



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

HIGH PERFORMANCE HVAC SYSTEMS

Energy Solutions for Small Business & Agriculture

Sullivan County Community College

Loch Sheldrake, NY

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TOPICS TO BE DISCUSSED

- ❖ The Message
- ❖ ASHRAE Standard 62.1
- ❖ 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 cost less than conventional HVAC systems
- ❖ You don't have to trade off IAQ for energy efficiency



ASHRAE Std. 62.1-2004

- ❖ 15cfm/person at 100% ventilation effectiveness
- ❖ 30-60% relative humidity
- ❖ multiple spaces calculations reqd.





Liability Implications of Std. 62.1

- ❖ Is the professional standard of care in sick building lawsuits
- ❖ 1st thing plaintiff's counsel looks for in sick building litigation
- ❖ Well established case law
- ❖ Potential high financial and reputation costs



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

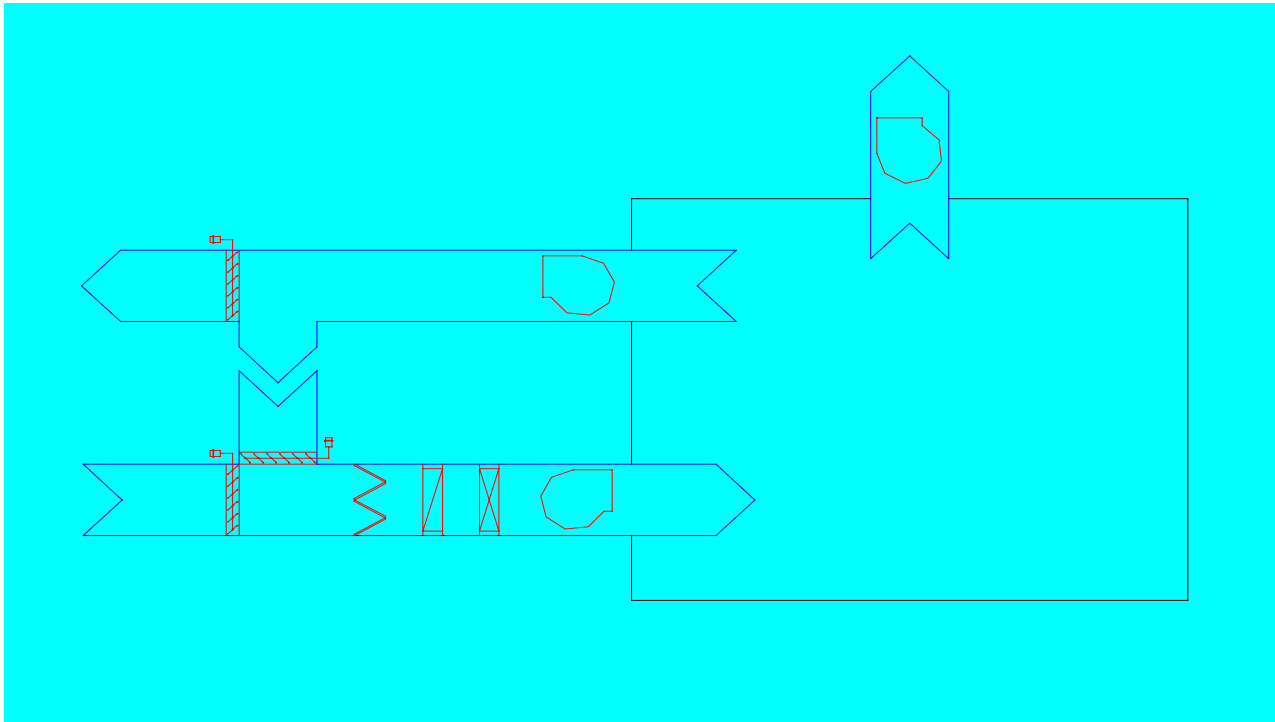
- ❖ World oil production will peak and then decline this decade
- ❖ World oil demand continues to increase, dollar is dropping
- ❖ Old HVAC systems in new bldgs. are 50-year long financial disasters for owners
- ❖ Dramatic reductions of energy use are needed





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

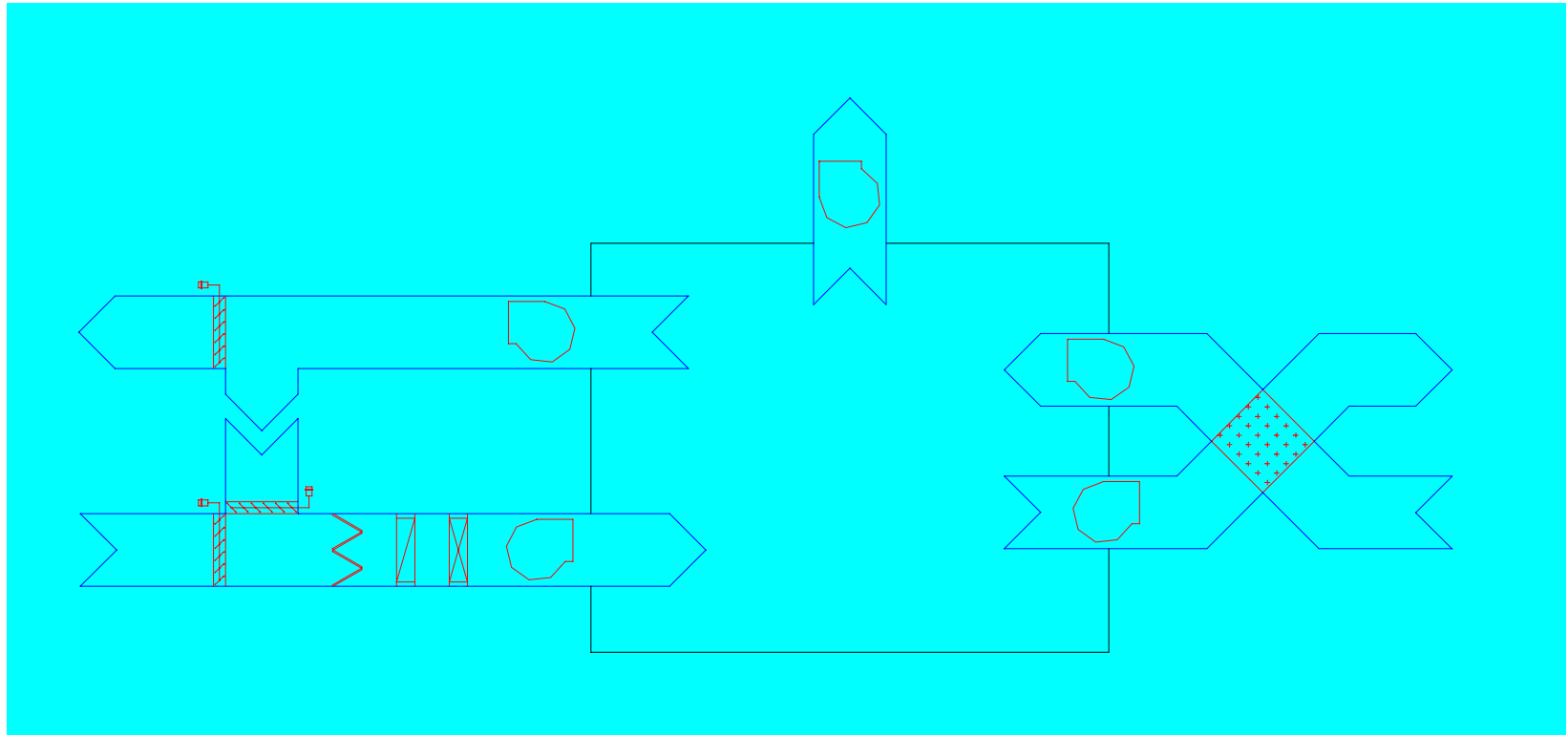


"GREEN" STRATEGIES

- ❖ 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



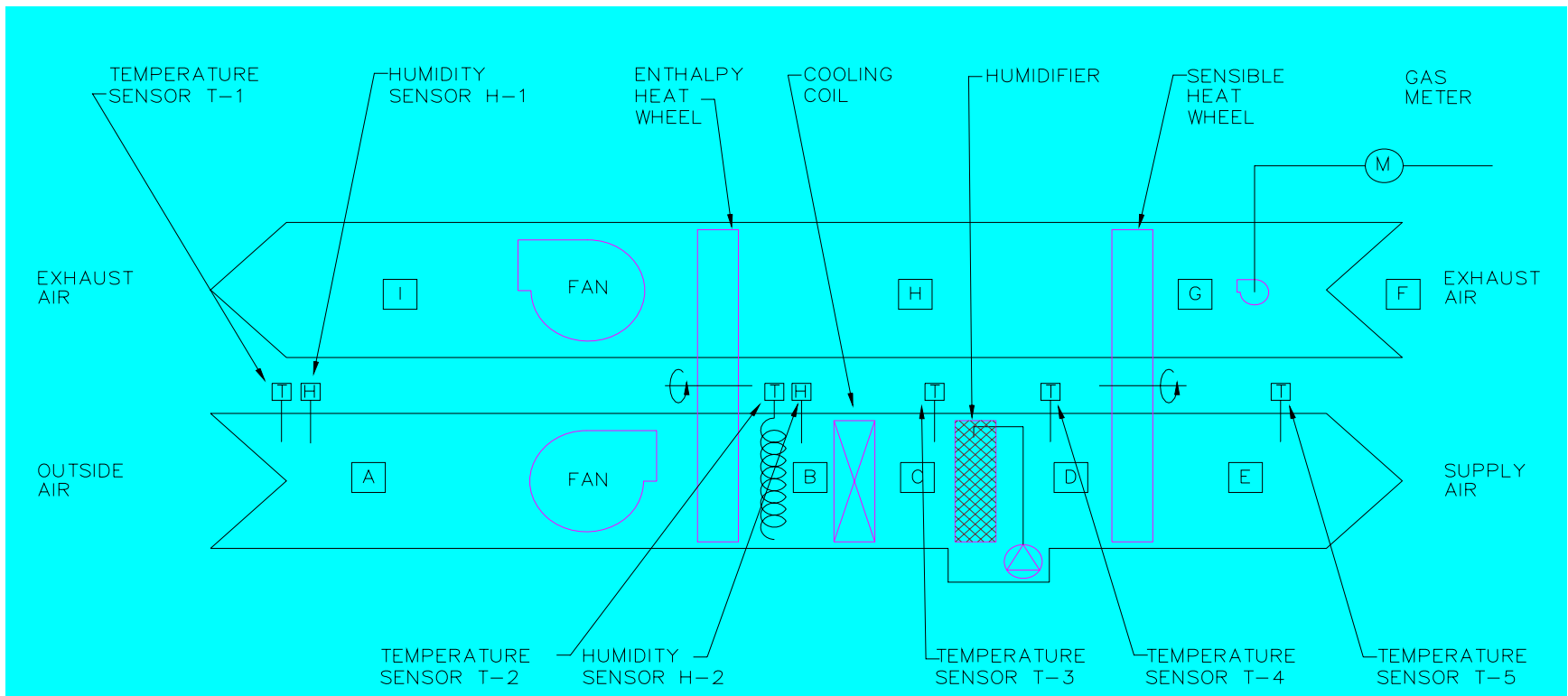
ALTERNATIVE SOLUTIONS – DUAL PATH SYSTEMS





ALTERNATIVE SOLUTIONS

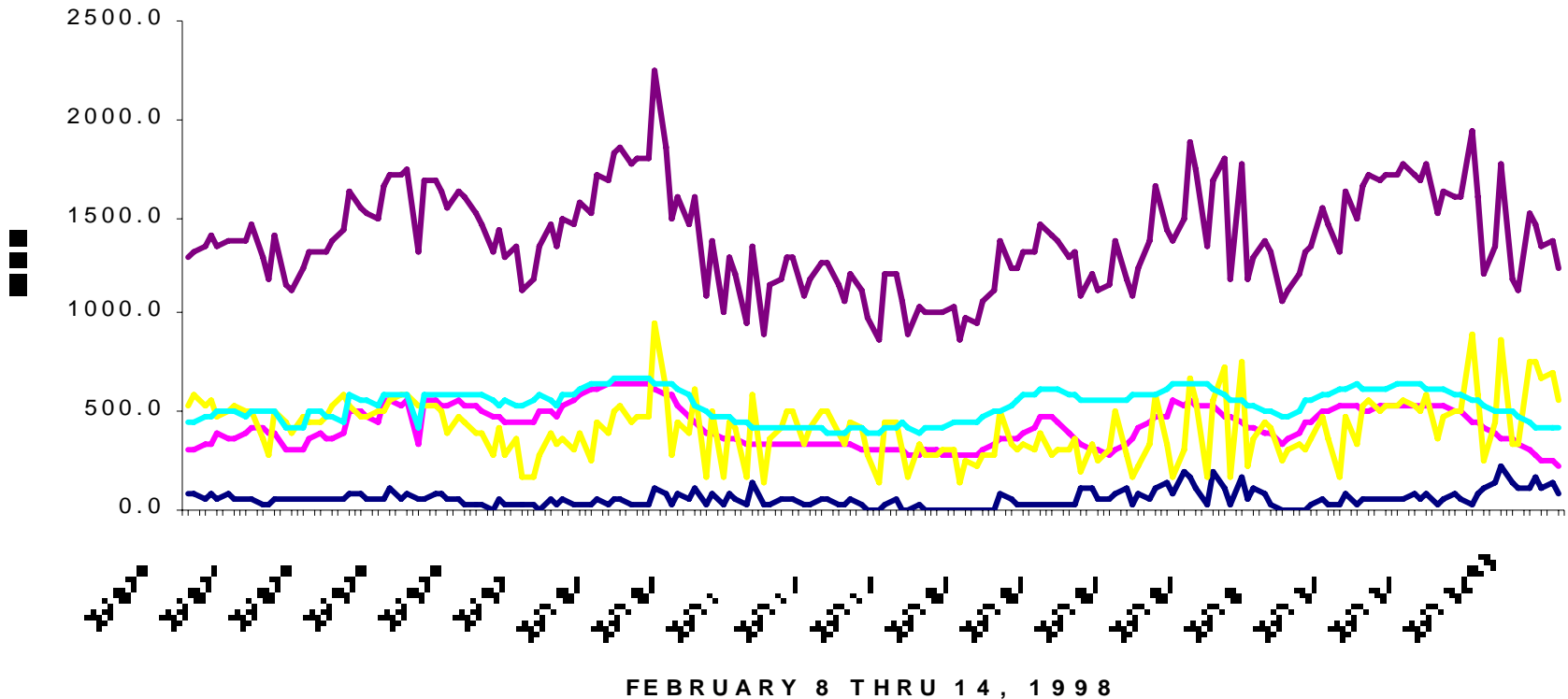
- Direct-Fired, Evaporatively Assisted
- Double Heat Wheel





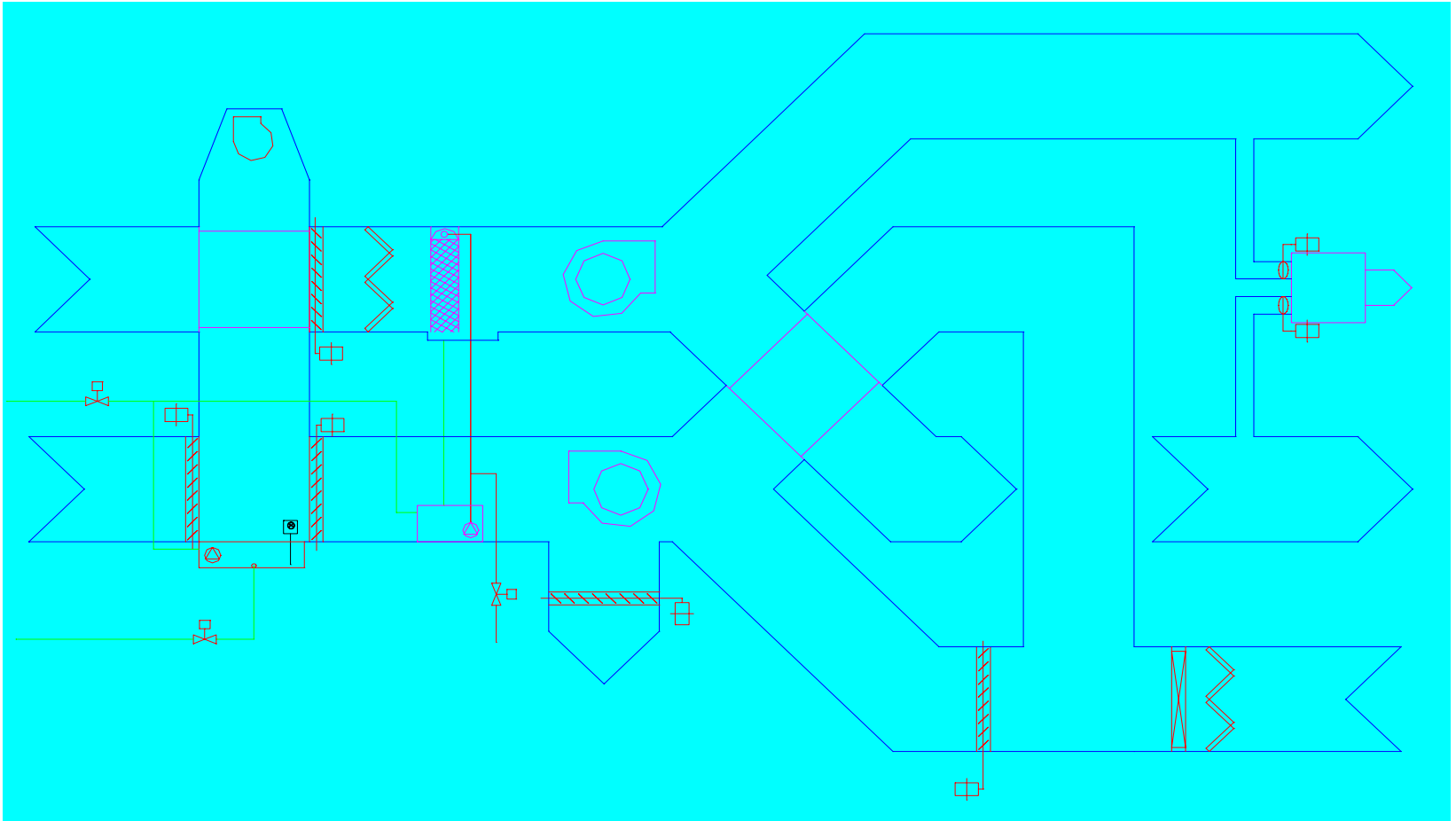
INDEPENDENT PRINTING ENERGY USE

HEATING ENERGY USE





ADVANCED SOLUTIONS: THE REGENERATIVE DOUBLE DUCT

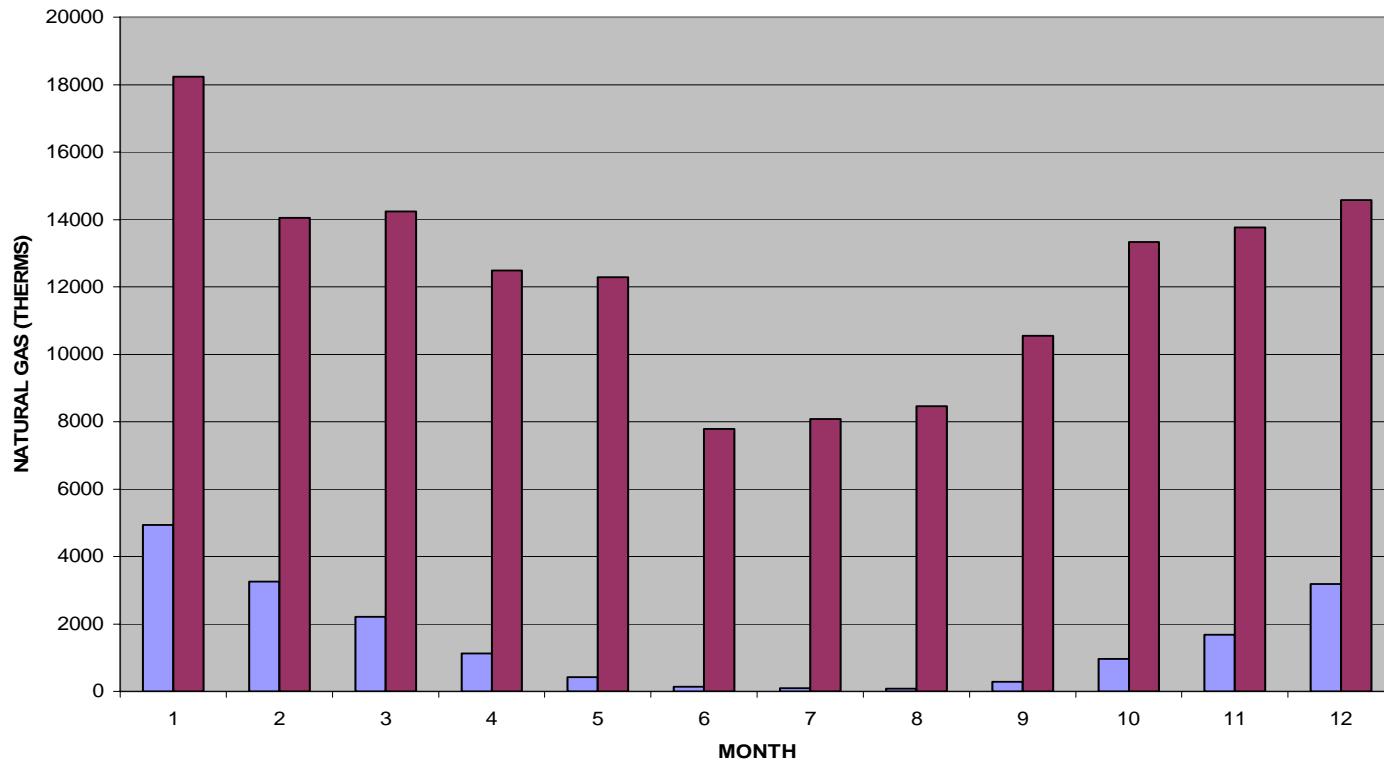




CLINTONVILLE HS RDD

PROJECTED NATURAL GAS USE

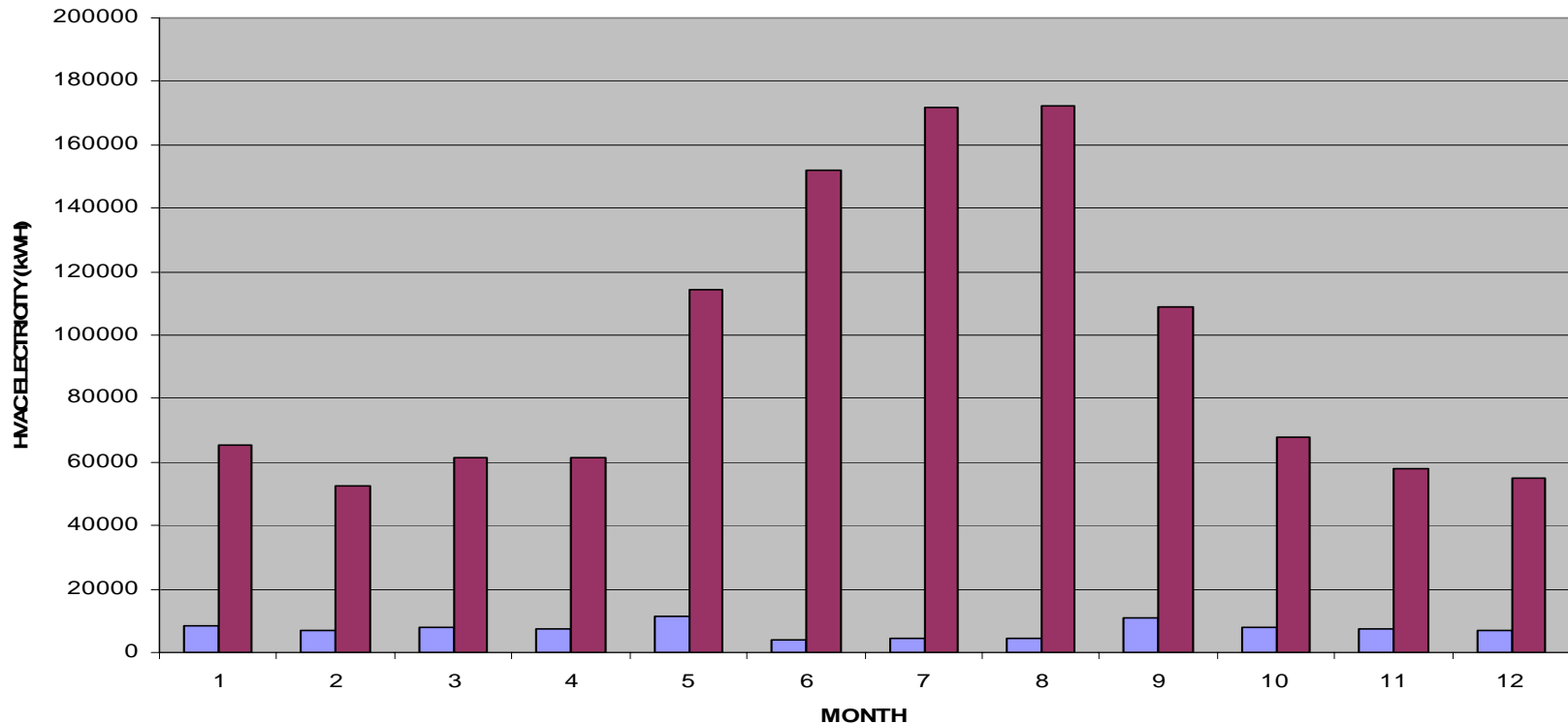
CLINTONVILLE HIGH SCHOOL





CLINTONVILLE HS PROJECTED HVAC ELECTRICAL ENERGY USE

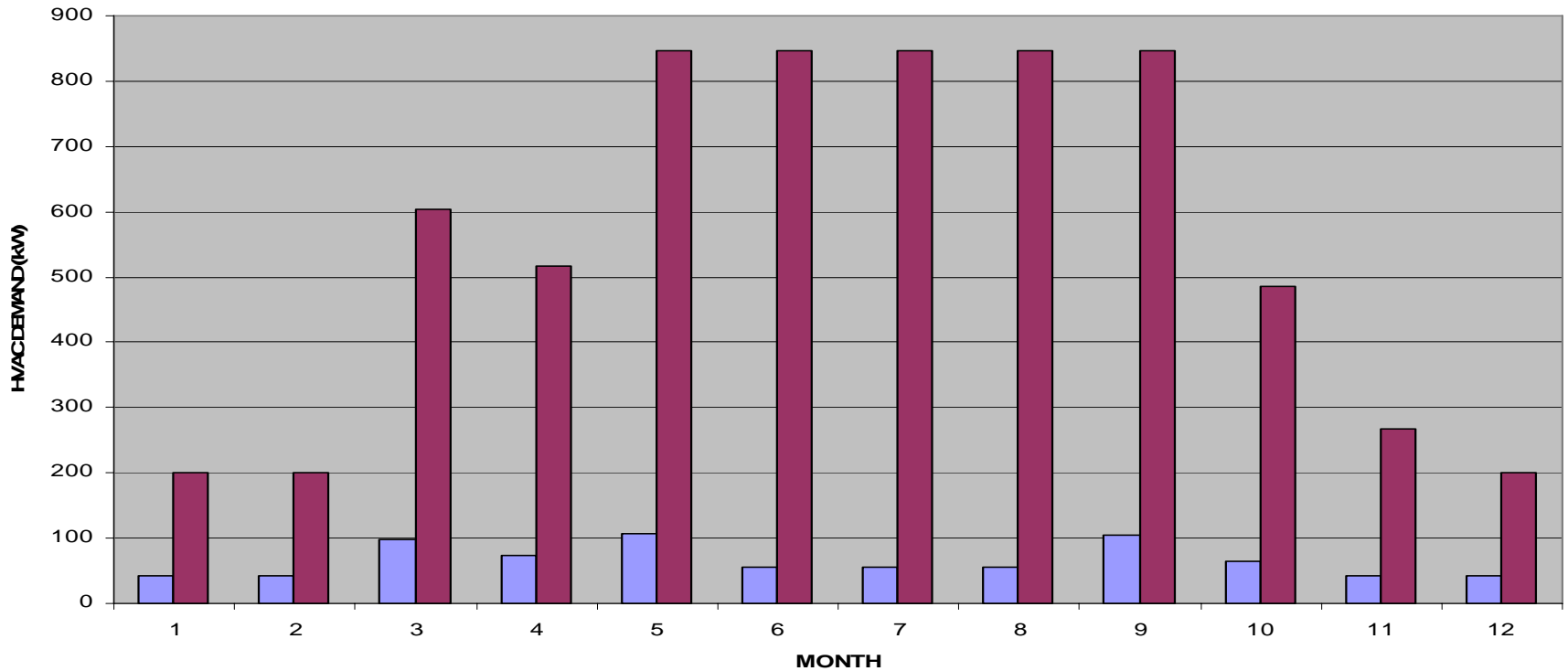
CLINTONVILLE HIGH SCHOOL





CLINTONVILLE HS RDD HVAC ELECTRIC DEMAND

CLINTONVILLE HIGH SCHOOL





Clintonville Actual Energy Costs

- ❖ HVAC system cost \$12.31/SF
- ❖ 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

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)	28%
Electrical Demand	25%
Gross Energy Cost Reductions:	29%
<u>Centerfold Project U.S. Dept. of Energy's 2002 Energy Smart Schools Calendar</u>	



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	-----	\$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 (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