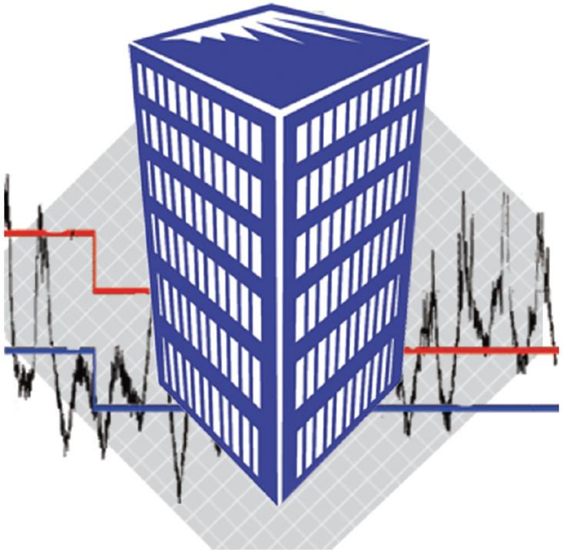
Retrofitting for Optimum HVAC Performance
by
Greg Jourdan
Wenatchee Valley College



“Diamonds are Forever”

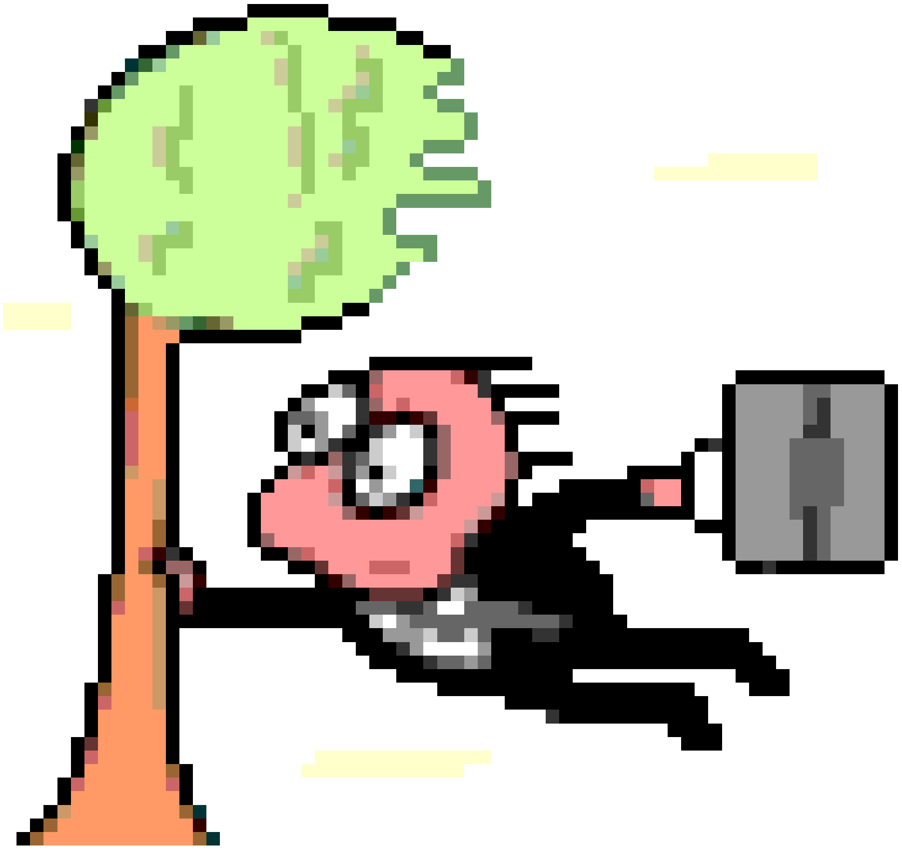
But the sparkle in your building may be wasted energy.

It’s the Little Things – The Low-Cost /No-Cost Changes That Save Energy

Agenda

- Upgrade Existing HVAC equipment
- Use controls for optimum performance and energy savings.
- Replace and updating existing controls
- Central chiller plant optimization
- Tuning up roof top units (RTUs)
- Commissioning and Tuning up
- ROI-Return on Investment
- Getting utility rebates to reduce capital costs

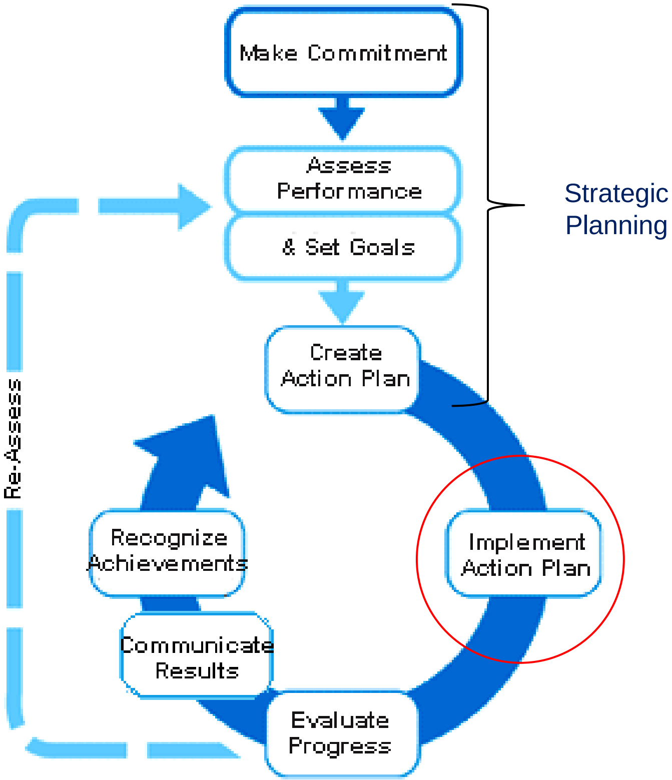
State of the Present Buildings: Blowing lots of Air but not Saving Much



Upgrading your equipment is an important step in a company's overall energy management plan

Energy-efficient Equipment Upgrades

- Writing and implementing an energy plan provides a strategy
  - Follow the eight-step process
  - A proven strategy for energy management developed by the EPA
  - Assists your organization in improving its energy and financial performance
  - Distinguishes your organization as an environmental leader
- Equipment upgrades are often required to maximize savings opportunities
  - Cost



Businesses are reducing their energy use by 30 percent or more through effective energy management practices *

* Source: EPA

Because financial investment is typically required, purchase and installment of equipment upgrades must be strategically planned

When is the Right Time to Upgrade?

- Low-cost, no-cost enhancements are typically made first
- Ideal times to upgrade to energy-efficient models and systems
  - As equipment fails
  - With a new facility or major remodel
  - As part of your energy plan

Knowing the estimated life span of your equipment helps determine when to upgrade

When Should Your Equipment Be Replaced?

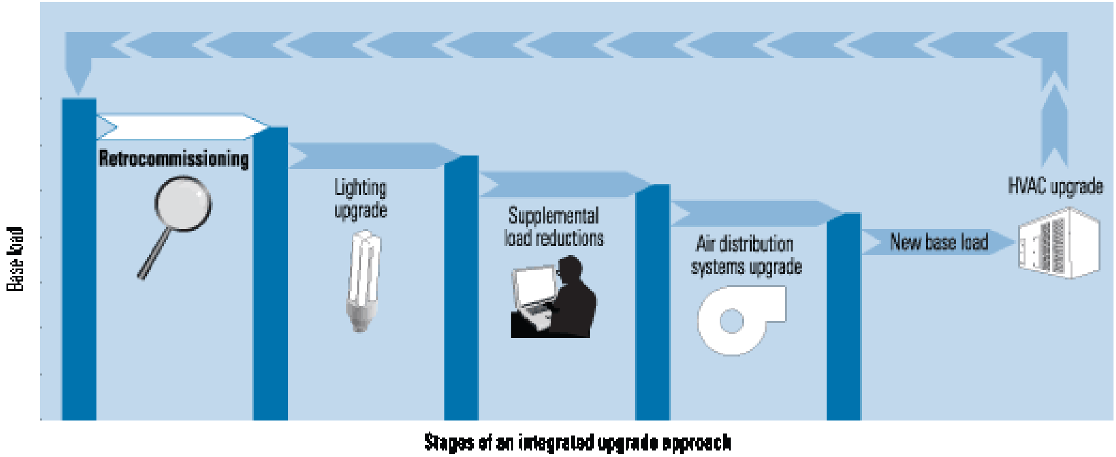
Equipment	Estimated Service Life	Factors
Motors	Not rated in terms of operation	• Deterioration of insulation performance • Wear of sliding parts • Deterioration of bearings
Lighting •Fluorescents •High Intensity Discharge (HID) •Electronic Ballasts	• 2 years for Fluorescent and HID lamps • Ballast operating life varies from 1 to 5.5 years based on manufacturer and type	• Turning lights off more frequently than the standard test time will diminish the life • Heat and voltage transients negatively affect ballasts
Water Heaters	6 , 9, or 12 years	Water properties (i.e., water softeners)
Chillers	15 - 25 years	Good maintenance practice required
Rooftop A/C	10 – 20 years	Good maintenance practice required
Boilers	19 – 29 years	• Boiler type (cast-iron and steel last longer than copper-tube) • Cycle times • Water type
Transformers	25 years	• Fluid maintenance • Winding resistance testing

Determining which initiatives to start with can be difficult, especially if a significant investment is required

Ways to Prioritize Opportunities

- Conduct a performance assessment to determine which items account for the highest consumption
- Determine the value of your proposed investment
  - Use Energy Star's Cash Flow Opportunity calculator (www.energystar.gov/index.cfm?c=business.bus financing)
- Consider a staged approach
  - Accounts for the interactions among all the energy flows in your building
  - A systematic method for planning upgrades that increases energy savings
  - Each stage includes changes that affect the upgrades performed in subsequent stages, producing the greatest possible energy and cost savings

Sample Staged Implementation



Courtesy: E source

Developing estimated savings of equipment upgrades can help prioritize initiatives

How Much Could You Save?

Upgrade to…	Realize Estimated Annual Savings of…
Motors	Varies from 85 percent (1 HP) to 95 percent (>75 HP) NEMA Premium Efficiency motors are 1 – 3 percent basis points more efficient than baseline motors
Lighting •T8 fluorescent lamps from T12 •Compact fluorescent lighting (from incandescent lighting) •High output fluorescent lighting (from probe start metal halide highbay lighting)	 •Up to 30 percent •Up to 75 percent •Over six times the rated life •Up to 30 percent
.5 kW/ton water cooled chiller (from .8 kW/ton)	37 percent
High performance windows	Six to eight percent Three year payback
10 EER rooftop A/C unit (from 8 EER)	20 percent
Daylighting (skylights/lightpipes, clerestory windows, roof monitors)	Range from $.25/ft2 to $.50/ft2 (Depends on building type, location, office area plan and local energy cost)
Occupancy sensors	Classrooms: 40 – 46 percent Private offices: 13 – 50 percent Restrooms: 30 – 90 percent Conference rooms: 22 – 65 percent Corridors: 30 – 80 percent Storage areas: 45 – 80 percent

•National data from independent studies

Many tools are available to help you develop your equipment checklist

Getting Started

Where To Begin

- Before deciding what investments to make, take an inventory of what equipment you have and determine what energy-saving opportunities exist
- Companies typically focus first on equipment and systems responsible for consuming the most energy

Energy Evaluation

- Your Utility will:
  - Evaluate your energy usage
  - Provide recommendations
  - Offer rebates
- You will receive:
  - Recommendations for installing energy improvements
  - Information about FPL's incentive programs
  - A list of low-cost measures that will help you save energy

Energy-efficiency Initiatives

- All buildings are controlled with a building automation system
  - Temperatures and lighting schedules are universal and set and controlled at the corporate office
  - Occupied, maintenance and unoccupied modes
  - Measure and monitor temperatures and energy use
- Third party billing program
  - Data base with usage and rates
  - Review of usage patterns
  - Use Energy Star Portfolio Manager

Even if your air conditioner is only 10 years old, you may save 20 percent on your cooling costs by replacing it with a newer, more efficient model

Incentives on A/C Equipment

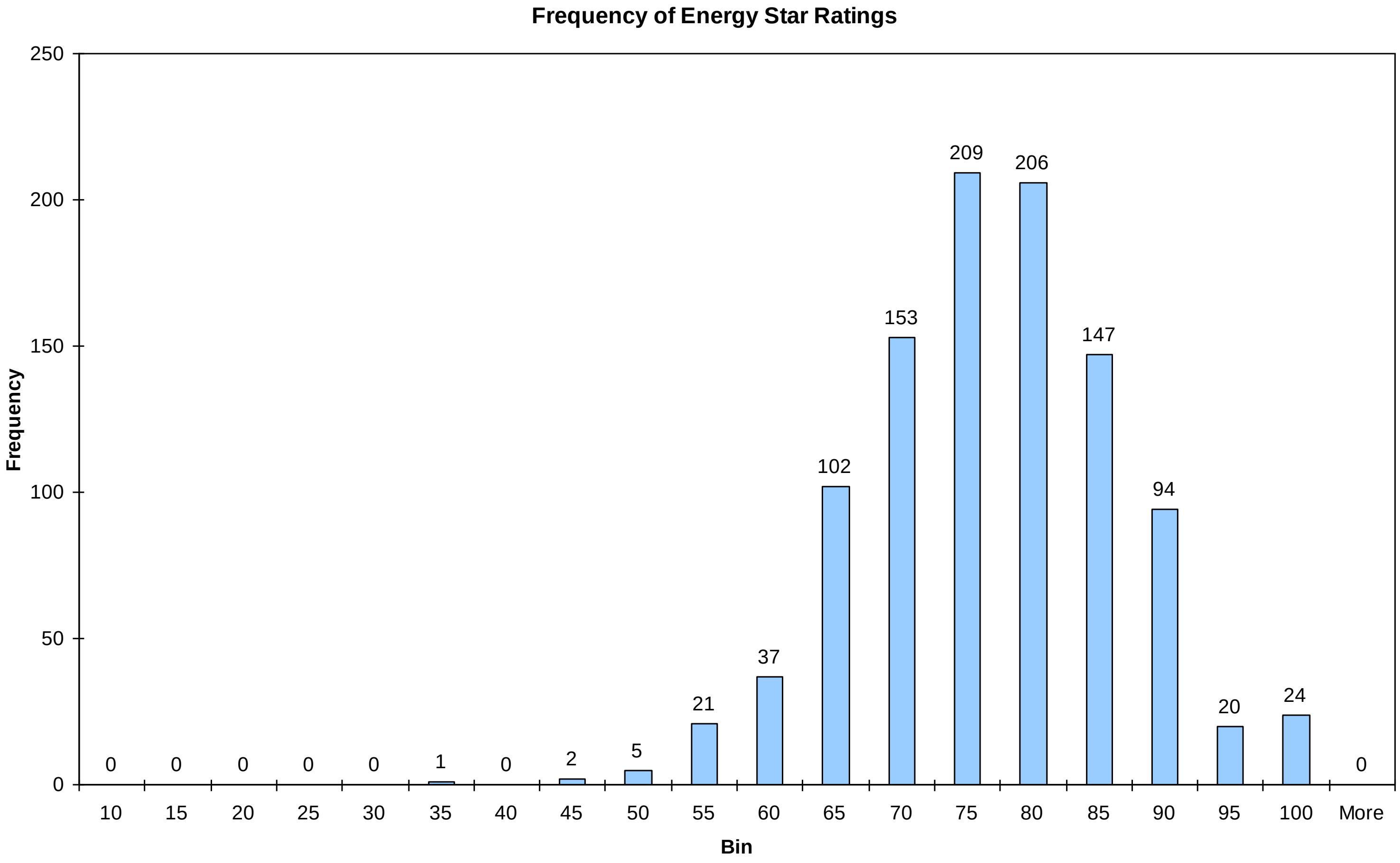
Qualification Requirements	Utility Incentives
• Reduced cooling costs • Lower maintenance costs • Comfortable environment for employees and customers	Rebate on qualifying high efficiency split/packaged DX unit • Replacements • Units installed during new construction • Rebates vary by size, type and efficiency of the new unit • Air-, water- or evaporative-cooled A/C or heat pump • Room units, including package terminal A/C or heat pump

Energy Star's Portfolio Manager helps you benchmark your energy usage

Energy Star Portfolio Manager

- Benchmarks your buildings against other similar sites
- Score 0 to 100 based on your efficiency
- Score 75 or better to earn Energy Star label for your building
- Use the data to determine your focus

Energy Star Scores and Compares you Buildings



Air Conditioning and Refrigeration contribute 25 to 60 percent of the buildings energy use

Air Conditioning

Upgrade Strategy

1. Use savings calculators to evaluate potential payback
   - http://www.energystar.gov/index.cfm?c=commer_refrig.pr_proc_commercial_refrigerators
2. Identify key product requirements based on your business needs
3. Source qualified products
4. Determine where to buy
5. Understand installation requirements
6. Develop and implement a maintenance plan

Heating Ventilation and Air-Conditioning (HVAC) Equipment

Upgrade Strategy

1. Reduce load on existing system(s)
2. Get quotes
   - Compare cost of standard unit to high efficiency unit, including lifecycle costs
   - Request that your HVAC professional conduct an Air Conditioning Contractors of America's (ACCA) Manual N Commercial Load Calculation to ensure proper sizing
3. Consider system enhancements based on your facility type and business requirements
   - Heating / Cooling unit upgrade
   - Energy Recovery Ventilation (ERV) system
   - Chiller
   - Thermal Energy Storage
4. Evaluate control systems to manage your new system's load
   - Demand Control Ventilation (DCV)
   - Programmable thermostat
   - Multiple zones

Upgrading a 10-ton unit from a 10.3 to a 13 EER system could produce an annual savings of $770

Sample Annual Savings: Direct Expansion Air Conditioner and Heat Pumps

Annual Hours of Operation	10.5 EER	11 EER	11.5 EER	12 EER	12.5 EER	13 EER	13.5 EER	14 EER
1000	$ 29	$ 96	$ 157	$ 213	$ 265	$ 312	$ 356	$ 397
1500	$ 35	$ 116	$ 190	$ 258	$ 320	$ 378	$ 431	$ 481
2500	$ 47	$ 156	$ 255	$ 347	$ 431	$ 508	$ 580	$ 647
3500	$ 59	$ 196	$ 321	$ 436	$ 542	$ 639	$ 730	$ 813
4500	$ 71	$ 236	$ 387	$ 525	$ 653	$ 770	$ 879	$ 980
5500	$ 83	$ 276	$ 453	$ 614	$ 763	$ 901	$ 1,028	$ 1,146
6500	$ 95	$ 316	$ 518	$ 704	$ 874	$ 1,032	$ 1,177	$ 1,313
7500	$ 107	$ 356	$ 584	$ 793	$ 985	$ 1,162	$ 1,327	$ 1,479
8500	$ 119	$ 396	$ 650	$ 882	$ 1,096	$ 1,293	$ 1,476	$ 1,646

Based on an existing 10-ton unit with an EER of 10.3, operating 10 months a year at $.082/kwh and $9.10/kwd rate plus 10 percent tax.

Even if your air conditioner is only 10 years old, you may save 20 percent on your cooling energy costs by replacing it with a newer, more efficient model

Approximately half of all U.S. commercial floor space is cooled by self-contained packaged air-conditioning units that have recently-improved energy-efficiency standards

Packaged Rooftop Air Conditioners

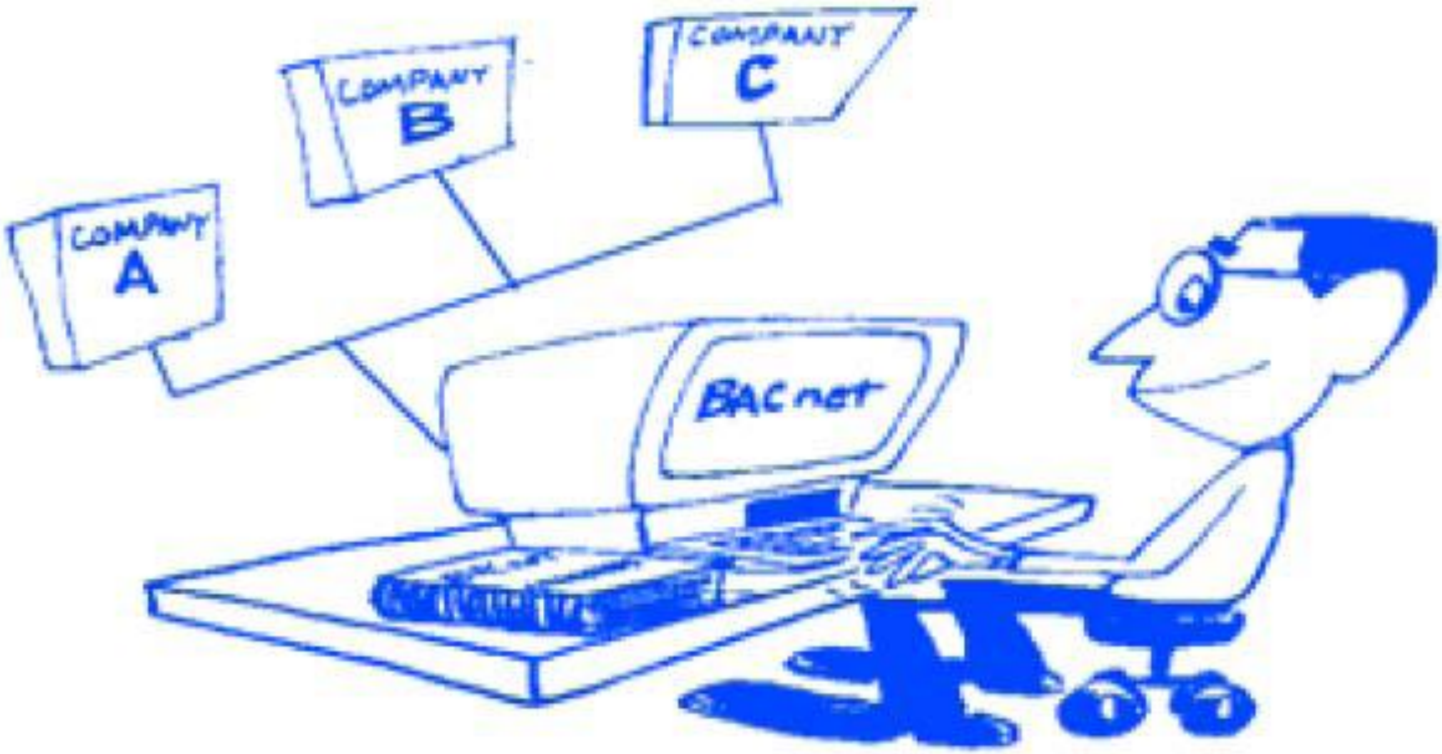
- Self-contained units that sit on rooftops
- Mass-produced machines include:
  - Cooling equipment
  - Air-handling fans
  - Gas or electric heating equipment (sometimes)
- Available in sizes ranging from one to more than 100 tons of air-conditioning capacity
- Energy-efficiency considerations
  - Select the right size
  - Consider high-efficiency levels recommended by the Consortium for Energy Efficiency
  - Evaluate high-efficiency models by performing a cost-effectiveness calculation
  - Pay attention to design, commissioning and maintenance

© E Source

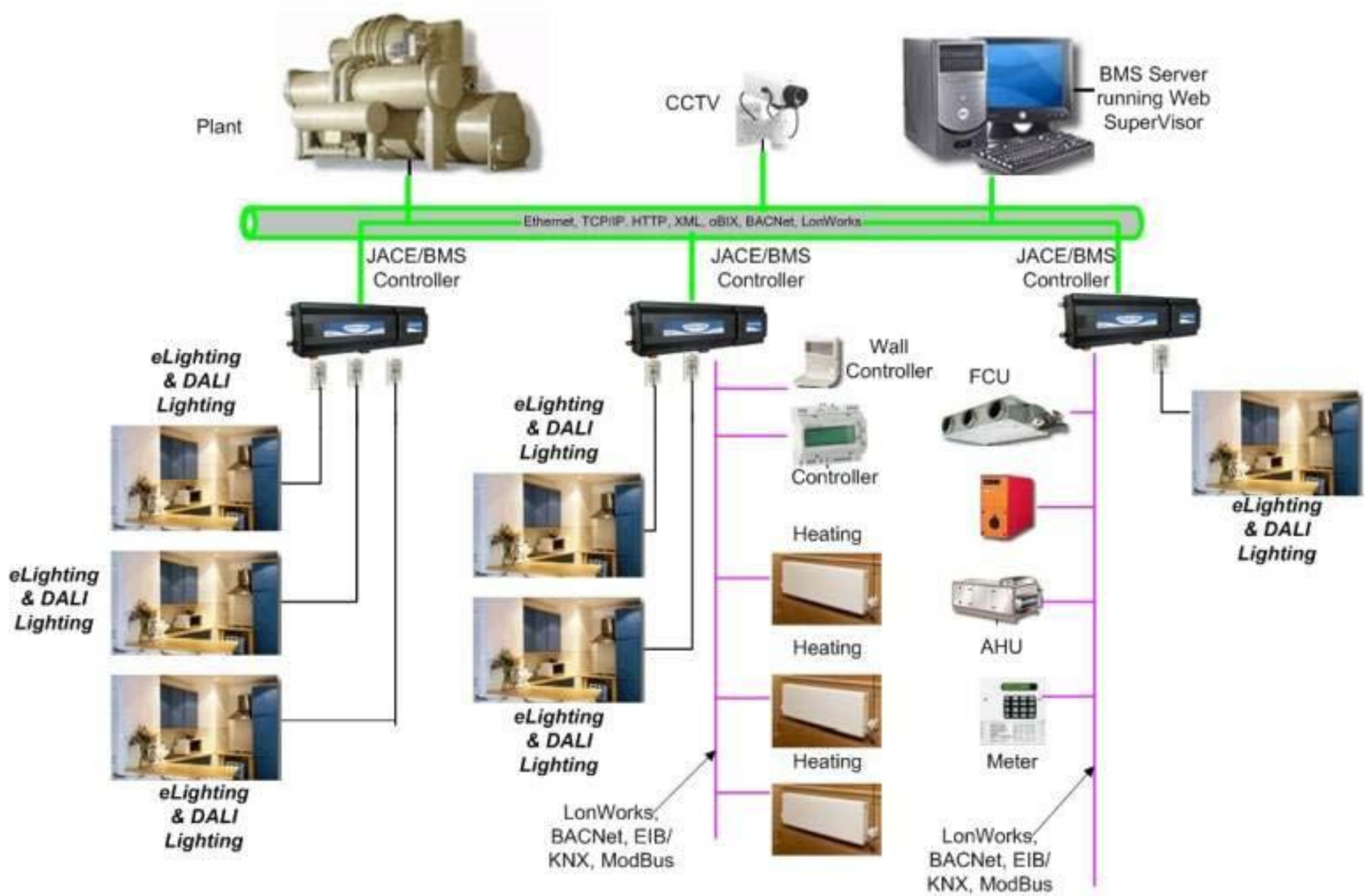
Unitary Air Conditioner Minimum Efficiency Requirements ASHRAE 90.1-2004		
	Full-load EER (Btu/watt)	
Size Range	Pre-2010	As of 2010*
65-135 kBtu/hr (5-11 ton)	10.3	11.2
135-240 kBtu/hr (11-20 ton)	9.7	11.0
240-760 kBtu/hr (20-63 ton)	9.5	10.0
>760 kBtu/hr (>63 ton)	9.2	9.7

DDC Controls-Use Open Networks BacNet (don't be confused with multiple systems)

DDC Controls-Use Open Networks BacNet (View all controls from one network)

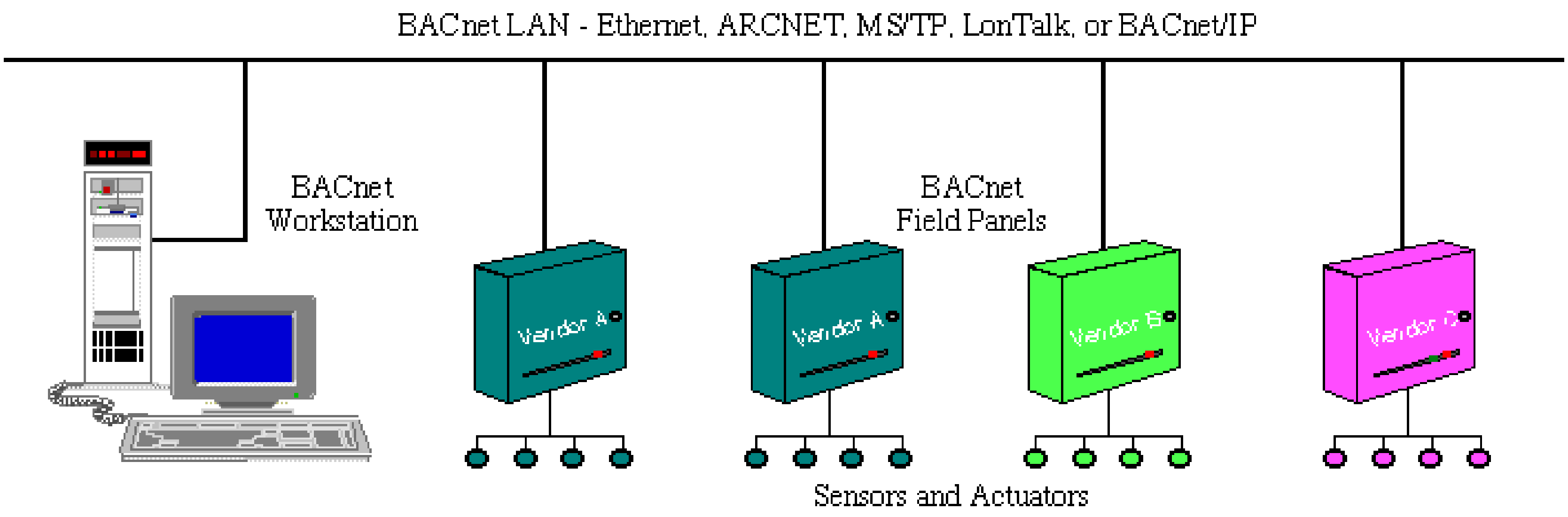


DDC Control Intervention is the Key



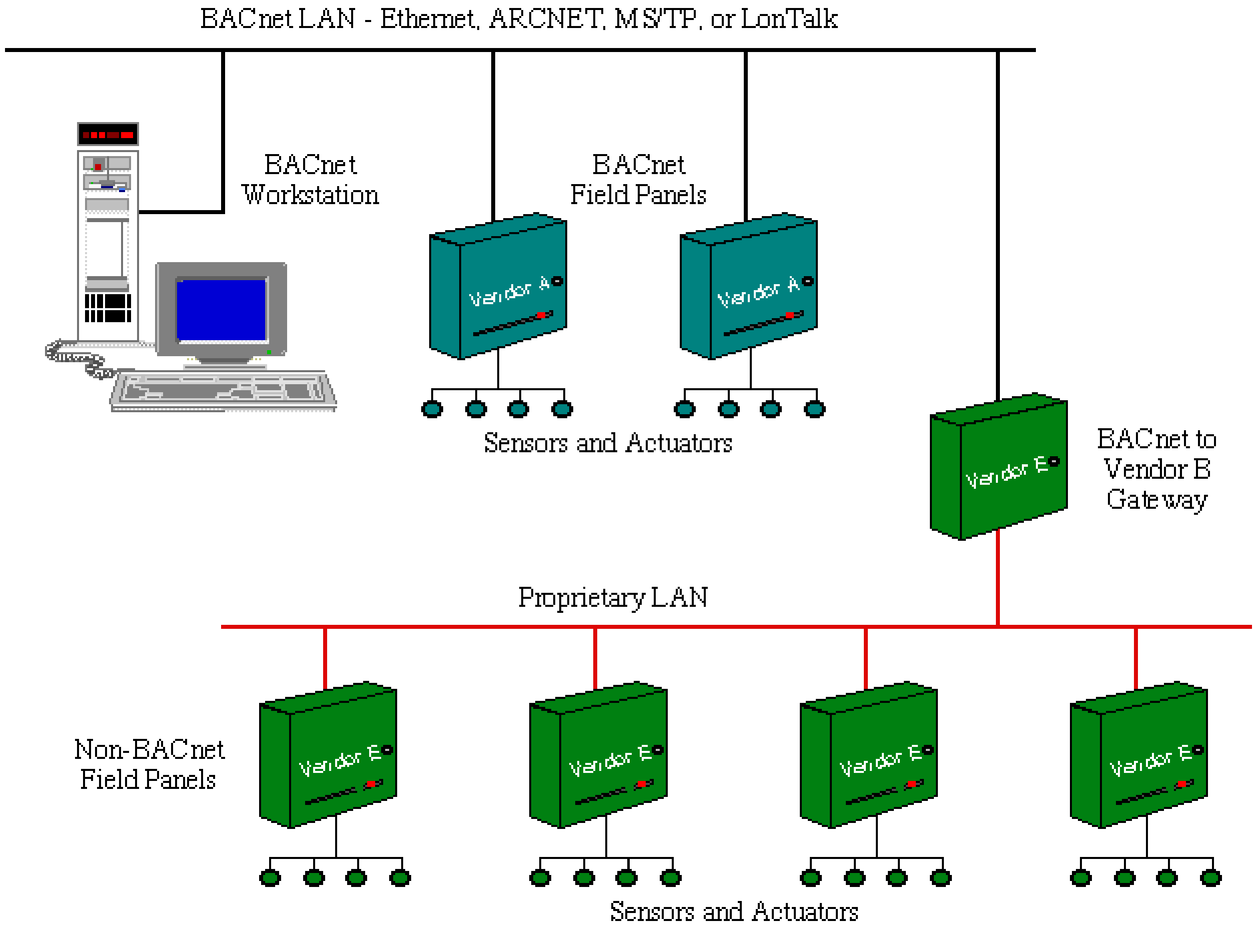
DDC Controls

Be Sure Your DDC Controls Vendor is Using BacNet



DDC Controls

- BacNet



Demand Control Ventilation adjusts ventilation rates based on actual occupancy at any given time

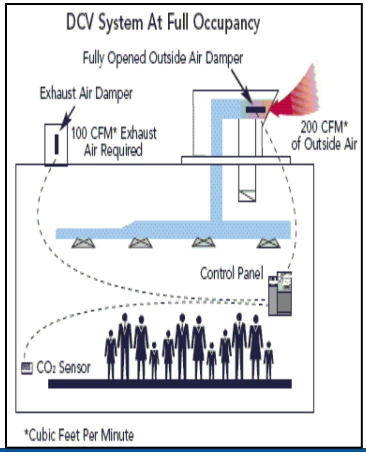
Demand Control Ventilation (DCV)

What is DCV?

- A system that controls a building's ventilation based on carbon dioxide (CO2) concentration
  - Sensors monitor the CO2 levels and send a signal to the HVAC system
  - Brings in only the air necessary for the actual occupancy
- Best for businesses with long operating hours, where occupancy varies greatly and is unpredictable
  - Stores, supermarkets, theaters and places of worship

Benefits to DCV

- Easily added to existing HVAC systems
- Reduces A/C costs by up to 10 percent or more annually
- Helps HVAC equipment operate more efficiently and last longer
- Maintains indoor air quality and comfort more efficiently



CO_2 sensors for demand control ventilation

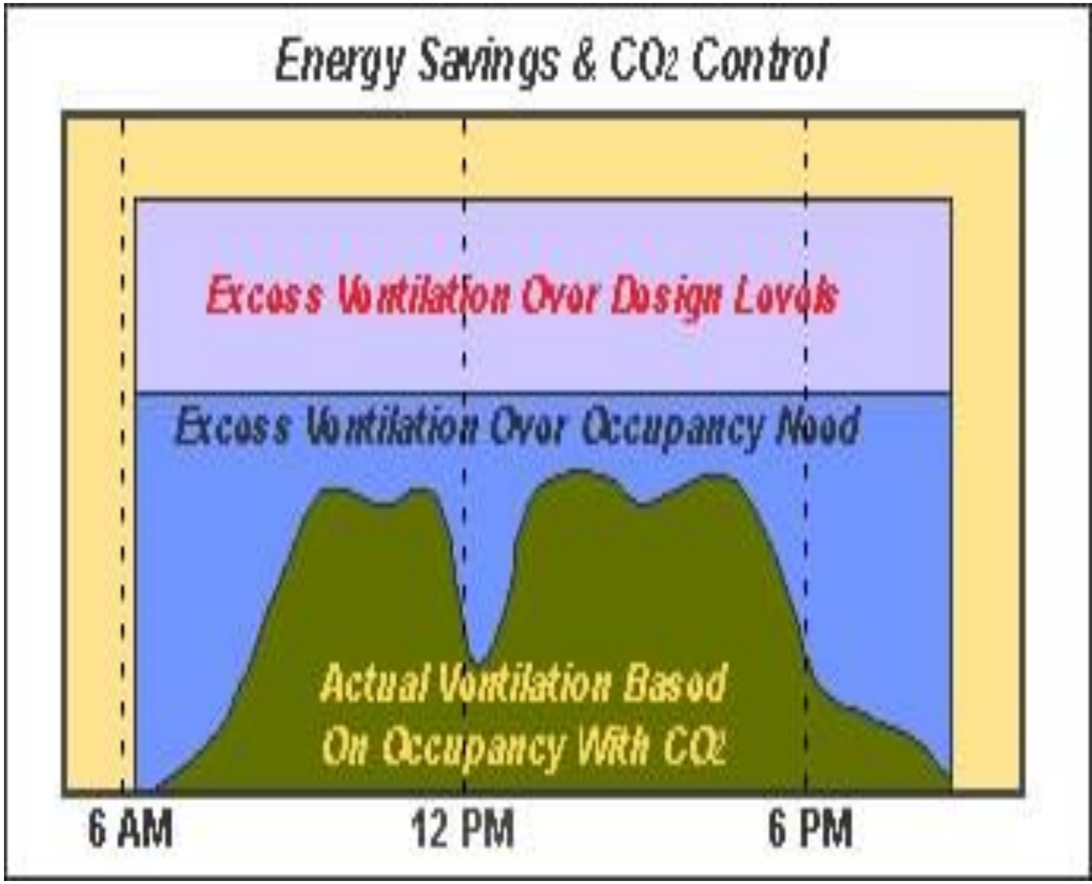
- Building air intakes are not measured and the delivery of outside air is not controlled, generally resulting in significant over-ventilation.
- Most buildings are over-ventilated 200% to 400% in excess of actual need., especially those with significant occupancy swings .
- CO_2 system determines real-time occupancy throughout the building and adjusts outside air to match the need and cut HVAC cost 5- 20%.

Ventilation control CO2 sensor technology

Elimination of excess outside air ventilation can save up to 20%

The cost for heating or cooling of excessive outside air for building ventilation can be up to 20% of HVAC cost.

There are occupancy variations and excess ventilation over design in most buildings.

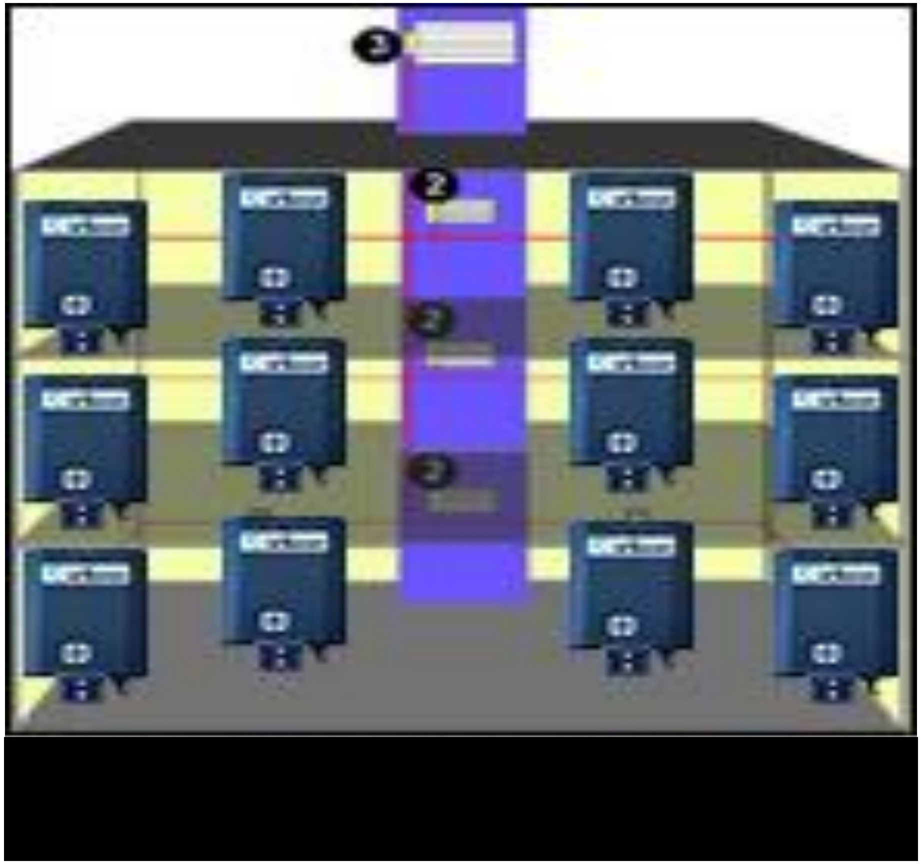


Ventilation control CO2 sensor Technology

Elimination of excess outside air ventilation for major energy savings

The City of Seattle has standardized on the AirTest CO2 sensor… although there was significant savings on cooling cost, the big savings was on heating costs.

— Seattle City Light



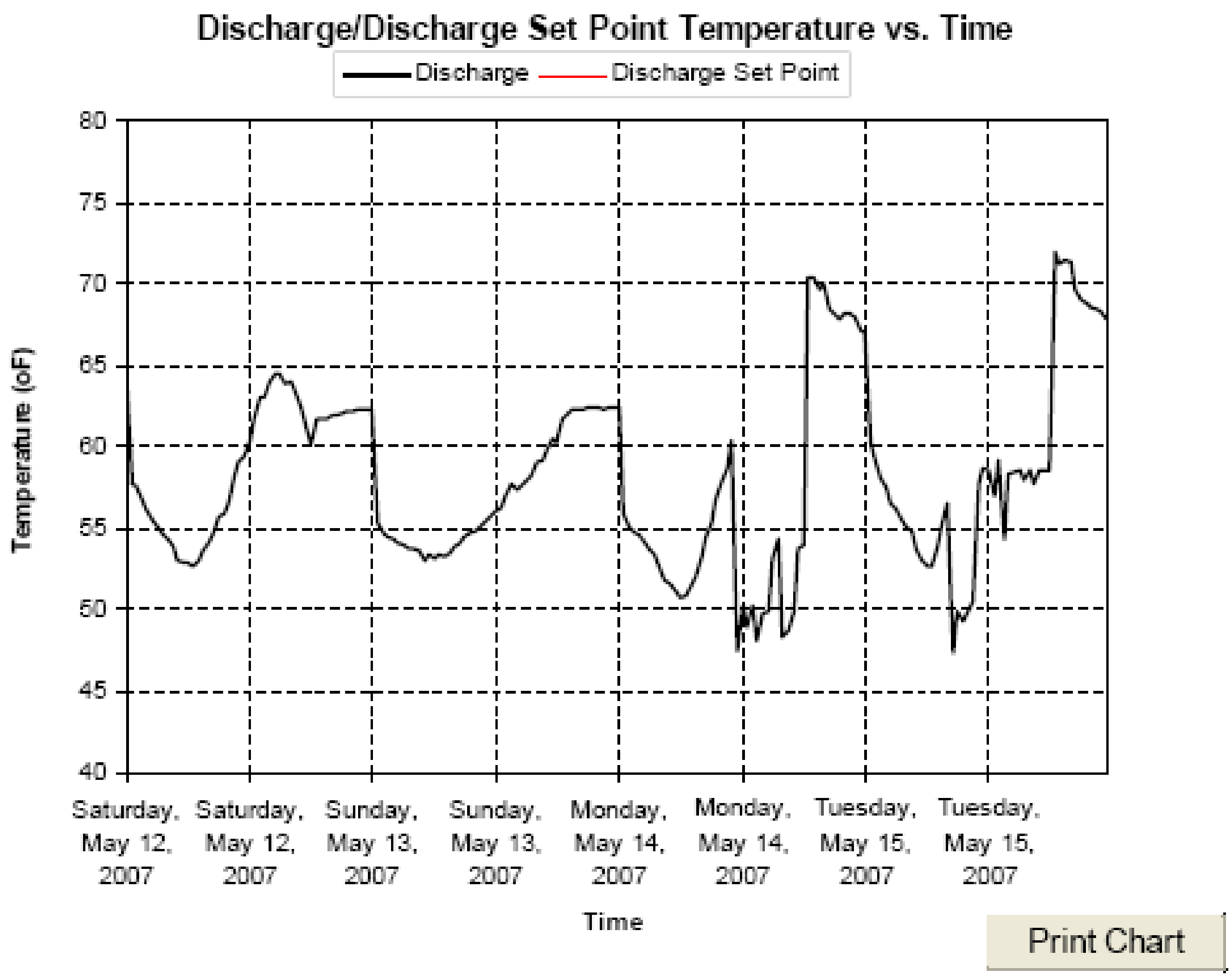
Occupancy Scheduling

- Shut off systems whenever possible
  - – Night unoccupied schedules
  - – Weekend unoccupied schedules
  - – Daytime no or low use unoccupied schedules
    - - Auditorium, class rooms, conference rooms
  - – Includes lighting
  - – Includes specialized exhaust
  - – Do not restart too early- Use a startup schedule based on building needs
  - – Do not use fresh air during warm-up except last 30 minutes for flushing building

Discharge-Air Temperature Control

- Discharge-air temperature control is designed to:
  - Cool a building based on:
    - Internal heat loads (as specified in preliminary specs)
      - May included interior and exterior zones
    - Outside weather conditions per design
    - Set to lowest temp to cool warmest design day
- Heat a building based on:
  - Internal loads (as specified in preliminary specs)
  - May included interior and exterior zones
  - Outside weather conditions per design
  - Set to warmest condition to heat on the coolest design day

Discharge-Air Temperature Control (Continued) Supply Fan 1



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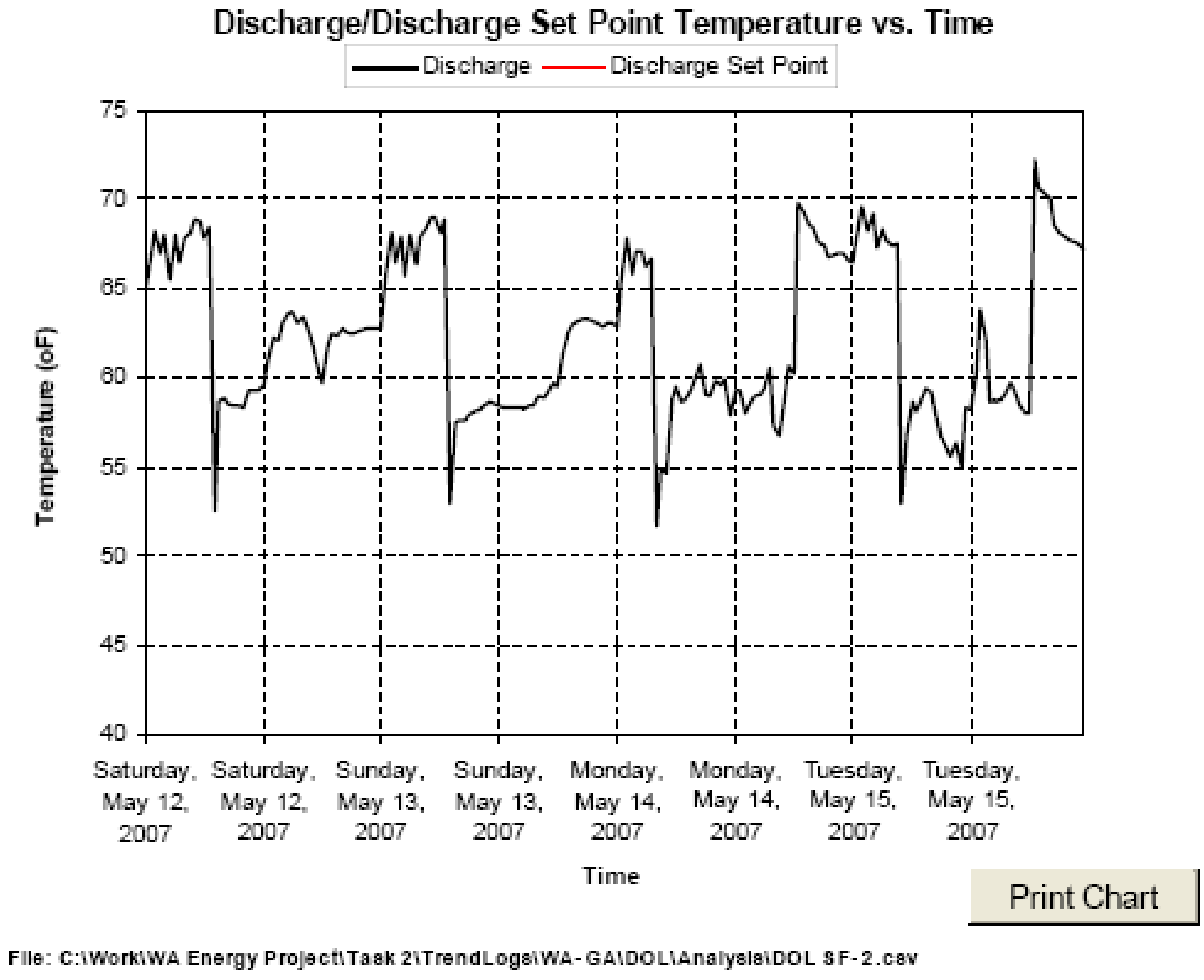
Discharge-Air Temperature Control (Continued) Supply Fan 2



Discharge-Static Pressure Control (Continued)

- Does the discharge static vary with some input signals?

  – Like discharge-air temperature, discharge static should follow the real load conditions

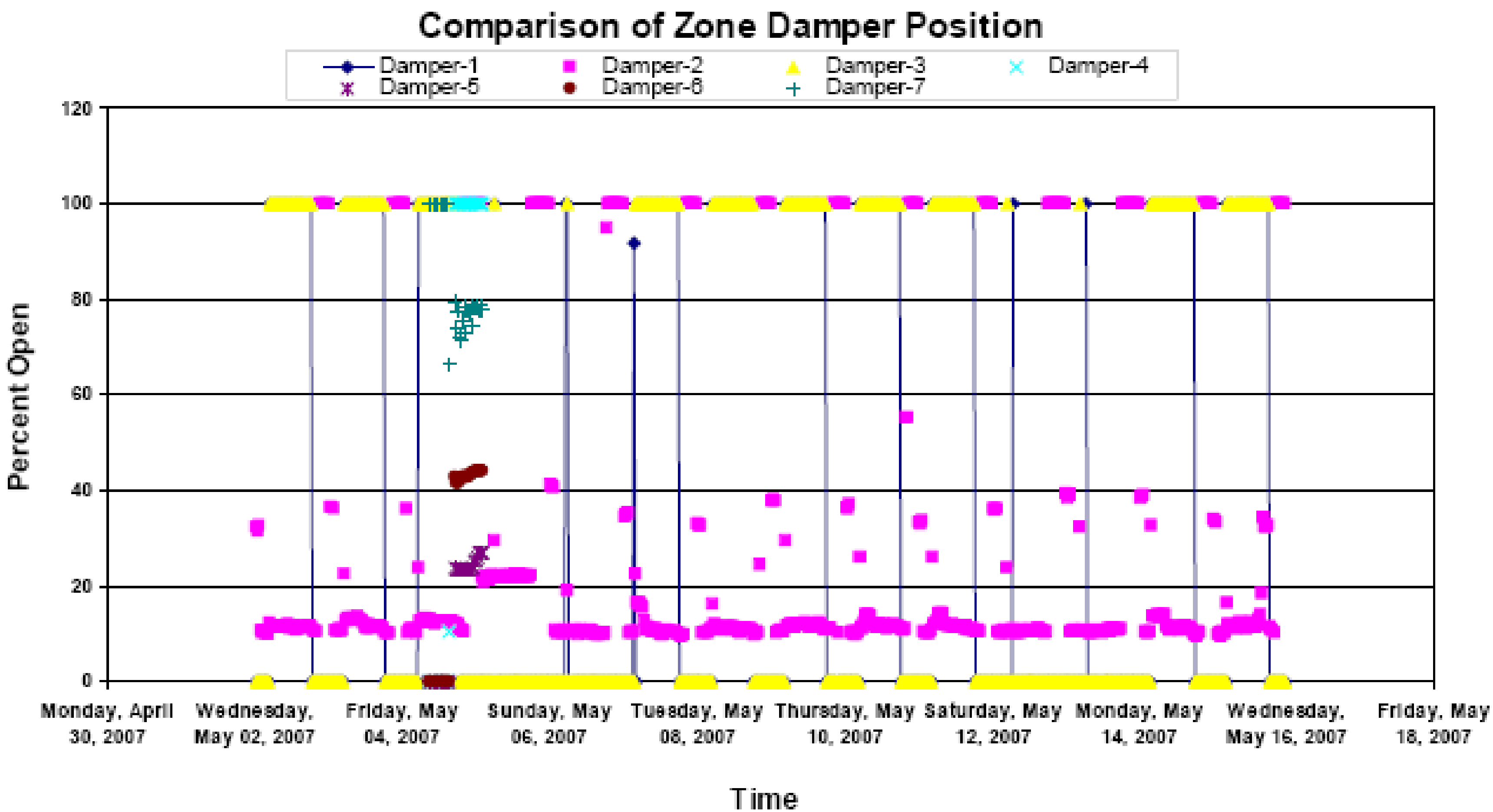
  - Too high and VAV boxes have trouble controlling

  - High noise levels in ceiling or at diffusers coming from VAV box

    - Extra load on air handler not required- Higher CFMs
    - More chiller load
    - More fan wear and belt wear
    - Higher fan energy cost. **Horsepower varies with the CUBE of the RPM**

  – Ideally VAV dampers should run in 50% to 75% range

Discharge-Static Pressure Control (Continued)



Air-Handler Heating & Cooling

- Are the heating and cooling coils efficient?

    Are they Clean?

    Valves not leaking through

    - Check (touch) coil for temperature of pipes at air-handler penetrations- Should be room temperature

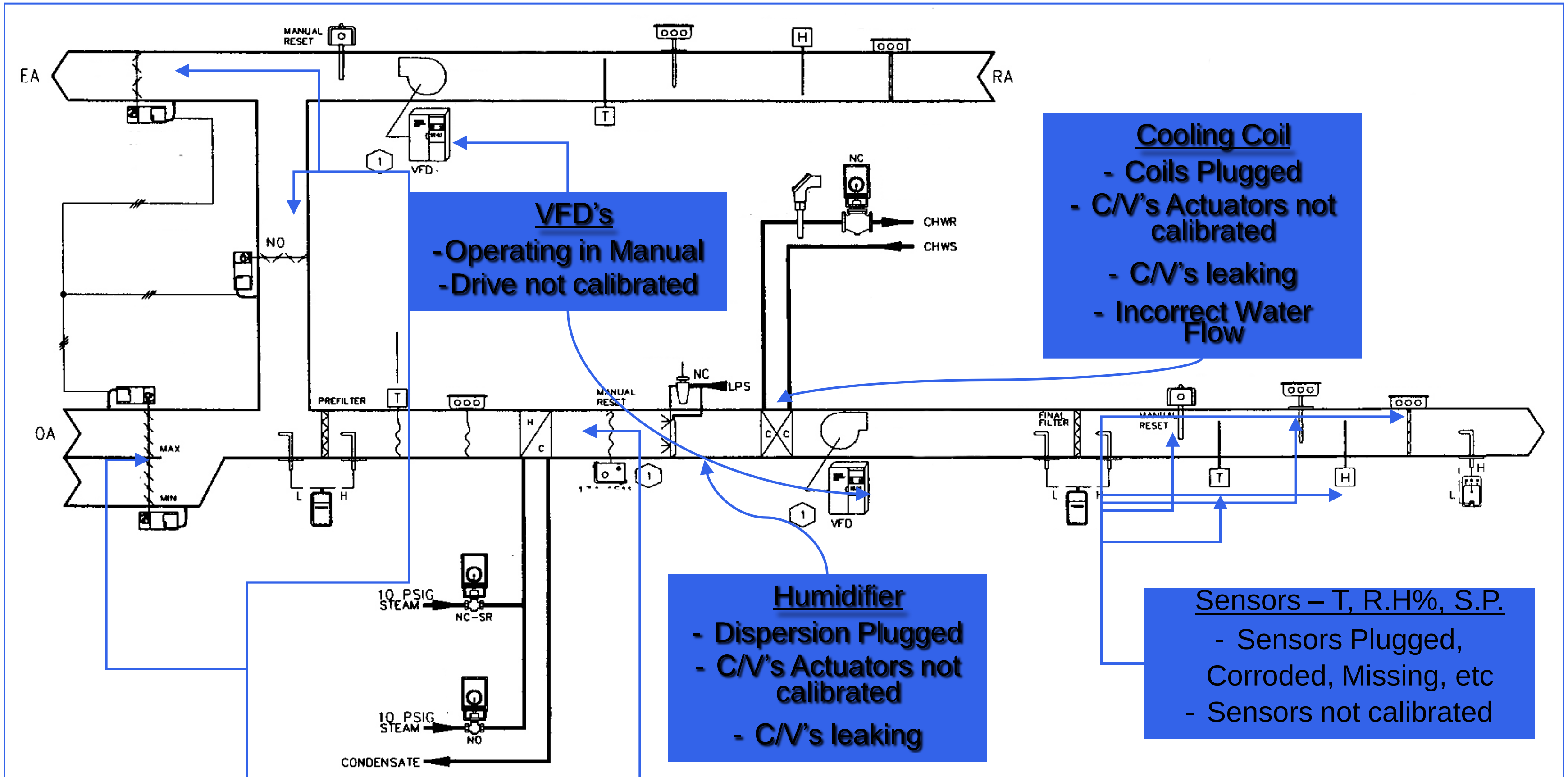
  – Loops locked out at some ODA temperature preventing heating and cooling at same time
    - Heating locked out above 50°F or lowest temp building can do without heat
    - Cooling locked out below 55°F or highest temp building can do without cooling
    - Critical on dual duct and multi-zone systems

- Balance point of building is critical when setting these lockouts

Where do Typical AHU Energy Saving Opportunities Come From?

- VAV boxes not accessible for maintenance, out of calibration,
- Constant volume terminal units installed with variable speed drive fans,
- Fans and pumps operating at higher/lower capacities than necessary,
- Poor sensor location, dirty filters and coils on Fan powered boxes, fan coils units, etc,
- Heating/cooling at the same time,
- Control valves passing,
- Incorrect Balancing
- Reset schedules not functioning, or set at inefficient levels

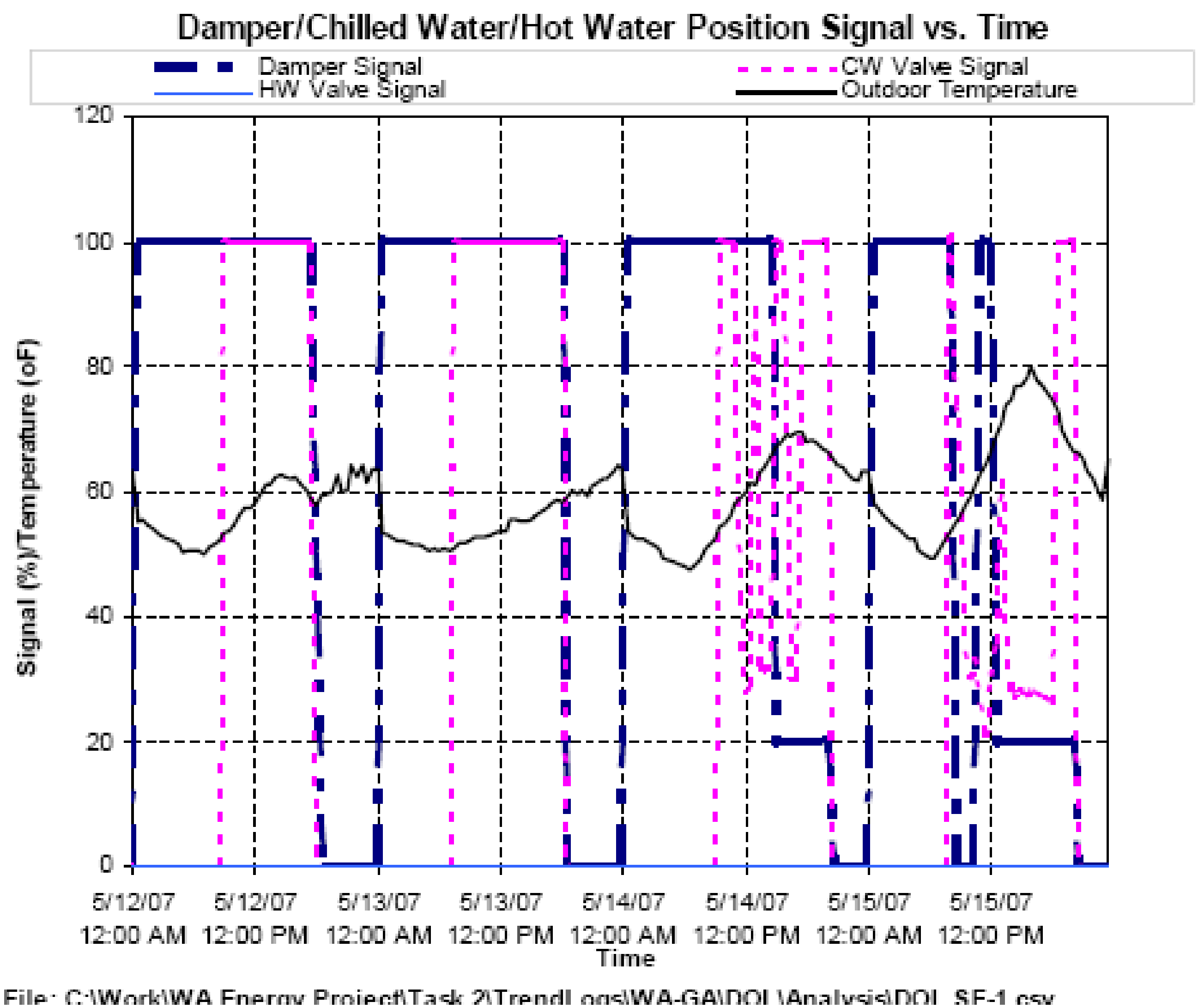
Typical AHU Control Schematic- (Used for illustrative purposes only)



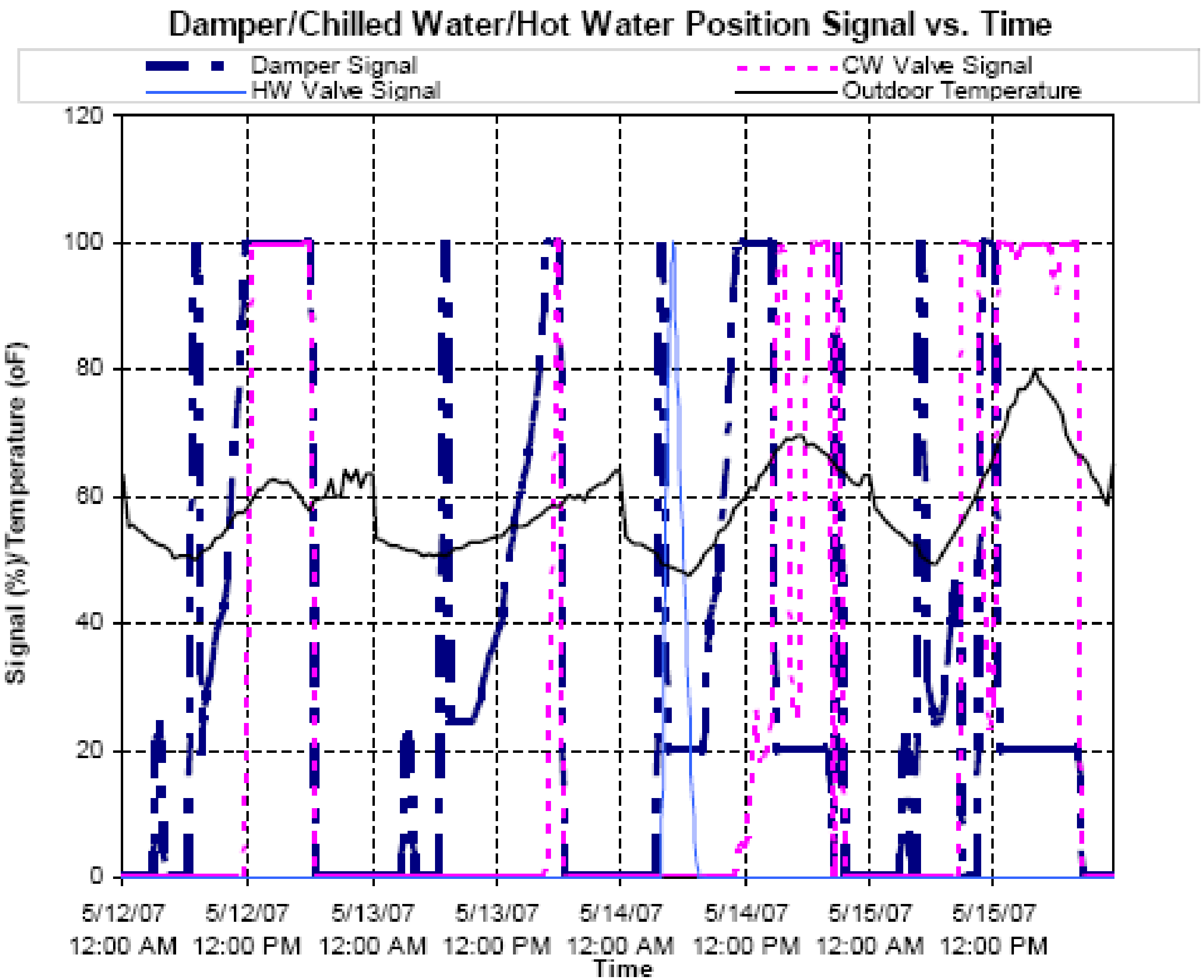
Mixed Air Dampers
- Dampers not calibrated
- % of F.A. Not correct
- Linkages Not working
- Actuators Not working

Heating Coil
- Coils Plugged
- C/V's Actuators not calibrated
- C/V's leaking
- Incorrect Water Flow

Air-Handler Heating & Cooling (continued) – Supply Fan 1



Air-Handler Heating & Cooling (continued) – Supply Fan 2



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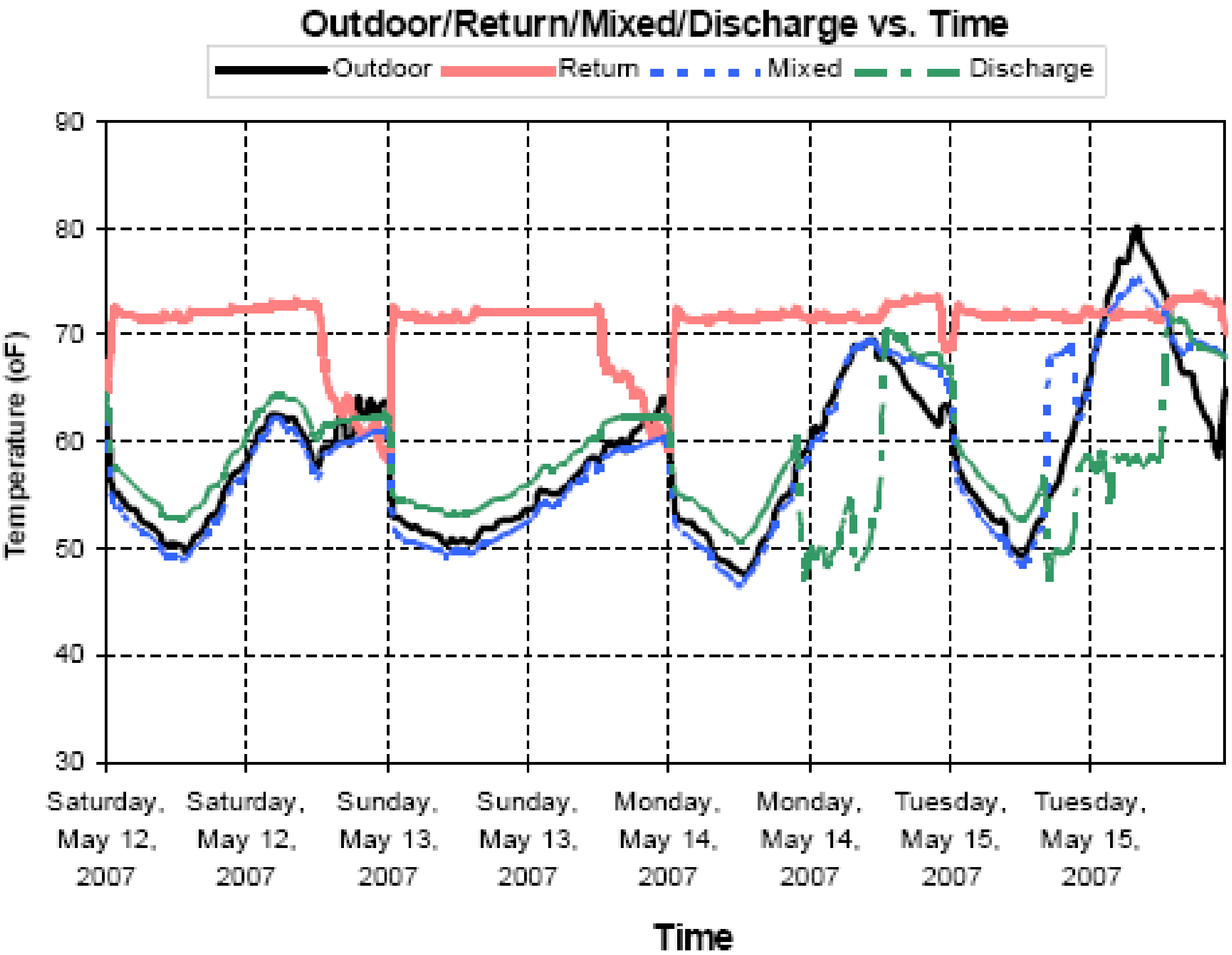
Air-Handler Economizer (continued) – Supply Fan 1, Air Temps vs. Time



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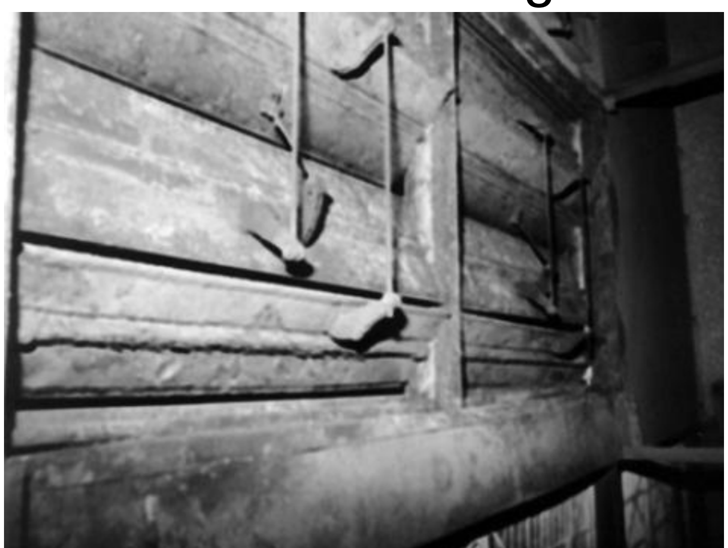
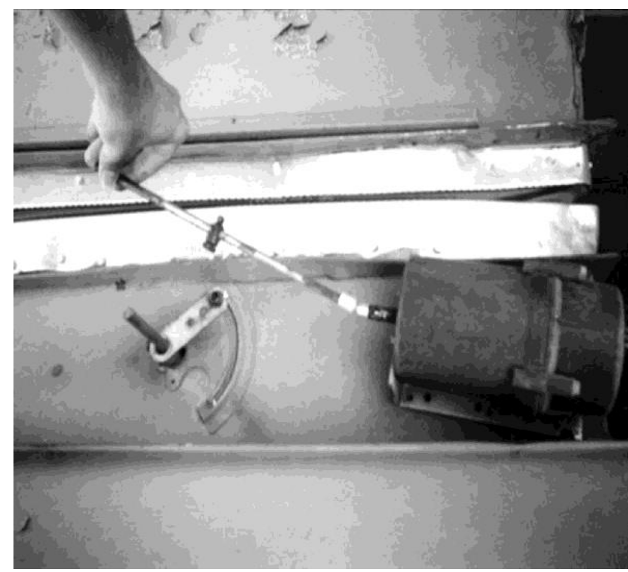
Why Economizers Fail and Increase Energy Use

- Jammed or frozen outside-air damper
- Broken and/or disconnected linkage
- Nonfunctioning actuator or disconnected wire
- Malfunctioning outside-air/return-air temperature sensor
- Malfunctioning controller
- Faulty control settings
- Installed wrong or wired incorrectly

Wired poorly



Jammed/Frozen Damper



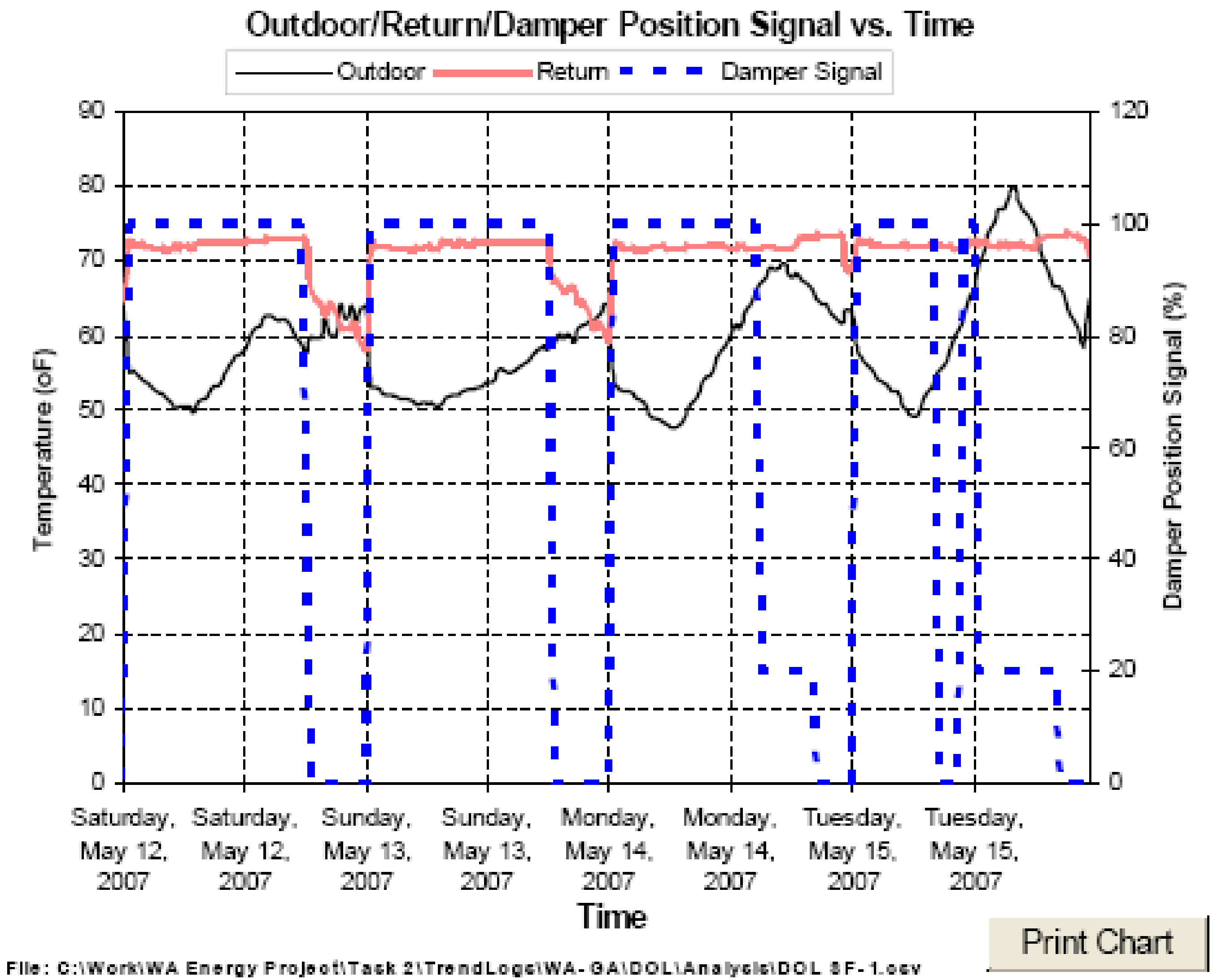
Disconnected Damper

Source:
Financial Times Energy

Packaged Rooftop Units with Economizers are Often Neglected, Hard to Access, or Installed Poorly

Poorly Design-Packaged Rooftop Units with Economizer Installed Next to Heat Source from Condenser

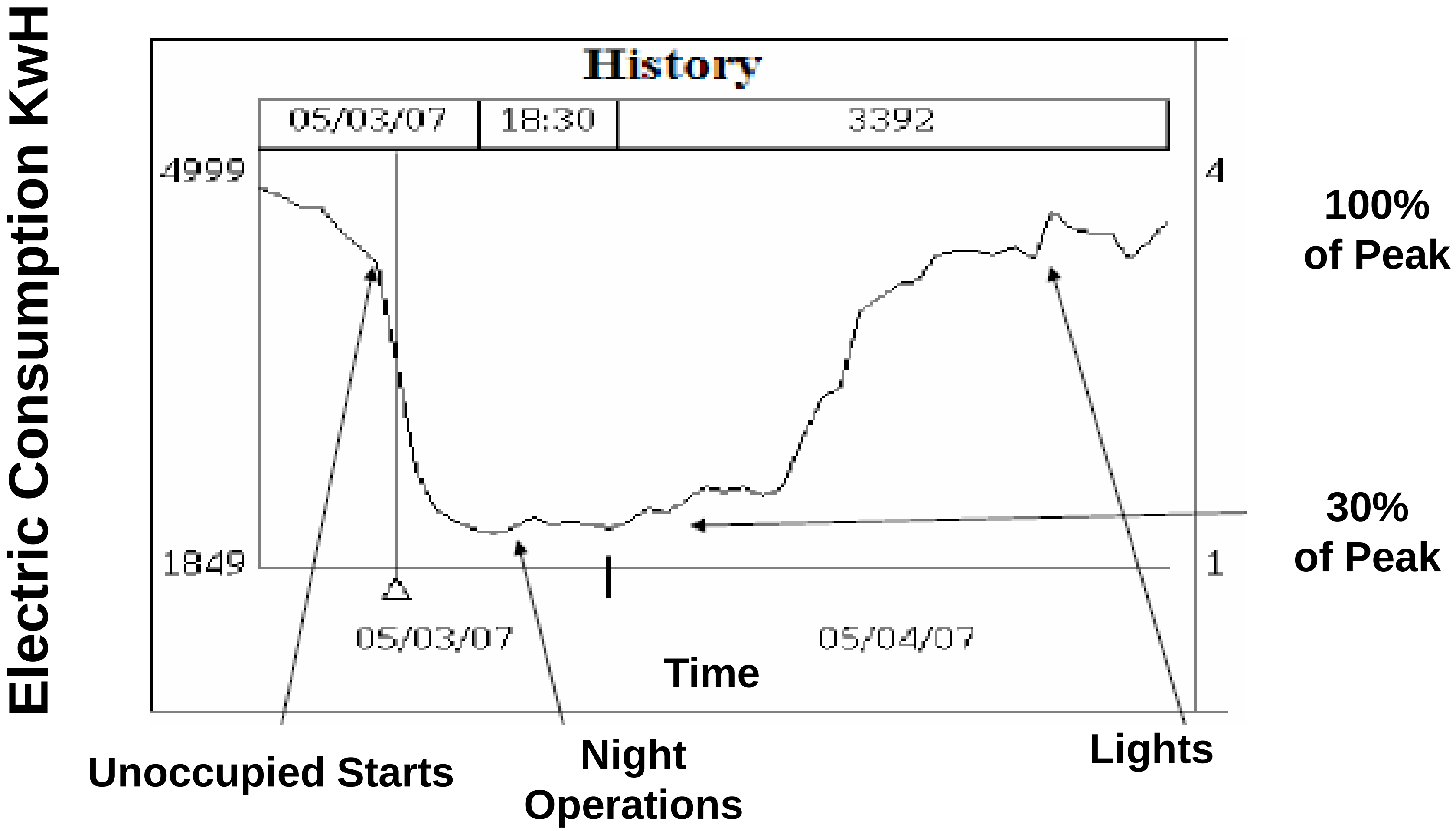
Air-Handler Economizer (continued) – Supply Fan 1, Damper Position vs. Time



Meter Profiles

- The meter profile will show the heart beat of the building
  - Modes of operations will show up
  - Demand
  - Time of use
  - Occupied/unoccupied periods
  - Weekend events

Meter Profiles (continued)



Central Plants

- Pumps that are paired in parallel should have a true lead/lag and recovery system
  - Never run more then one pump except when load requires it
  - Use VFD drive pumps in optimal configuration- all running pumps need to be at same speed
- Never run 2 chillers partly loaded when one will carry load
  - Use auto lead/lag sequence
  - Chillers with VFD should be used for load following
  - Chillers without VFDs should always run close to full load

Compressor Illustrations

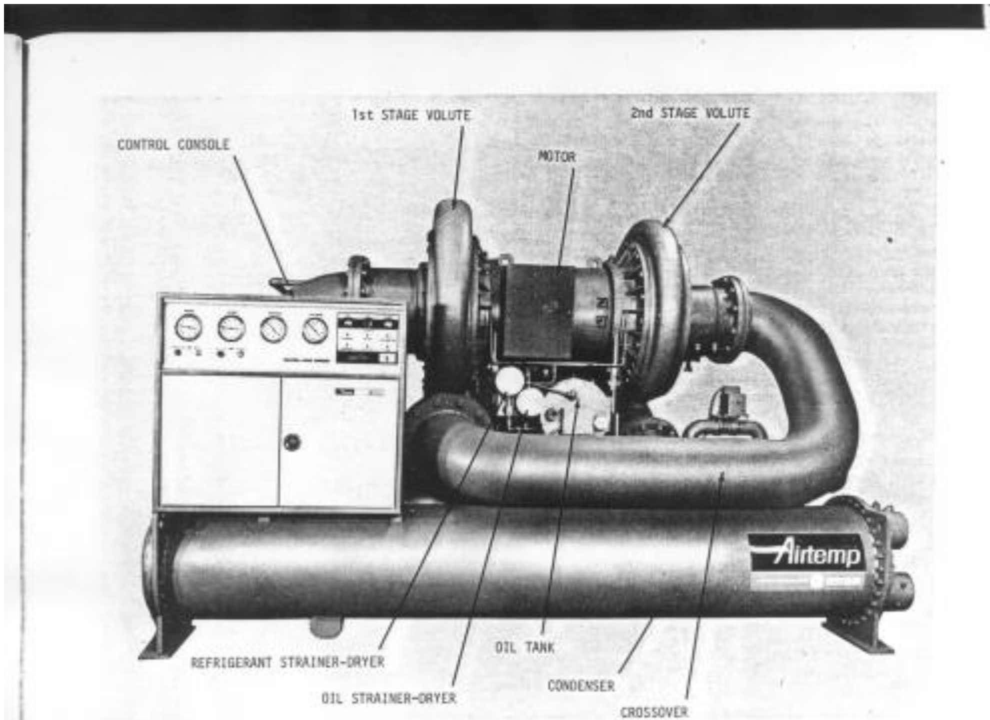


Fig. 4-65. Two-stage centrifugal compressor. System uses water-cooled condenser. Also note control panel mounted directly on system. (Airtemp Div., Chrysler Corp.)

Centrifugal Compressor

Photo courtesy of Modern Refrigeration and Air Conditioning, 1979

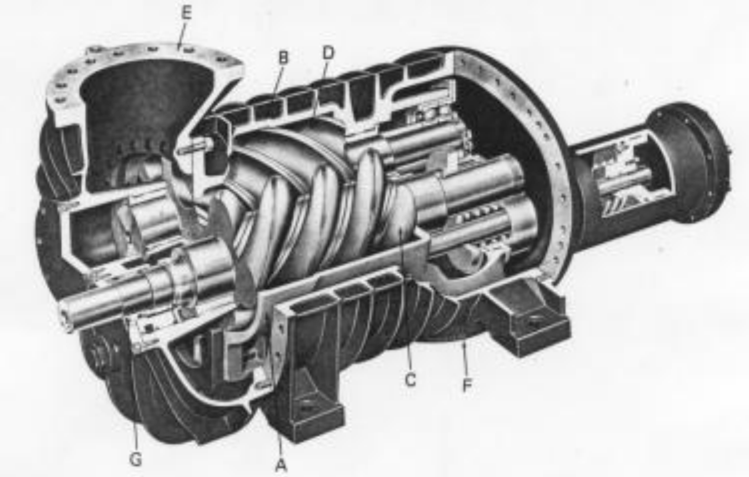


Fig. 4-61. A screw type compressor which uses two modified helical gears. A—Male section of the cylinder. B—Female section of the cylinder. C—Male motor-driven rotor. D—Female rotor. E—Suction inlet. F—Discharge. G—Shaft seal. (Stal Refrigeration AB)

Screw Compressor

Photo courtesy of Modern Refrigeration and Air Conditioning, 1979

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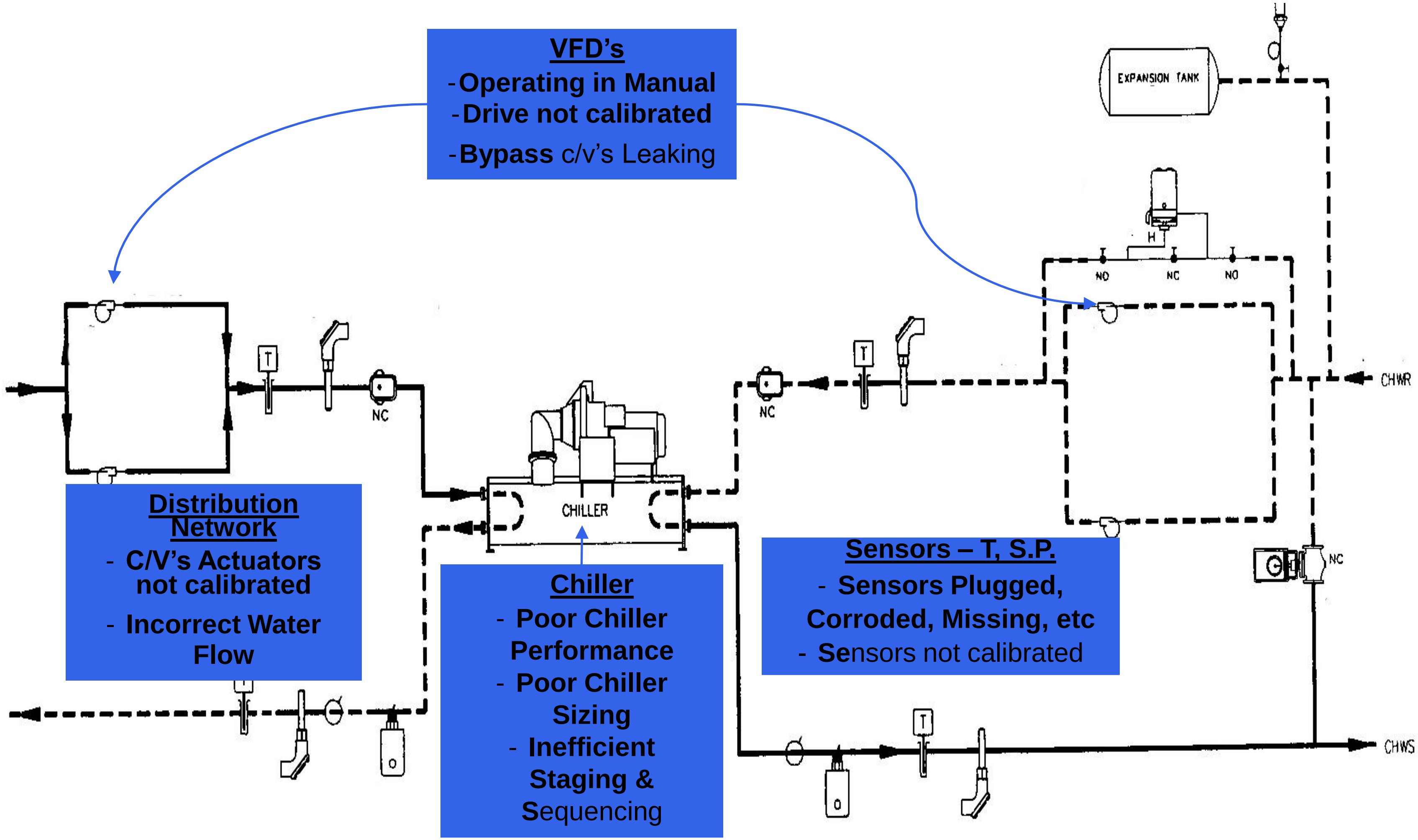
VFD's
-Operating in Manual
-Drive not calibrated
-Bypass c/v's Leaking
EXPANSION TANK
H
NO
NC
NO
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NC
CHWR
CHILLER
Distribution Network
- C/V's Actuators not calibrated
- Incorrect Water Flow
Chiller
- Poor Chiller Performance
- Poor Chiller Sizing
- Inefficient Staging & Sequencing
Sensors – T, S.P.
- Sensors Plugged, Corroded, Missing, etc
- Sensors not calibrated
NC
T
CHWS

Central Plants (continued)

- Use a chilled water reset schedule– For each degree rise in chilled water temperature, the chiller will gain about 2% efficiency
  - – Run chillers at 80 to 90% load when possible
  - – Run smaller chillers as load-following
    - - Let the 1500-ton chiller stay fully loaded and run the 500-ton chiller as the lag unit
  - – Run smaller chiller at night for better part-load efficiency
  - – Use a fully integrated lead/lag control scheme so chillers are not running “just because”
    - - Typical operations will start a unit in the morning because this afternoon they might need it

Central Plants (continued) Chillers

Oil-free refrigerant compressor technology

Turbocor oil-free compressor retrofit reducing HVAC costs to 70%

This revolutionary technology provides efficiencies up to 30% better than any other compressor in its size range in addition to being extraordinarily quiet and virtually vibration free.

— 2003 AHR Expo Innovation Awards

Central Plants (continued) Chillers

Oil-free refrigerant compressor technology

Oil-free compressor with VFD and magnetic bearings

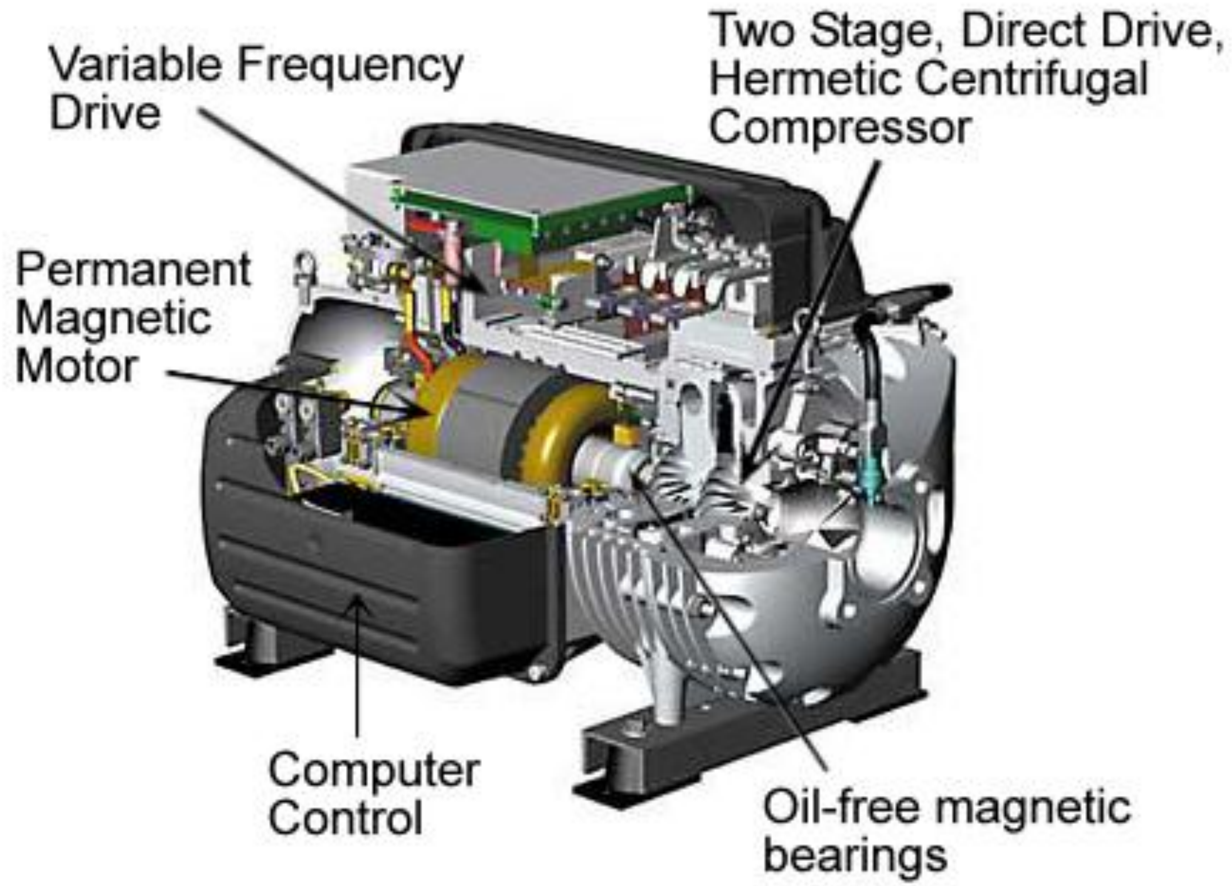
Based on test results, 30-40% energy savings over reciprocating air-cooled compressor technologies are realistic.

— San Diego Regional Energy Office

[redacted]

Central Plants (continued) Chillers

The Turbocor compressor at a glance



Redefining the compressor

- With built-in VFD, Turbocor matches cooling load at 60 tons to 700 tons +
- Compact (approx.1/5 ordinary size)
- Light (Less than 270lb)
- Quiet (less than 70dB at full load)
- Virtually frictionless (magnetic bearings)
- On board digital electronics
- **Highly e**nergy efficient and oil-free

Central Plants (continued) Chillers

Whether it’s 60 to 120 tons

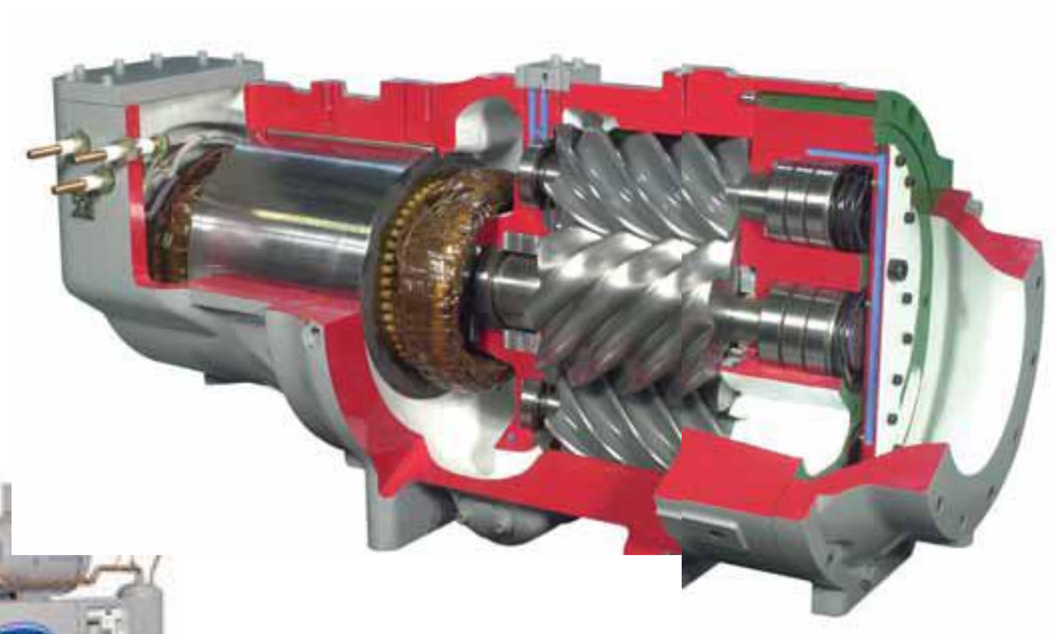
Central Plants (continued) Chillers

Or 720 tons - - -

Turbocor starts on less than 2 amps

Central Plants (continued) Chillers

- Carrier Evergreen Machine
- Very Good IPLV and kW/Ton

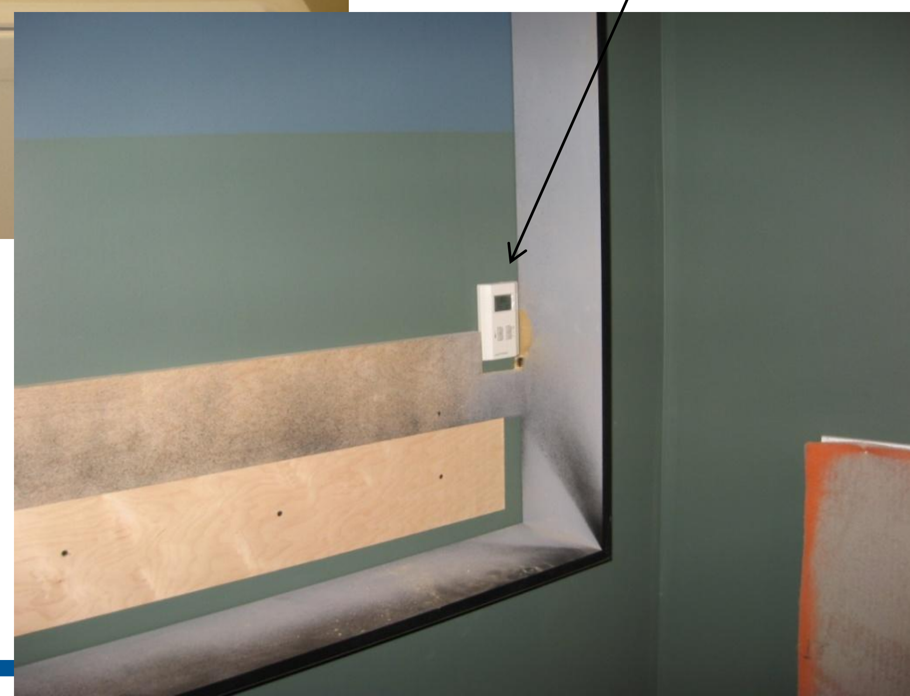


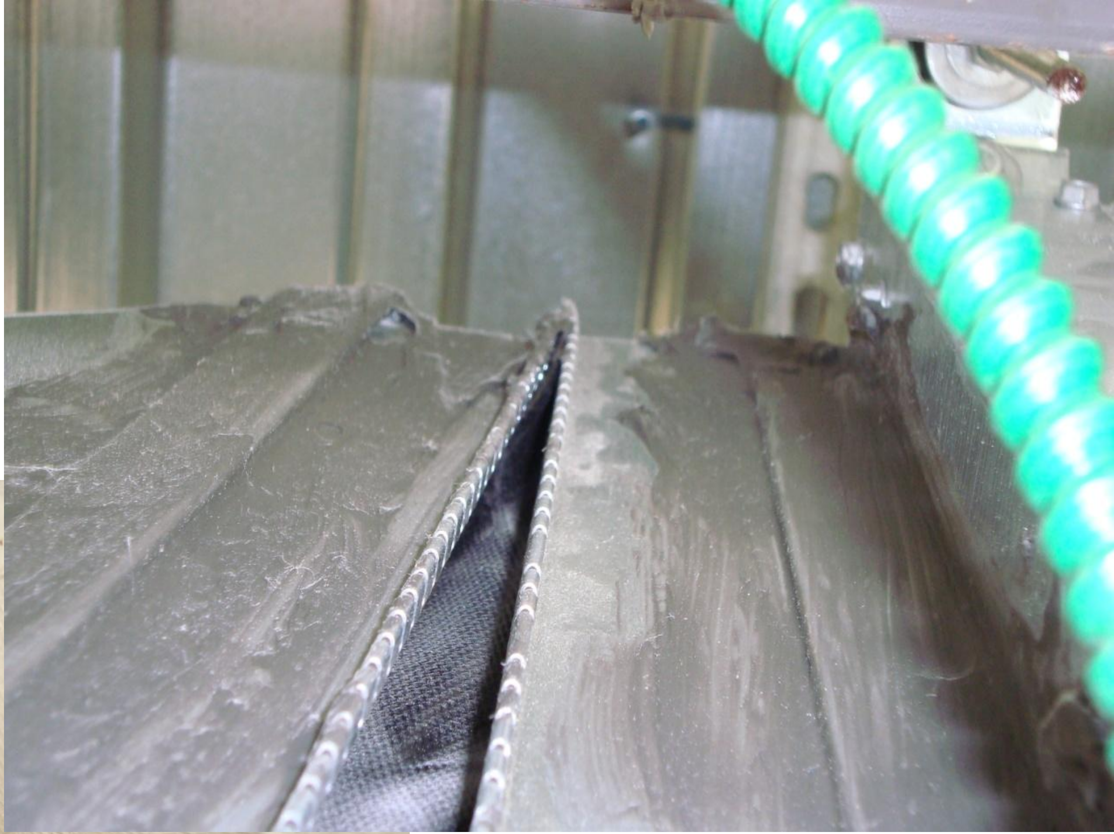
Re-Commissioning
Saves Money and Energy

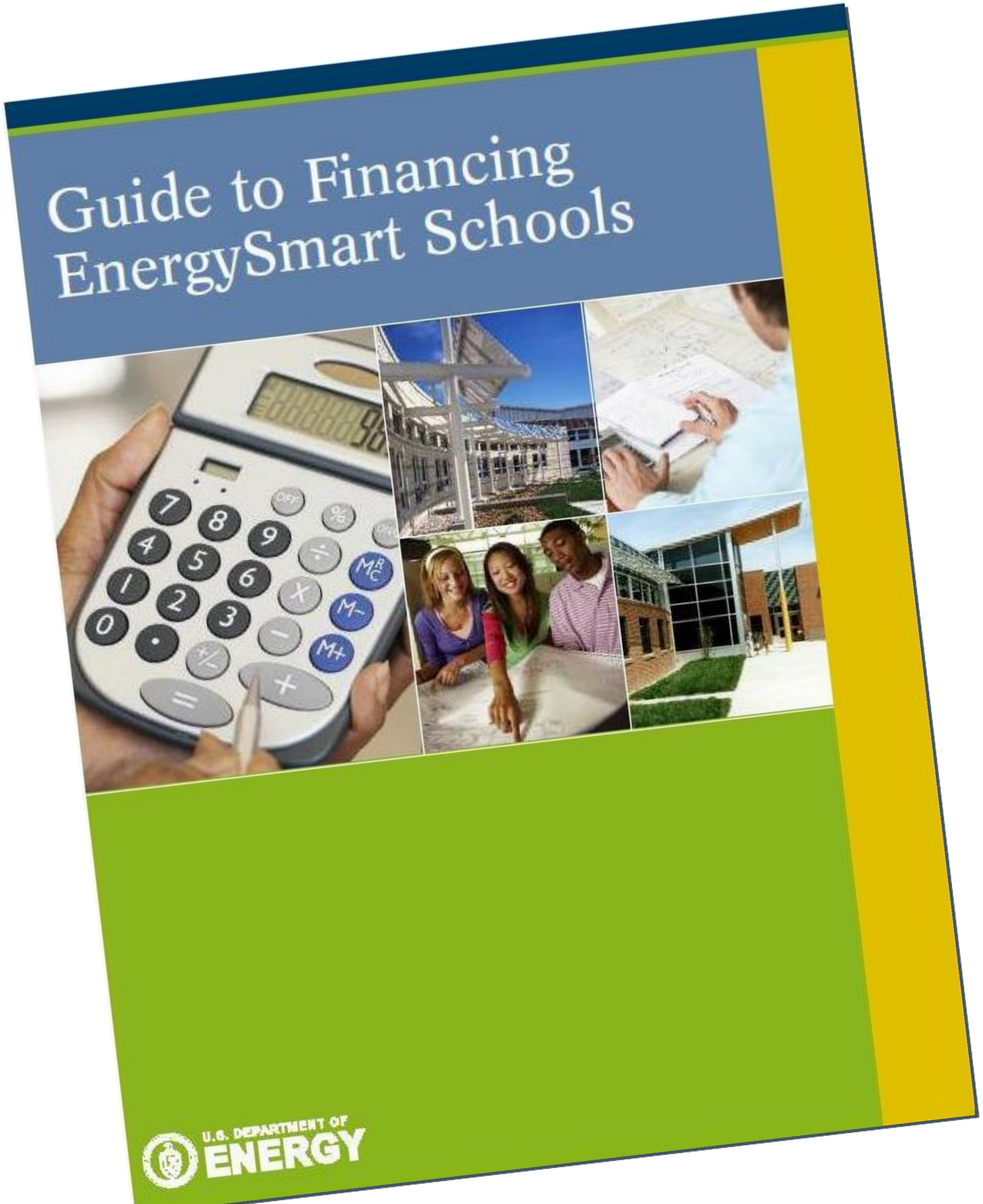
- Existing HVAC
- Chiller plants
- Controls
- Electrical
- Plumbing

This is why We need Commissioning

Where is my T stat






Guide to Financing
EnergySmart Schools
U.S. DEPARTMENT OF
ENERGY

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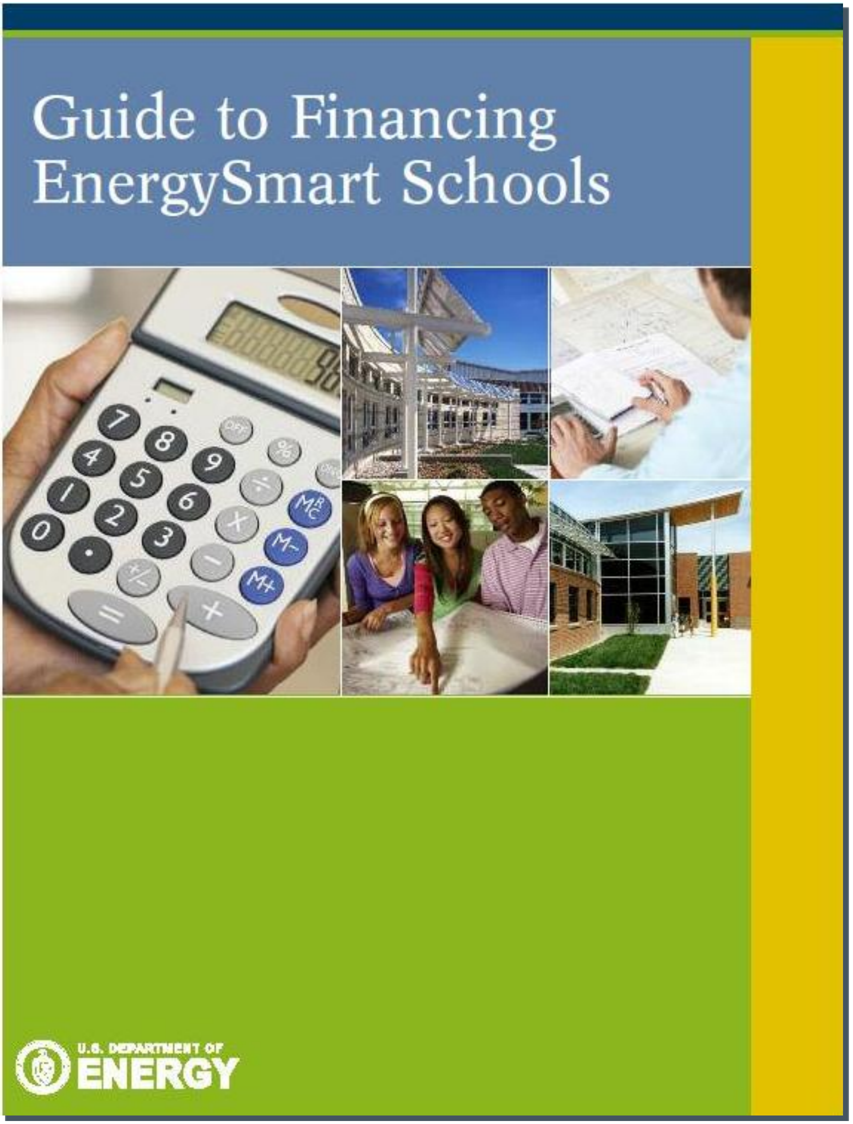

Co-branded by ASBO
Endorsed by NSBA

- **Principles of Financing**
- **Making a Business Case**
- **Financing Options**
- **State, Federal and Non-Profit Resources**

Financing High-Performance Schools

Principle 1. Determine Project Objectives

Principle 2. Avoid Cream Skimming

Principle 3. Identify All Cash Flows

Principle 4. Focus on Life-Cycle Cost Analysis

Principle 5. Select an Effective Cost-Benefit Mechanism

Principle 6. Monitor and Verify Results

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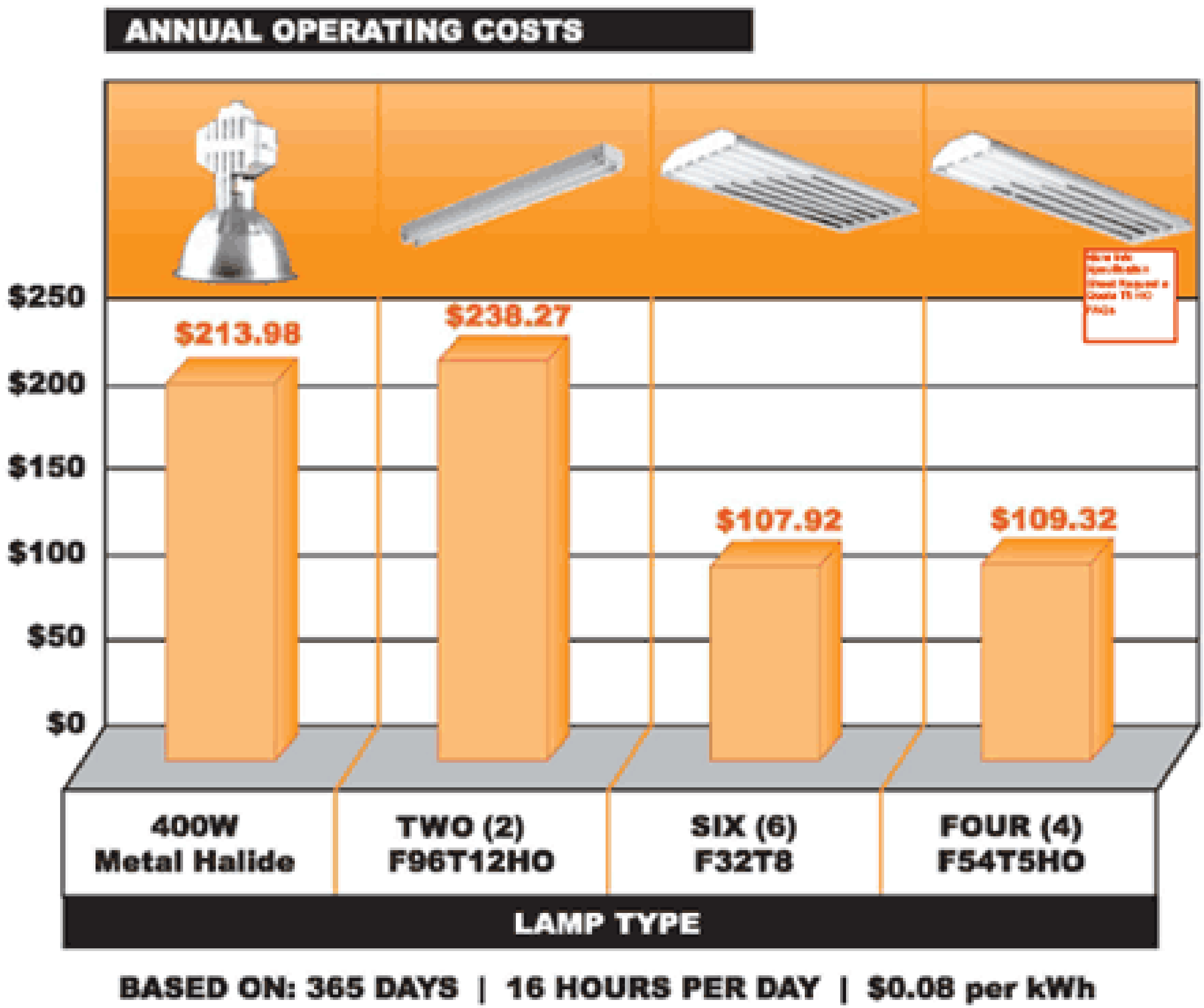
Return on Investment

- ROI is typically a 5 year window max for buildings

$$ROI = \frac{(\text{Gain from Investment} - \text{Cost of Investment})}{\text{Cost of Investment}}$$

Versus

ROI Operating Costs Examples for Lights



Selecting a Contractor for HVAC Energy Upgrades

Selecting experienced, competent contractors and energy professionals is critical to the success of your project

- Ask for multiple references and be sure to check them
- Get written cost estimates
- Only hire contractors who are licensed and insured
- Ask your contractor to certify that the work conforms to state and local regulations and codes
- Verify that the contractor carries workers compensation insurance
- Make sure that the contractor is experienced and is using energy-efficient equipment

Conclusions

- Upgrade Existing HVAC equipment
- Use controls for optimum performance and energy savings.
- Replace and updating existing controls
- Upgrade with new Compressors in your Central chiller plant
- Tuning up roof top units (RTUs)
- Commissioning and Tuning up
- Determine your ROI-Return on Investment
- Get utility rebates to reduce capital costs

Retrofitting for Optimum HVAC Performance
by Greg Jourdan
Wenatchee Valley College
Thank You
Think Energy Efficient and Green!!