

Fundamentals for Energy Managers

The ABCs of Energy, Part II

HVAC

Please be courteous to our speakers



*Turn off all cell phones
and
Set pagers to vibrate*

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Services

- Investment-grade energy audits
- Energy efficiency scoping studies
- Measurement and verification (M&V)
- Simulation and modeling
- Building recommissioning
- Utility-sponsored SPC
- Architectural and mechanical design review

Clients

- Utilities
- Government Entities
- Corporate Entities
- ESCO's
- Engineering and Consulting Firms

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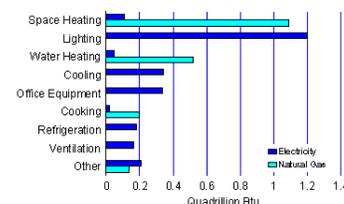
- ✘ No Lighting
- ✘ No New Construction
- ✓ Overview of HVAC Systems & Equipment
 - ✓ Energy Use in Buildings
 - ✓ Overview of System Types
 - ✓ Overview of Equipment
- ✓ Introduction to HVAC Retrofits
 - ✓ Overview of System Optimization
 - ✓ Overview of Equipment Retrofits

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Figure 12. Electricity and Natural Gas Consumption by End Use, 1995

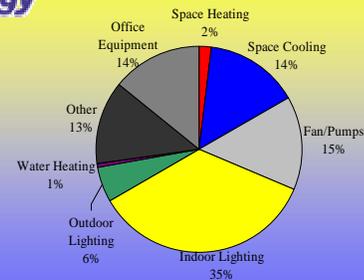


Energy Information Administration
1995 Commercial Buildings Energy Consumption Survey

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Source: Commercial Building Survey Report 1999, Pacific Gas and Electric Company

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2003 Energy Commercial End Use Intensities for California

Table 21 - Annual Electric End-Use Intensities (kWh per Conditioned Square Foot)

	Cooling	Heating	Vent	Refrigeration	Water Heating	Cooking	Interior Lighting	Other	Total
Office	4.46	7.00	1.47	0.29	0.22	0.36	3.72	3.06	12.84
Restaurants	8.29	2.04	2.72	8.49	2.38	54.21	5.55	2.95	75.62
Retail	3.47	2.24	1.21	1.48	0.17	0.53	5.91	2.33	13.84
Grocery	5.78	2.92	1.38	27.03	0.49	7.03	7.86	2.95	46.96
Ref. Warehouse	4.17	3.60	0.42	15.14	0.02	0.65	2.66	1.95	22.36
Warehouse	4.06	1.50	0.37	0.62	0.05	0.16	1.99	1.52	6.94
Schools	2.44	7.20	0.86	0.44	0.69	0.30	3.22	0.82	6.82
Colleges	3.55	0.12	1.23	0.36	1.74	0.53	4.48	1.90	10.44
Hospitals	6.20	8.73	2.61	0.62	2.14	1.76	6.00	4.35	21.20
Lodging	3.69	6.89	1.14	0.99	1.46	1.69	2.96	1.29	10.87
Miscellaneous	5.11	2.01	1.27	0.59	0.30	1.64	3.51	3.40	12.00
Desert/Mountain	4.41	5.38	1.31	3.01	0.38	4.16	4.34	2.90	15.96
Valley	3.91	4.90	1.24	3.63	0.34	5.64	4.33	2.42	16.27
Coastal	3.99	2.72	1.20	1.73	0.22	1.98	3.77	2.08	11.96
Hill	4.69	5.91	1.38	1.50	0.27	3.74	4.08	2.76	13.77
Total	4.34	4.35	1.79	2.03	0.77	3.11	4.02	2.49	13.64

Source: Commercial Building Survey Report 1999, Pacific Gas and Electric Company

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2003 Energy Heat Balance in Buildings

- Over a long time, the heat entering a building must equal the heat leaving
- Over a short time, entering and exiting heat flows are virtually never balanced:
 - If $Q_{in} > Q_{out}$ Space temperature rises
 - If $Q_{in} < Q_{out}$ Space temperature drops
- Heat Sources/Sinks
 - Lighting
 - Occupants
 - Computer & Equipment
 - HVAC Systems & Components

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2003 Energy Cooling and Heating Loads

- Internal
 - Lighting
 - Occupants
 - Computer & Equipment
- Envelope
 - Solar Gain
 - Conduction
- Outside Air
 - Required for Healthy Environment



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2003 Energy Major HVAC System Components

- Built-up Air Handlers
- Packaged Equipment
- Chillers
- Cooling Towers
- Boilers
- Pumps, Fans, and Motors
- Controls



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2003 Energy Types of Air Handlers

- Single Zone
 - Controlled by one thermostat
- Variable Air Volume
 - Single flow, variable volume
- Multizone
 - Two air flows mix near the unit
- Dual Duct
 - Two air flows mix near the zone

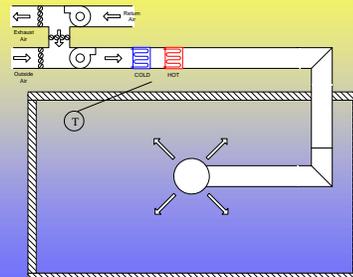


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2003 Energy Single Zone Air Handler



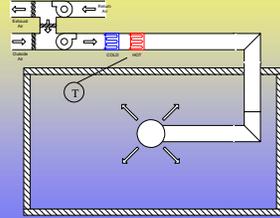
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2003 Energy Field Identification of Single Zone Systems

- Controlled by one (1) thermostat
- Air flow rate is constant (typically)
- Average supply air temperature varies
- Generally associated with Packaged Units

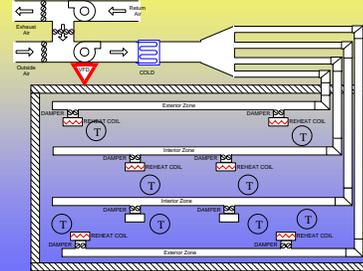


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2003 Energy Variable Air Volume Air Handler



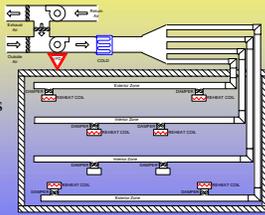
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2003 Energy Field Identification of VAV Air Handler

- Some method of fan control
 - VFD
 - Inlet vanes
 - Varicone
- Many Thermostats/Zones
- VAV boxes
 - Often serve several diffusers
 - One duct in, one duct out
 - May have hot water or electric resistance coil for heat/reheat

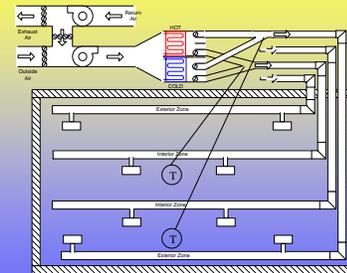


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2003 Energy Multizone Air Handler



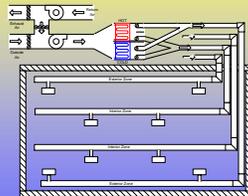
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2003 Energy Field Identification of Multizone Air Handler

- Typically No fan control
- Parallel heating and cooling coils
- Mixing air dampers at unit
- Multiple ducts leaving fan room
- Actuators for each duct



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2003 Energy Multizone Actuators



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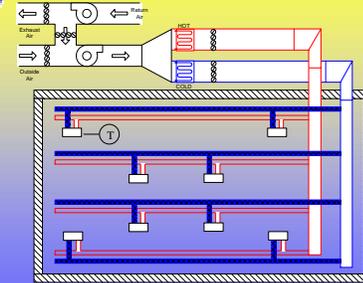
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2003 Energy More Multizone Actuators

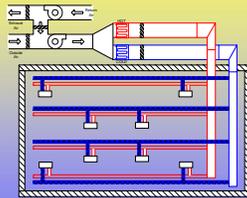


2003 Energy Dual Duct Air Handler



2003 Energy Field Identification of Dual Duct Air Handler

- No fan control
- Parallel heating and cooling coils
- Two large ducts at coils
- Many thermostats/zones
- DD mixing boxes above space
- Two ducts in, one duct out



2003 Energy Low-Cost/No-Cost

- AKA retrocommissioning, tune ups, premium maintenance
- Focus on identifying opportunities
- Data Logging
- Cost Effective



2003 Energy Capital Projects

- Significant Expense
- Focus on economic justification
- Third party financing
- Utility or Government Incentives



2003 Energy Two Components to Savings

- Potential to generate savings
- Savings over time

2003 Energy Savings Components



Performance Potential: Miles Per Gallon
 Existing → Tune-Up → After
 15 mpg → 20mpg

Performance:
 Miles driven per year

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2003 Energy Summary of Equipment Efficiencies

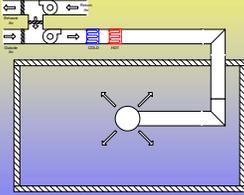
- Efficiency: Ratios developed to represent equipment ability to absorb or generate heat relative to the input energy required by that equipment

Equipment Type	Single Point Efficiency	Multi-Point or "Seasonal" Efficiency	Field or Local Efficiency
Chiller	kW/Ton	IPLV	APLV
Packaged AC	EER	SEER/PLV	-
Furnace	Thermal Efficiency	SE	-
Boiler	Combustion Efficiency	-	-
Heat Pump	COP	HSPF	-

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2003 Energy Single Zone Air Handler Opportunities

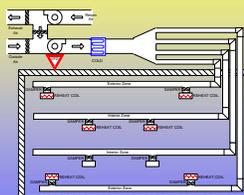
- Replace with High Efficiency Unit
- Reduce operating hours
- Repair economizer
- Convert to VAV if large and over ventilated



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2003 Energy VAV Air Handler Opportunities

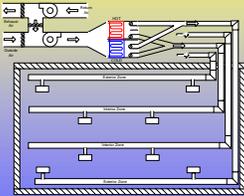
- Reduce operating hours
- Repair economizer
- Reset duct static pressure
- Reset discharge air temp to optimize
 - Simultaneous heating & cooling
 - Economizer operation
 - Fan power
- Add DDC zone control
 - Nighttime shutdown of zones



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2003 Energy Multizone Air Handler Opportunities

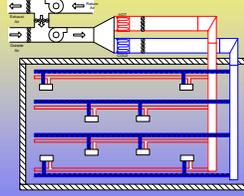
- Reduce operating hours
- Repair economizer
- Minimize simultaneous heating and cooling
 - Lockouts
 - HD and CD temperature reset
- Convert to VAV



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2003 Energy Dual Duct Air Handler Opportunities

- Reduce operating hours
- Repair economizer
- Minimize simultaneous heating and cooling
- Convert to VAV - expensive



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2003 Energy Large Economizers



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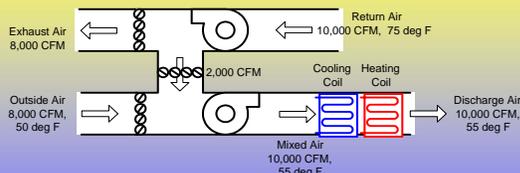
2003 Energy Packaged Equipment Opportunities

- Replace with High Efficiency
- Consider incremental cost when replacing units
- Reduce operating hours
- Repair/retrofit economizer
- Larger units have similar opportunities to above
- Downsize oversized units
- Consider evaporative cooling



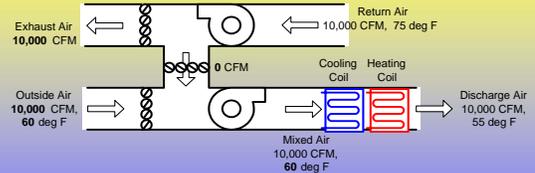
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2003 Energy Economizer Offsetting All Cooling



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2003 Energy Economizer Reducing Mechanical Cooling



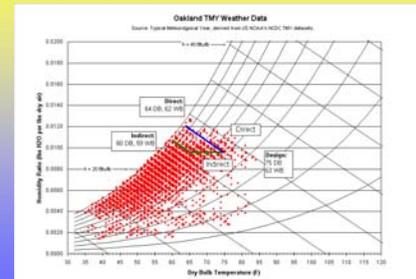
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2003 Energy Retrofit Economizer



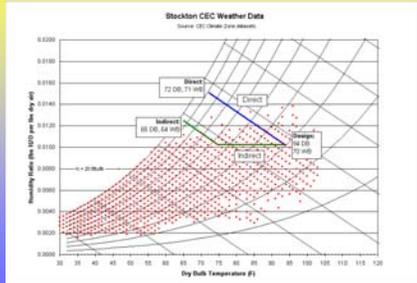
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2003 Energy Evaporative Cooling - Oakland



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2003 Energy Evaporative Cooling - Stockton



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2003 Energy Chillers

- Verify Temperatures
- Reduce CW setpoint (check with manufacturer)
- Lockout pumps with chiller
- Variable speed CHW pumping
- Driveline Retrofit
- Chiller replacement
 - Consider refrigerant



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2003 Energy Chillers – Driveline Retrofit

- Less efficiency improvement
- Less expensive if inaccessible location
- Consider Downsizing
- Recent Example:
 - 800 Ton to 600 Ton
 - 0.345 kW/Ton @ 600 Ton, 70 CW
 - 0.253 kW/Ton @ 300 Ton, 60 CW



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2003 Energy Chillers - Replacement

- Long payback
- Eliminates refrigerant problems
- If replacement is needed, very cost-effective
- Match chiller to actual load not design load in multiple chiller plant

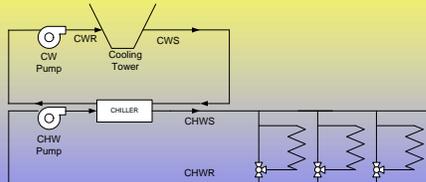


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2003 Energy Chillers: Primary Pumping

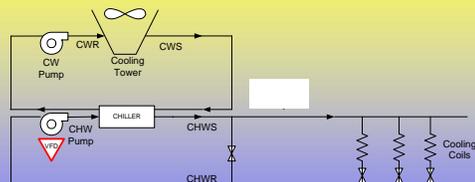


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2003 Energy Chillers: Variable Primary Pumping

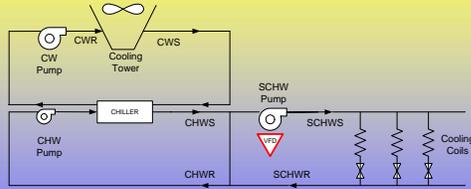


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2003 Energy Chillers: Primary-Secondary Pumping



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2003 Energy Cooling Towers

- Run fans in parallel (VFDs)
- Reduce condenser water setpoint where practical
- Install water side economizer (if oversized)
- Regular Maintenance



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2003 Energy Water Side Economizer



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2003 Energy Boilers

- Reduce operating hours (check w/ colleagues and manufacturer)
- Lockout pumps
- Regular cleaning, combustion testing
- Heat recovery (very large systems)
- Replace with smaller condensing units



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2003 Energy Pumps, Fans, and Motors

- Reduce operating hours
- Look for closed valves (pumps)
- Lockouts
- VFD's
- Trim pump impellers
- Resheave fans
- Premium Efficiency Motors



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2003 Energy Motor Efficiencies

NOMINAL FULL LOAD EFFICIENCIES FOR EPACT AND NEMA PREMIUM™ MOTORS
 Covered Equipment: 1-200 horsepower NEMA design B and D, three phase, low voltage, general purpose motors
 ODP and TFC, 1800, 1800, and 3600 RPM

Initiative Web Page: www.eef.org/ind/motors/motors_main.php3
 Motor Decisions Matrix Web Page: www.jccrc.com/mtrr.htm
 For more information, contact: Steve Mason, 617-589-1949 ext 225, e-mail: smason@eef.org

HP	Open Drip-Proof (ODP)				Totally Enclosed Fan-Cooled (TEFC)			
	EPACT Efficiency	NEMA Premium Efficiency	EPACT Efficiency	NEMA Premium Efficiency	EPACT Efficiency	NEMA Premium Efficiency	EPACT Efficiency	NEMA Premium Efficiency
1.0	85.0	87.5	85.0	87.5	85.0	87.5	85.0	87.5
1.5	85.0	87.5	85.0	87.5	85.0	87.5	85.0	87.5
2.0	85.0	87.5	85.0	87.5	85.0	87.5	85.0	87.5
3.0	85.0	87.5	85.0	87.5	85.0	87.5	85.0	87.5
4.0	85.0	87.5	85.0	87.5	85.0	87.5	85.0	87.5
5.0	85.0	87.5	85.0	87.5	85.0	87.5	85.0	87.5
7.5	85.0	87.5	85.0	87.5	85.0	87.5	85.0	87.5
10	85.0	87.5	85.0	87.5	85.0	87.5	85.0	87.5
15	85.0	87.5	85.0	87.5	85.0	87.5	85.0	87.5
20	85.0	87.5	85.0	87.5	85.0	87.5	85.0	87.5
25	85.0	87.5	85.0	87.5	85.0	87.5	85.0	87.5
30	85.0	87.5	85.0	87.5	85.0	87.5	85.0	87.5
40	85.0	87.5	85.0	87.5	85.0	87.5	85.0	87.5
50	85.0	87.5	85.0	87.5	85.0	87.5	85.0	87.5
75	85.0	87.5	85.0	87.5	85.0	87.5	85.0	87.5
100	85.0	87.5	85.0	87.5	85.0	87.5	85.0	87.5
150	85.0	87.5	85.0	87.5	85.0	87.5	85.0	87.5
200	85.0	87.5	85.0	87.5	85.0	87.5	85.0	87.5
250	85.0	87.5	85.0	87.5	85.0	87.5	85.0	87.5
300	85.0	87.5	85.0	87.5	85.0	87.5	85.0	87.5
400	85.0	87.5	85.0	87.5	85.0	87.5	85.0	87.5
500	85.0	87.5	85.0	87.5	85.0	87.5	85.0	87.5
750	85.0	87.5	85.0	87.5	85.0	87.5	85.0	87.5
1000	85.0	87.5	85.0	87.5	85.0	87.5	85.0	87.5

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2003 Energy Controls

- Check for Overrides
- Twist Timers
- Timeclocks – Programmed correctly?
- Programmable Thermostats – proper setpoints, setbacks, and setups
- EMS – examine all setpoints and schedules to verify they make sense, or have contractor do it



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2003 Energy Time Clock Inside Unit



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2003 Energy Reduce Excess Outside Air

- Take control of exhaust fans
 - Ex: paint booth ventilation
- Radiant heat where ever OA is uncontrollable
 - Warehouses
 - Repair Garages
- Economizers stuck full open
 - Stuck closed is more common



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2003 Energy Unit Heater in Garage



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2003 Energy Other Opportunities

- Lighting upgrade (T8s, Premium T8s, HOT5, etc.)
- Lighting controls
- Load Shifting
- Cogeneration
 - Recip Engine
 - Microturbine
 - Fuel cell
 - Waste heat recovery
- Plug Load Control (vending machines, PC monitors)
- Energy Star office equipment & appliances
- Solar

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2003 Energy HVAC Retrofit Process

- Identify Opportunities
 - Billing information / Benchmarking
 - Walk-through Audit
 - Independent Audit
- Rank potential projects based on your criteria
- Conduct analysis & Re-rank projects
- Develop performance specifications
- Get Bids
- Build projects
- Verify & Commission projects
- Operate & Maintain

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2003 Energy Benchmarking Resource



http://208.254.22.6/index.cfm?c=evaluate_performance.bus_portfolio.manager

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2003 Energy Project Indicators

- Equipment that is 10+ years old
- Any system with the capacity to simultaneously heat & cool
- Pneumatic Controls (look for air hoses)
- Facilities that have changed occupancy
- Facilities with higher utility bills
- Facilities that will be undergoing construction (think incremental cost)

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2003 Energy Recommendations

- Review consumption information and benchmark facilities if possible
- Perform a self audit and/or hire auditor
- Collect data on system performance
- Prioritize opportunities (capital vs. no cost)
- Make use of incentives and programs
- Periodically re-audit (controls fail, usage changes)
- Develop a relationship with a consultant you trust
- Ask questions

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2003 Energy EEMs and Data Collection

HVAC EEM	Visual Inspection	Measurements			Good EMS Candidate?
		Temperature	Runtime	Power/Current	
Economizer	X	X			Maybe
Fan/Pump Runtime			X	X	Maybe
Unit Runtime		X	X	X	No
Lockouts			X	X	Yes
Deck Temperature Reset		X			Yes
CW Temp Reduction		X			Yes
Packaged Unit Replacement	X				No
VAV Conversion					Maybe
Motor Loading				X	No

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2003 Energy Data Collection

- Runtimes
- Motor Loading
- CHW & CW flows (get help)
- OAT, RAT, MAT, SAT (Economizer operation)
- Duct Temps (VAV, DD)
- Mixing Valve Operation
- Combustion Efficiency



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2003 Energy Questions?



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