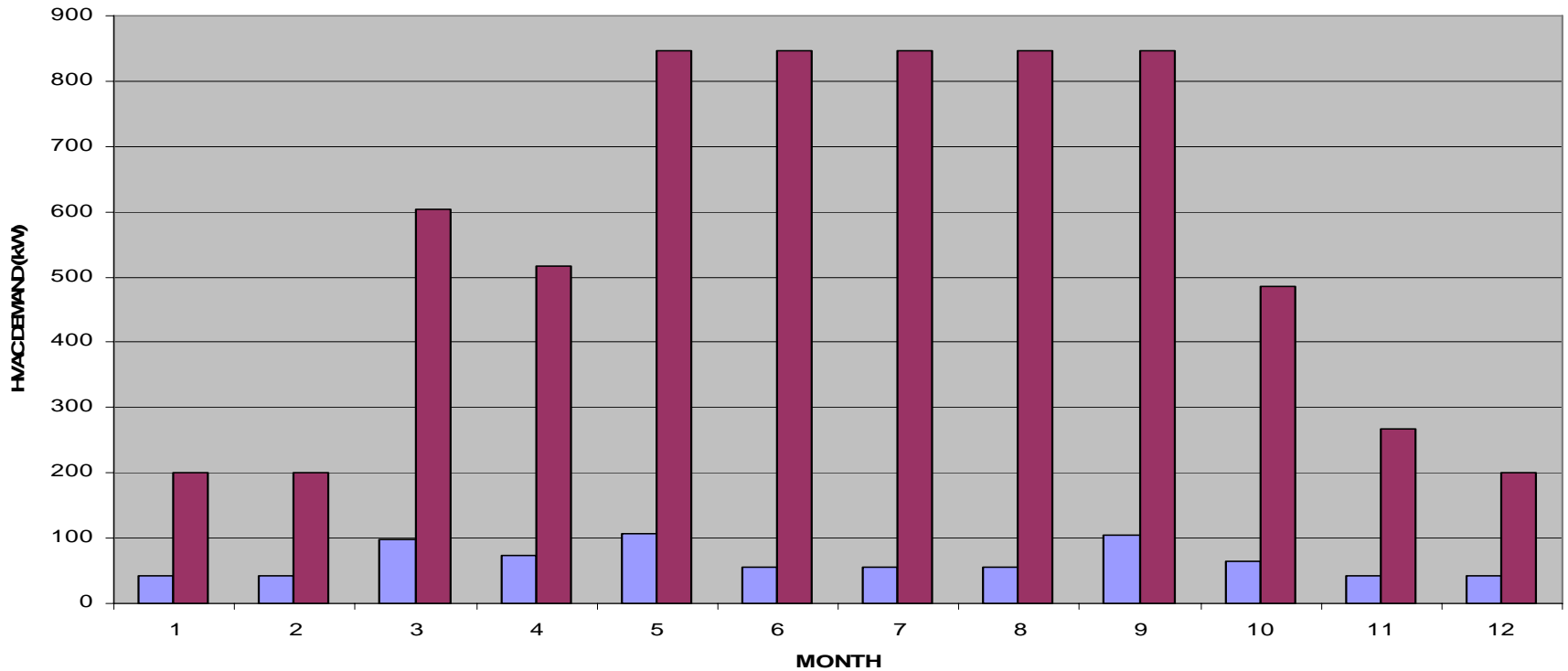
CLINTONVILLE HIGH SCHOOL





# CLINTONVILLE HS RDD HVAC ELECTRIC DEMAND

CLINTONVILLE HIGH SCHOOL





# Clintonville Actual Energy Costs

- ❖ HVAC system cost \$12.31/SF to build
- ❖ Energy costs closely matched estimates
- ❖ First year total energy costs, excluding pool heating were \$0.79/SF
- ❖ Clintonville HS runs 7 days/week, 7 am–11 pm
- ❖ Typical Wisconsin (5 days/week) school energy costs ~\$1.25/SF; typical YMCA ~\$3.00/SF



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# WAUSAU WEST HIGH SCHOOL Wausau, Wisconsin





# WAUSAU WEST HS

<b>Area (SF):</b>	<b>275,000</b>
<b>System Types:</b>	<b>Regenerative Double-Duct</b>
<b>Primary Heating Plant Reduction:</b>	<b>60%</b>
<b>Primary Cooling Plant Reduction:</b>	<b>92%</b>
<b>Gross Energy Use Reductions:</b>	
<b>Natural Gas</b>	<b>38%</b>
<b>Electricity (kWh)</b>	<b>28%</b>
<b>Electrical Demand</b>	<b>25%</b>
<b>Gross Energy Cost Reductions:</b>	<b>29%</b>
<b><u>Centerfold Project U.S. Dept. of Energy's 2002 Energy Smart Schools Calendar</u></b>	



# RDD NEW CONSTRUCTION COSTS (ALL IN MIDWEST)

## ❖ HVAC Costs

- \$10-\$13/SF (new)
- \$14-\$15/SF (retrofit)

## ❖ Electrical Costs

- \$6-9/SF (new)



# HOW CAN HIGH PERFORMANCE BUILDINGS COST LESS TO BUILD?

- ❖ Reduced thermal loads mean smaller boilers and chillers
- ❖ Reduced thermal loads mean smaller ductwork
- ❖ 100% outside air delivery means fewer AHUs, lower controls expense
- ❖ Smaller boilers and chillers mean smaller pumps, pipes, electrical and gas service
- ❖ Smaller equipment takes up less floor space



## COMPARISON OF OLD RIVER ROAD SCHOOL AND THOMPSON BROOK SCHOOL

School	Thompson Brook (Avon, CT)	Old River Road (Rockton, IL)
Ventilation	Re-circulation	100% outside air
Annual energy savings(2002 \$)	-----	\$63,000
HVAC Costs	\$21/SF	\$10.22/SF
Electrical Costs	\$11/SF	\$6/SF
Bldg. Area	100,000 SF	100,000 SF



# NEW HOWELL, NJ ELEMENTARY SCHOOLS (2)

- ❖ \$131/SF (\$138/SF budgeted)
- ❖ 70,000 SF each
- ❖ 100% O.A. ventilation
- ❖ 2 x 40 ton chillers
- ❖ 50 kW solar PV array (provides
- ❖ 5-6% of total energy)





## NEW HOWELL, NJ ELEMENTARY SCHOOLS (2)

- ❖ >60% less energy than ASHRAE Std. 90.1-1999
- ❖ LEED Silver expected
- ❖ 50% reduction in student absentee rates over first five months of operation



# 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
- ❖ >70% less energy than ASHRAE Std. 90.1-1999





# HOWELL MIDDLE SCHOOL DOE-2 HVAC ENERGY STUDY SUMMARY

	Regenerative Double Duct	Water- cooled VAV w/ Reheat	Air-cooled VAV w/ Reheat	Ground Source Heat Pump
Elect. (kWh)	150,948	325,940	381,055	584,355
Elect. (kW)	151	304	436	273
Gas (Therms)	12,326	37,571	37,571	6,417
Bldg. Total Energy (\$)	\$86,702	\$134,972	\$149,126	\$153,231



# **BENEFITS OF A HIGH PERFORMANCE HVAC SYSTEM**

- ❖ Superior indoor air quality (100% O.A.)
- ❖ Greatly reduced energy consumption (30-90%)
- ❖ Substantially reduced heating and cooling plant size and costs, alternative energy more attractive
- ❖ Easy to construct and maintain
- ❖ Competitive or lower construction costs
- ❖ Quiet (under 30 dBA and NC in classrooms)



# CONSTRUCTION BENEFITS OF A HIGH PERFORMANCE HVAC SYSTEM

- ❖ Fewer roof penetrations
- ❖ Fewer mechanical rooms, less total mechanical space
- ❖ Precise humidity control to protect interiors
- ❖ Ability for designers to “sell up” to owners on IAQ and energy performance instead of competing on price



# THE FUTURE AND WHAT IS POSSIBLE

- ❖ Zero net energy schools and other buildings at comparable construction costs (energy from solar + wind)
- ❖ Near zero net water consumption (rainwater recovery and cooling coil water recovery)



# The Message Again

- ❖ Vastly more energy-efficient HVAC systems are available than what you are used to (up to 10X better)
- ❖ They don't have to cost more to install
- ❖ They can and should even cost less than conventional HVAC systems especially when non-HVAC associated savings are included
- ❖ You don't have to trade off IAQ for energy efficiency



# Q&A