



An Energy-Efficiency Workshop and Exposition

Orlando, Florida

Fundamentals for Energy Managers

The ABCs of Energy, Part II

HVAC



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Orlando, Florida

Please be courteous to our speakers



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



Who is kW Engineering?

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



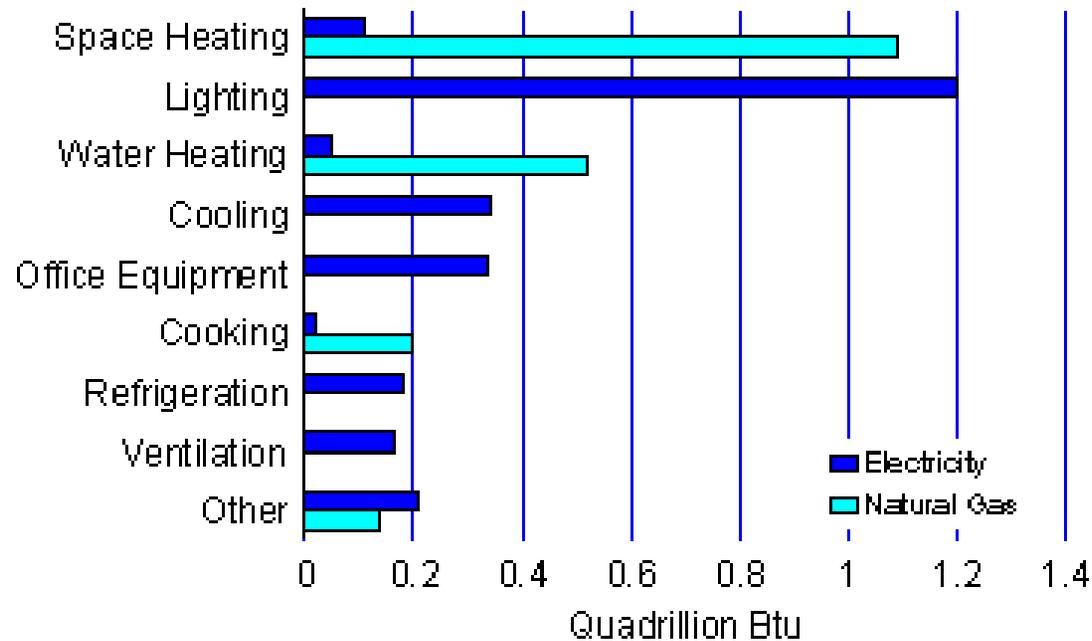
What will this seminar cover?

- ✘ 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



Commercial Energy Use by Fuel and End Use

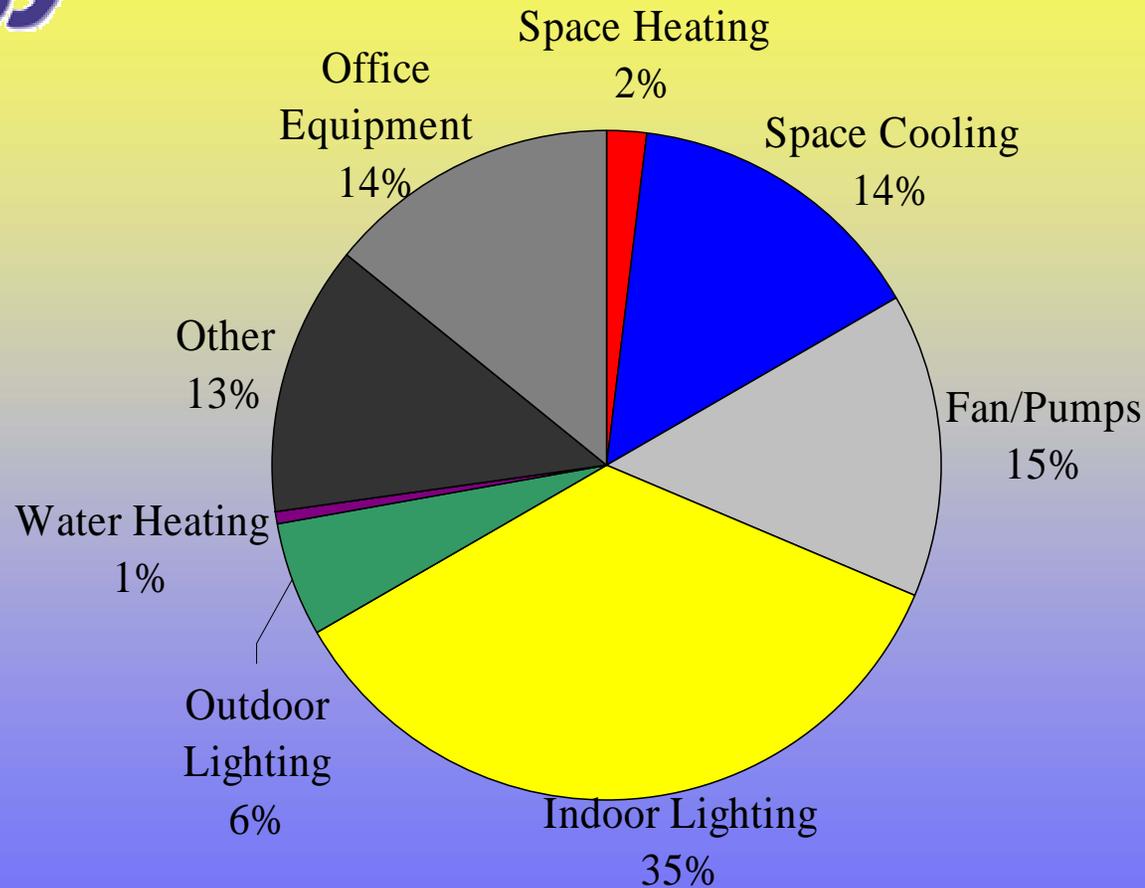
Figure 12. Electricity and Natural Gas Consumption by End Use, 1995



Energy Information Administration
1995 Commercial Buildings Energy Consumption Survey



Typical Energy Use: Large Office Building



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



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	35.62
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	7.96	2.95	46.96
Ref. Warehouse	4.17	3.60	0.42	15.14	0.02	0.05	2.66	1.95	22.36
Warehouse	4.06	1.50	0.37	0.62	0.05	0.16	1.99	1.52	6.04
Schools	2.44	7.20	0.86	0.44	0.69	0.39	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 Valley	4.41	5.38	1.31	3.01	0.38	4.16	4.34	2.90	15.96
Coastal Hill	3.91	4.90	1.24	3.63	0.34	5.64	4.33	2.42	16.27
Total	3.99	2.72	1.20	1.73	0.22	1.98	3.77	2.08	11.96
Total	4.69	5.91	1.38	1.50	0.27	3.74	4.08	2.76	13.77
Total	4.34	4.35	1.29	2.03	0.27	3.11	4.02	2.49	13.64

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



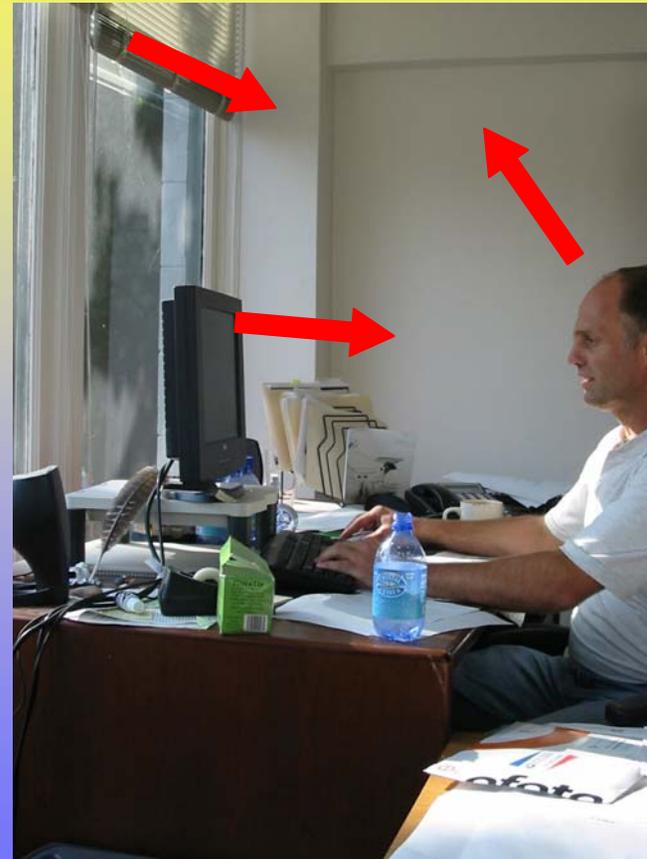
Heat Balance in Buildings

- 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



Cooling and Heating Loads

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





Major HVAC System Components

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





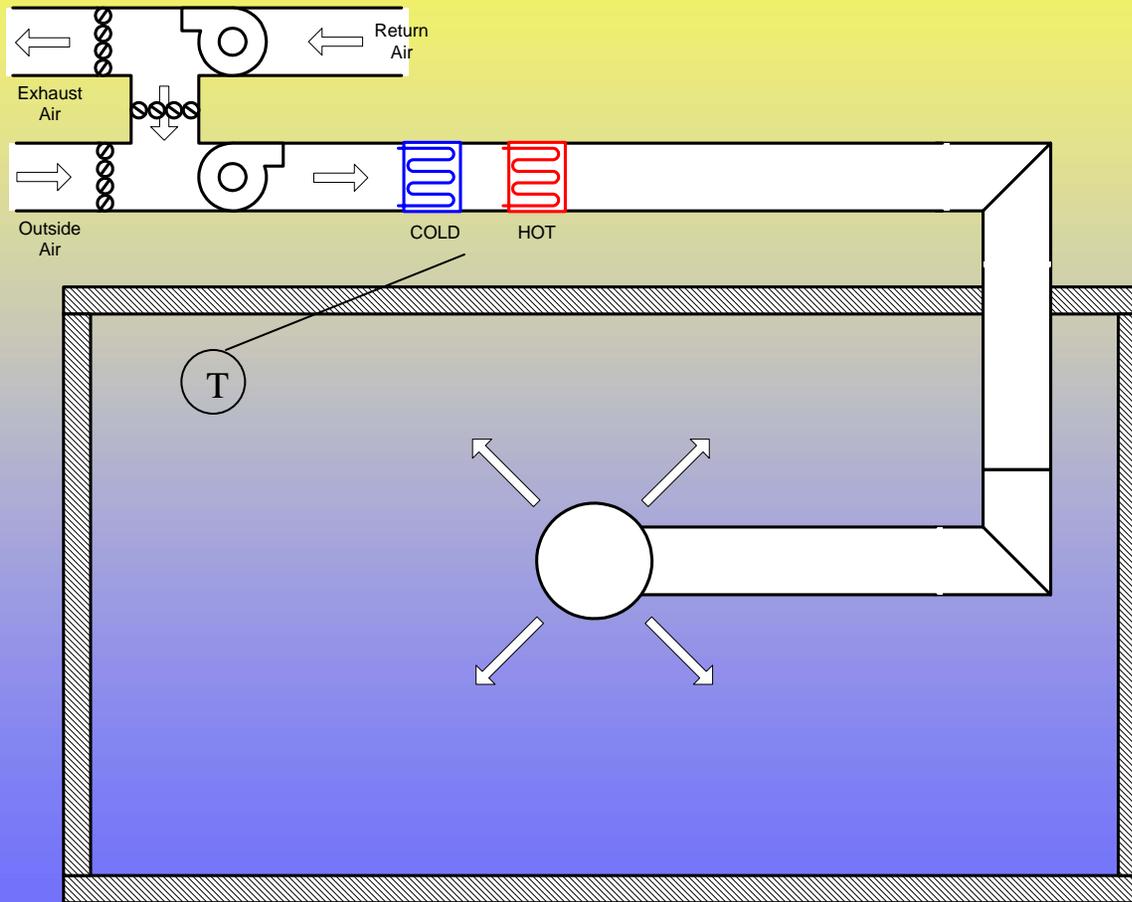
Types of Air Handlers

- 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





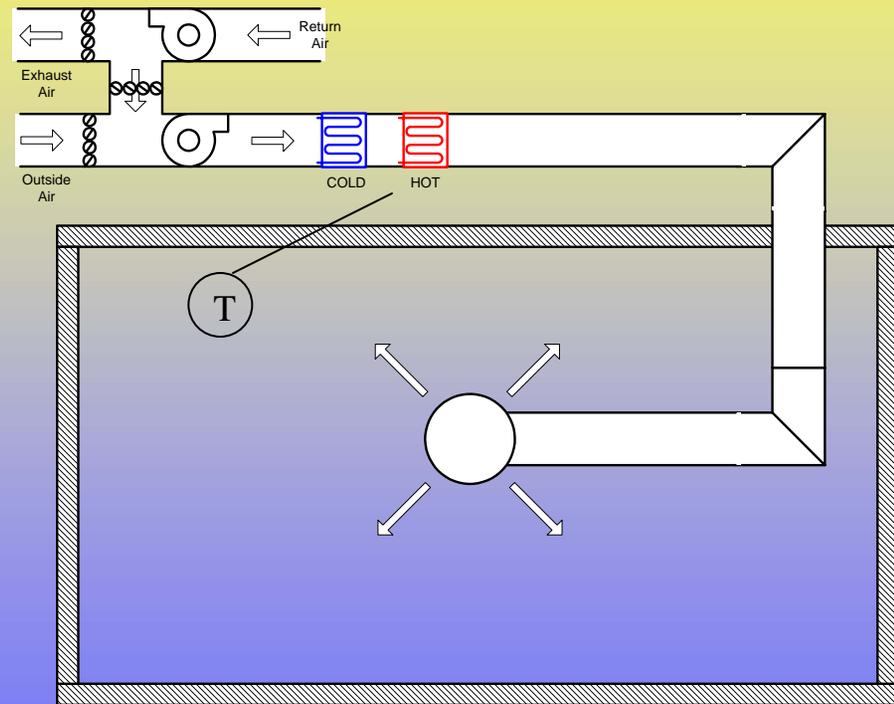
Single Zone Air Handler





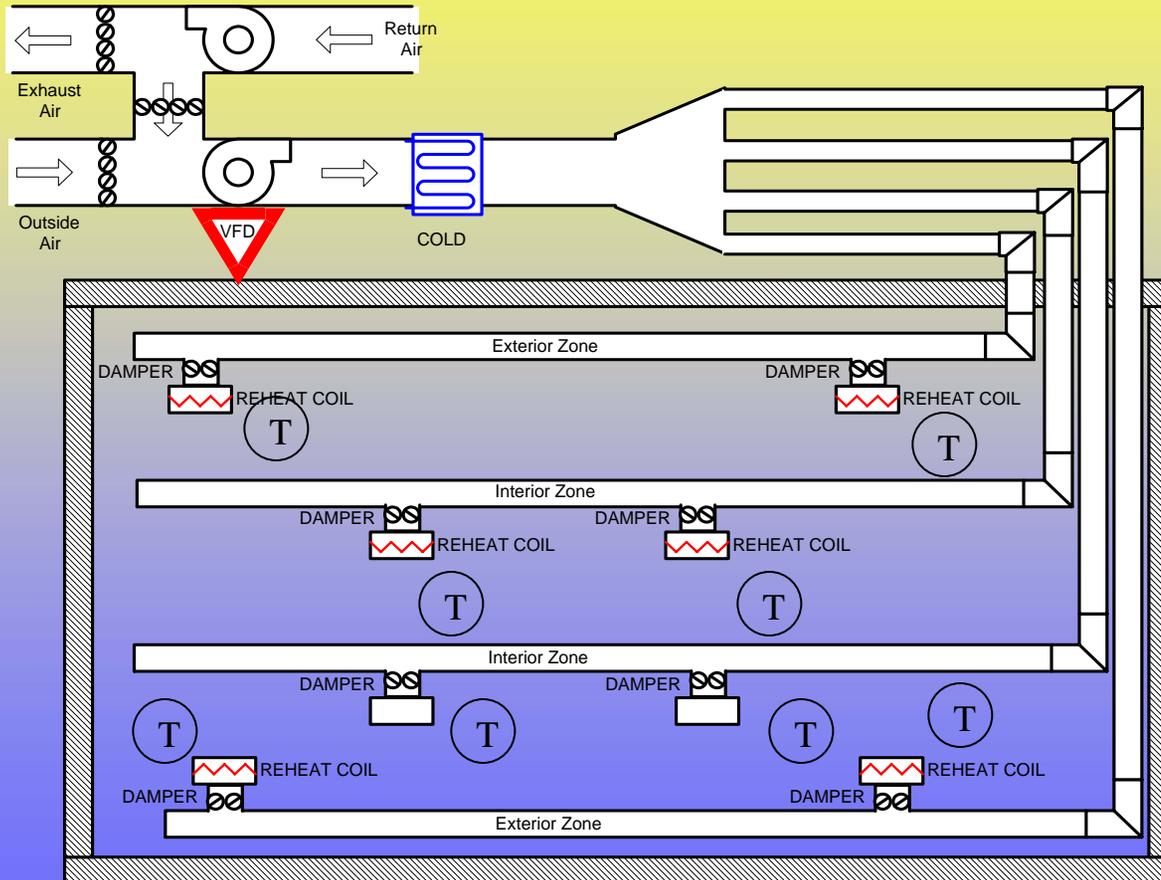
Field Identification of Single Zone Systems

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





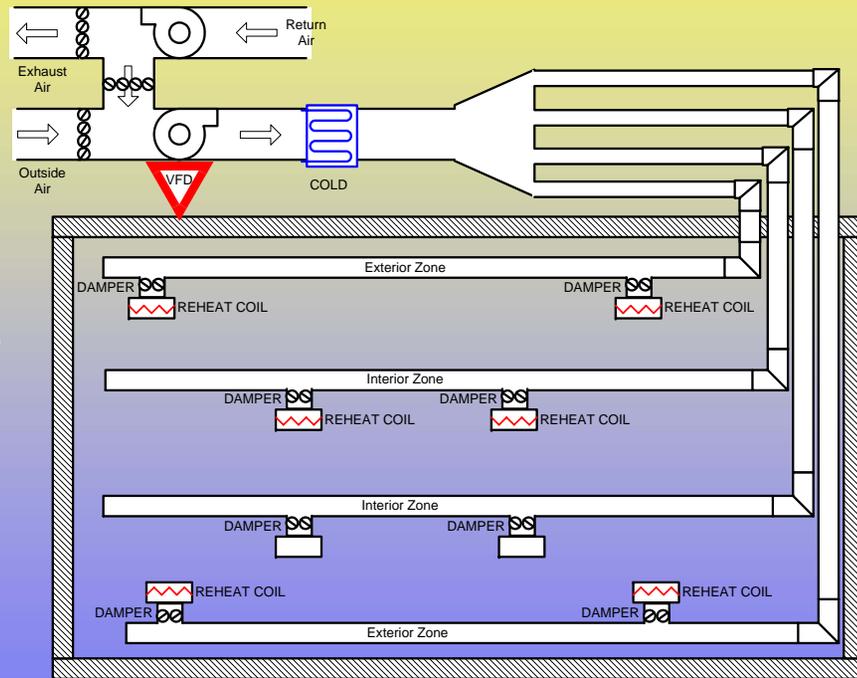
Variable Air Volume Air Handler





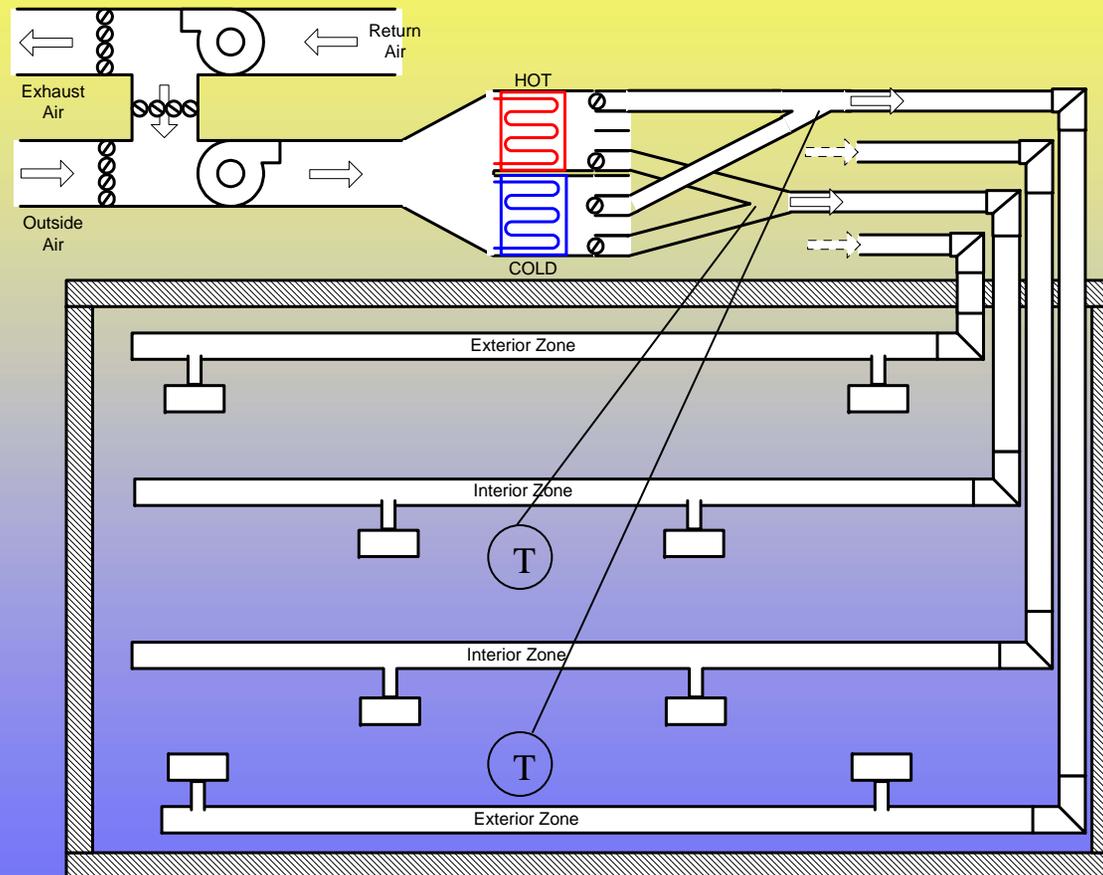
Field Identification of VAV Air Handler

- 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





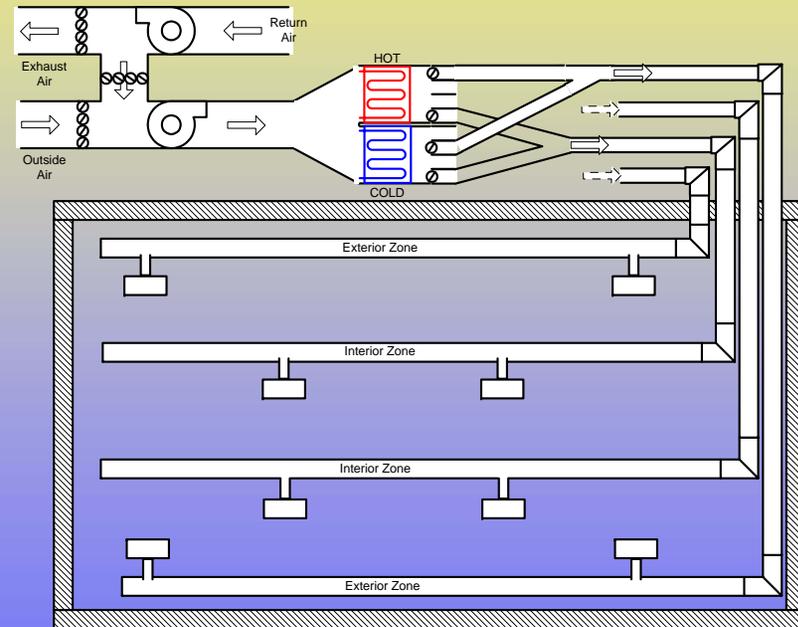
Multizone Air Handler





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





Multizone Actuators





More Multizone Actuators



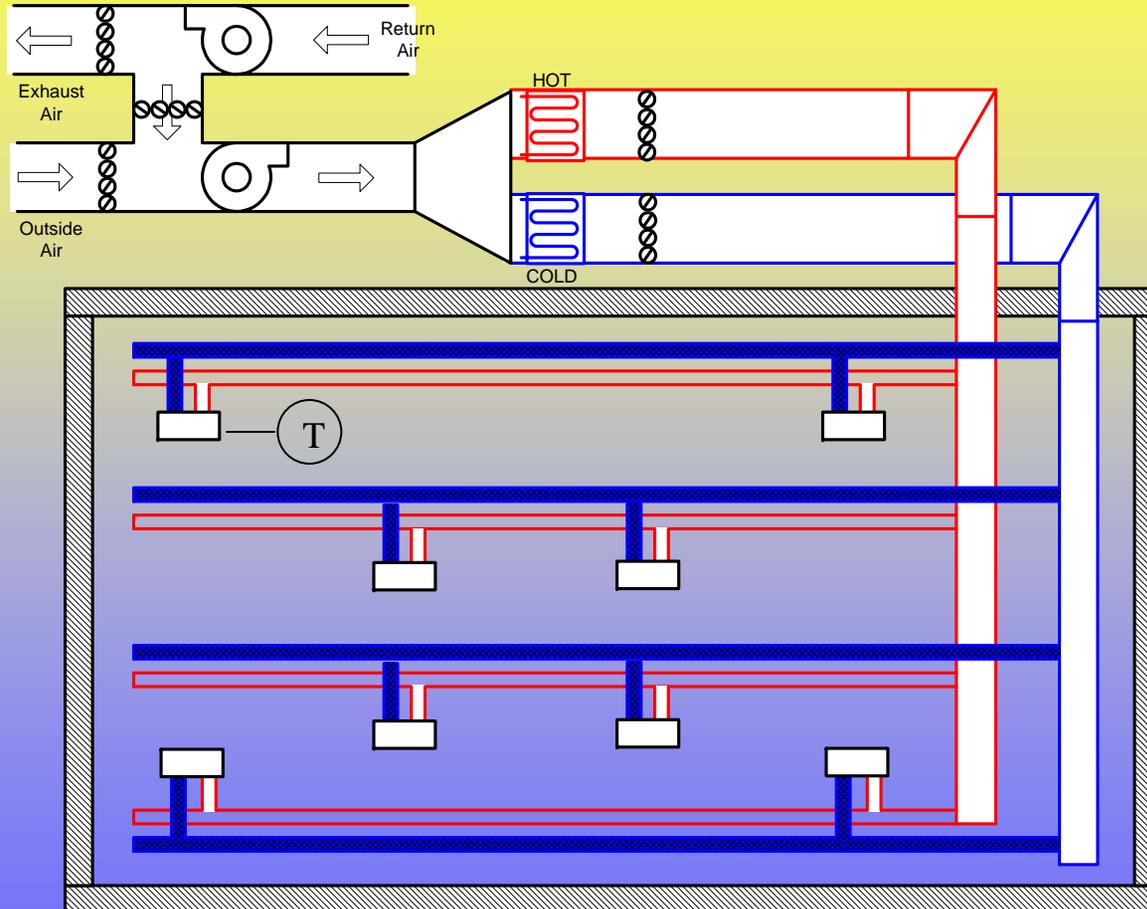
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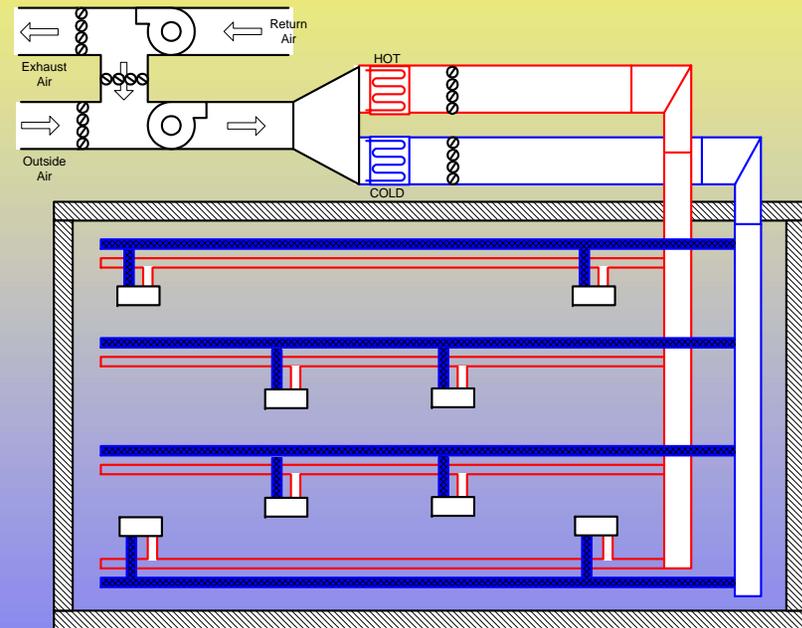
Dual Duct Air Handler





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





Low-Cost/No-Cost

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



2003 Capital Projects

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





Two Components to Savings

- Potential to generate savings
- Savings over time



Summary of Equipment Efficiencies

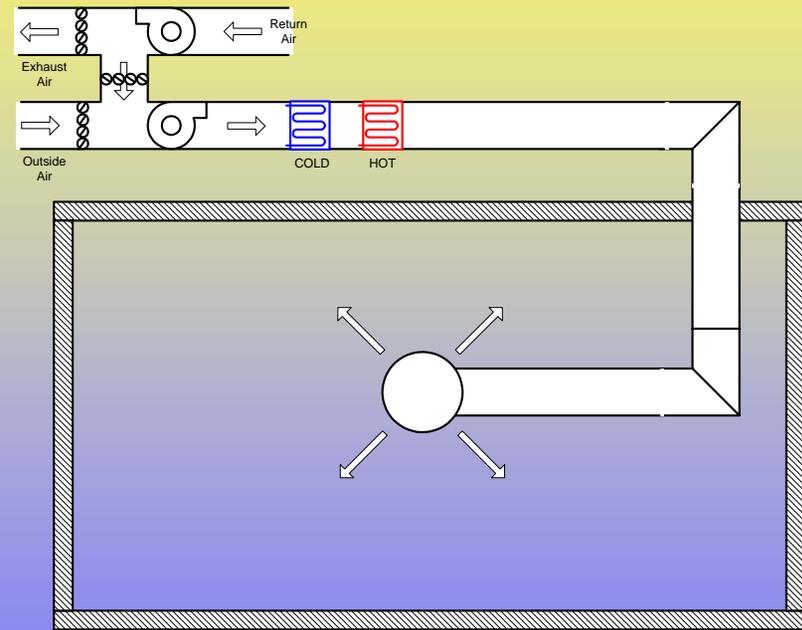
- Efficiency: Ratios developed to represent equipment ability to absorb or generate heat relative to the input energy required by that equipment

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



Single Zone Air Handler Opportunities

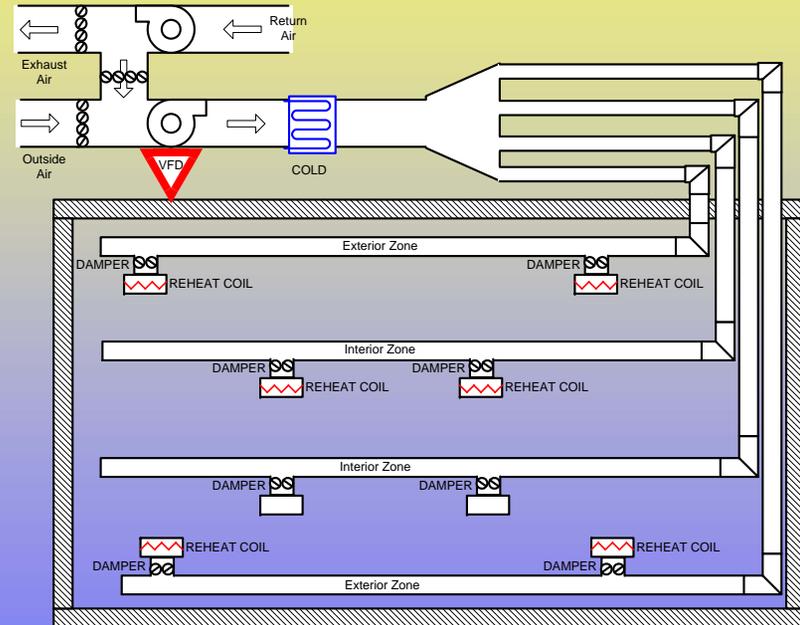
- Replace with High Efficiency Unit
- Reduce operating hours
- Repair economizer
- Convert to VAV if large and over-ventilated





VAV Air Handler Opportunities

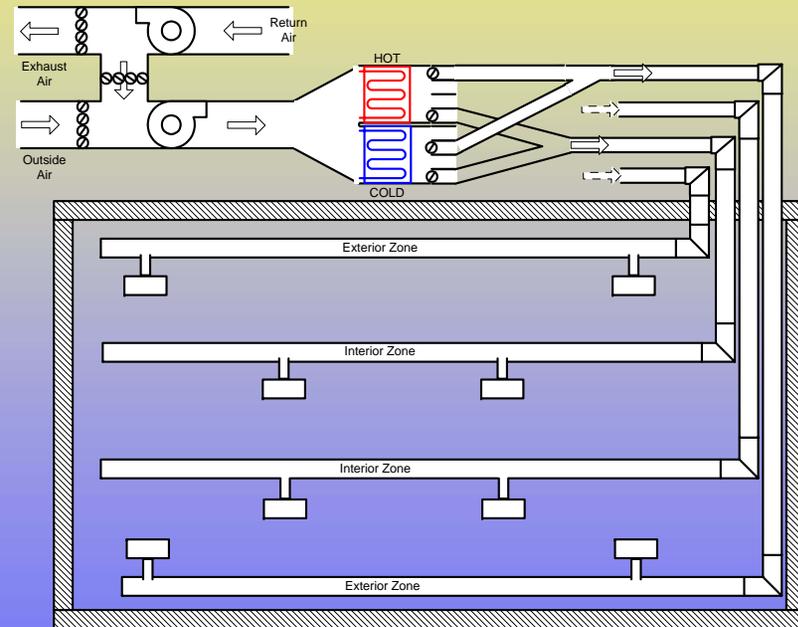
- Reduce operating hours
- Repair economizer
- Reset duct static pressure
- Reset discharge air temp to optimize
 - Simultaneous heating & cooling
 - Economizer operation
 - Fan power
- Add DDC zone control
 - Nighttime shutdown of zones





Multizone Air Handler Opportunities

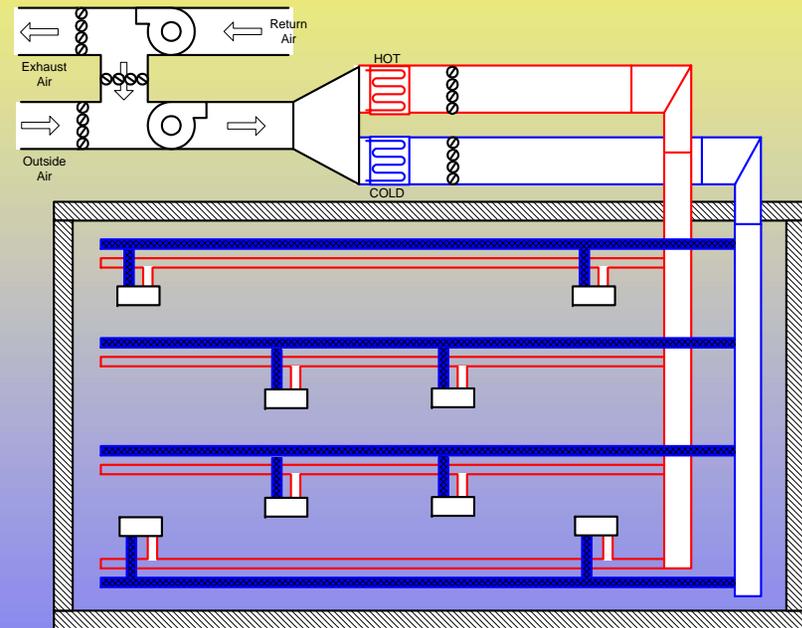
- Reduce operating hours
- Repair economizer
- Minimize simultaneous heating and cooling
 - Lockouts
 - HD and CD temperature reset
- Convert to VAV





Dual Duct Air Handler Opportunities

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





Large Economizers



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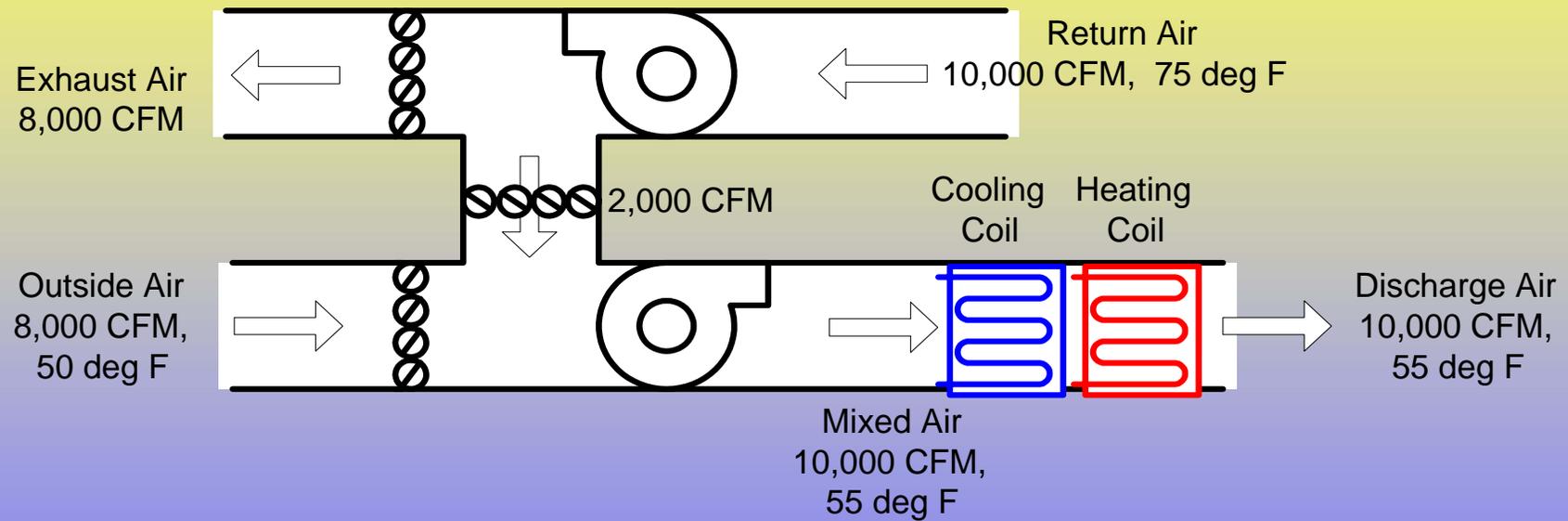
Packaged Equipment Opportunities

- 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



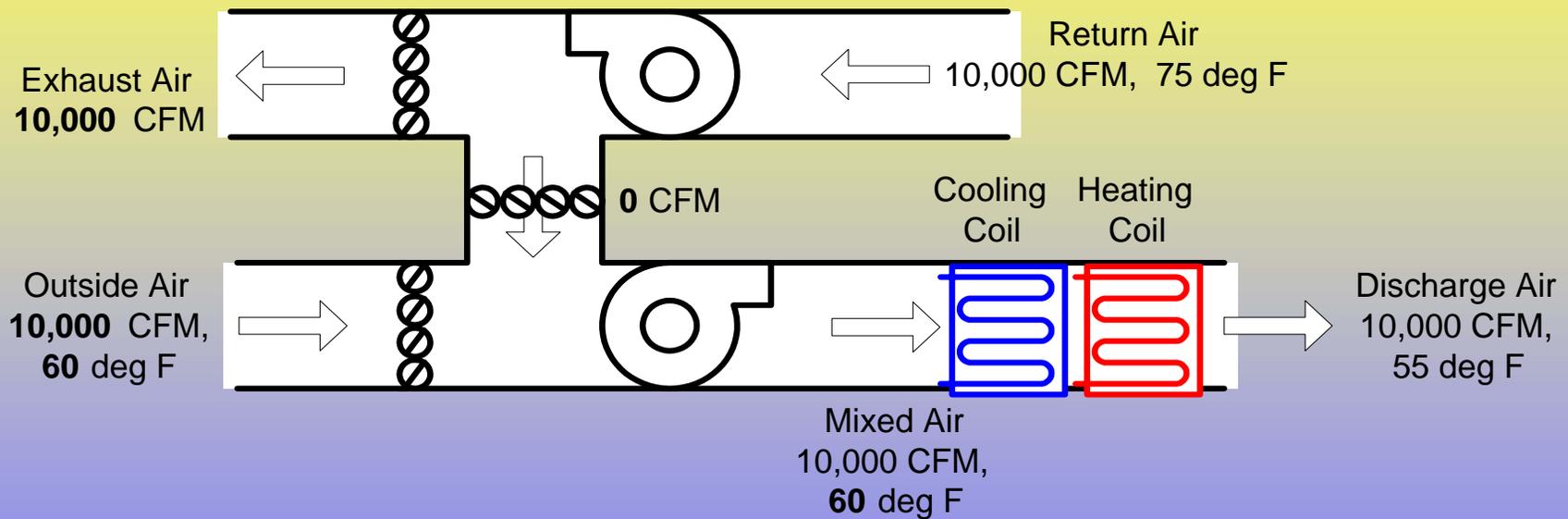


Economizer Offsetting All Cooling





Economizer Reducing Mechanical Cooling





Retrofit Economizer



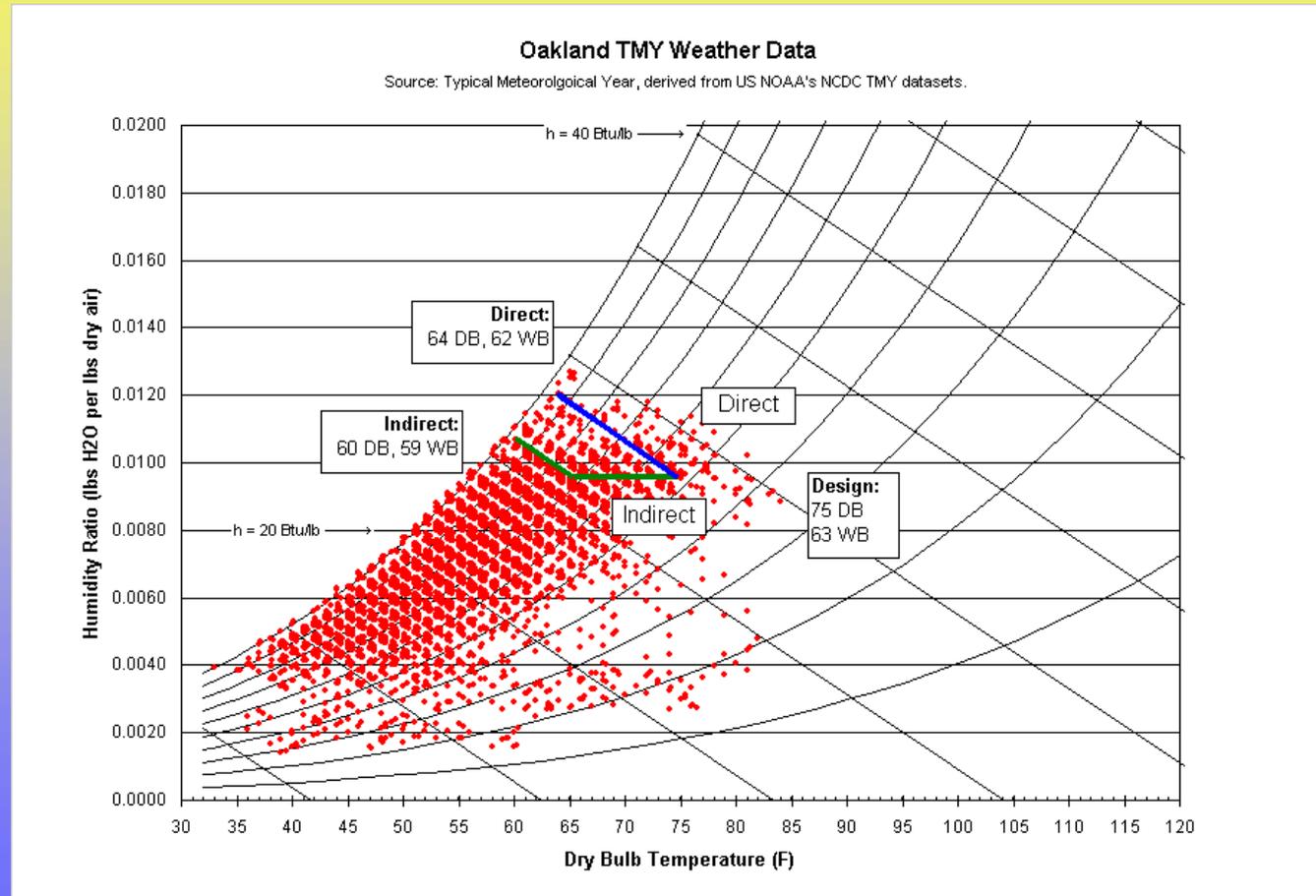
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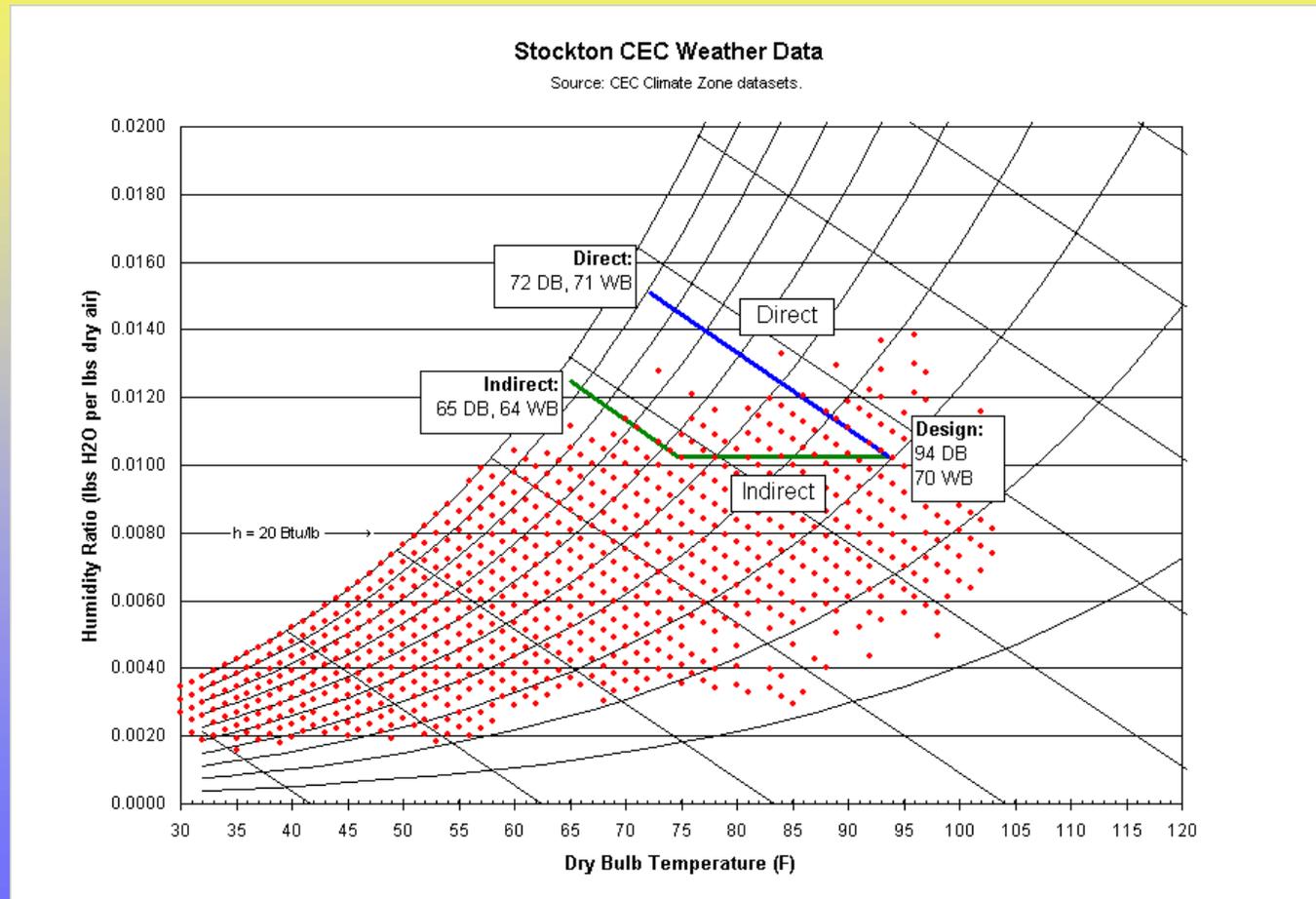


Evaporative Cooling - Oakland





Evaporative Cooling - Stockton



Energy 2003 Chillers

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





Chillers – Driveline Retrofit

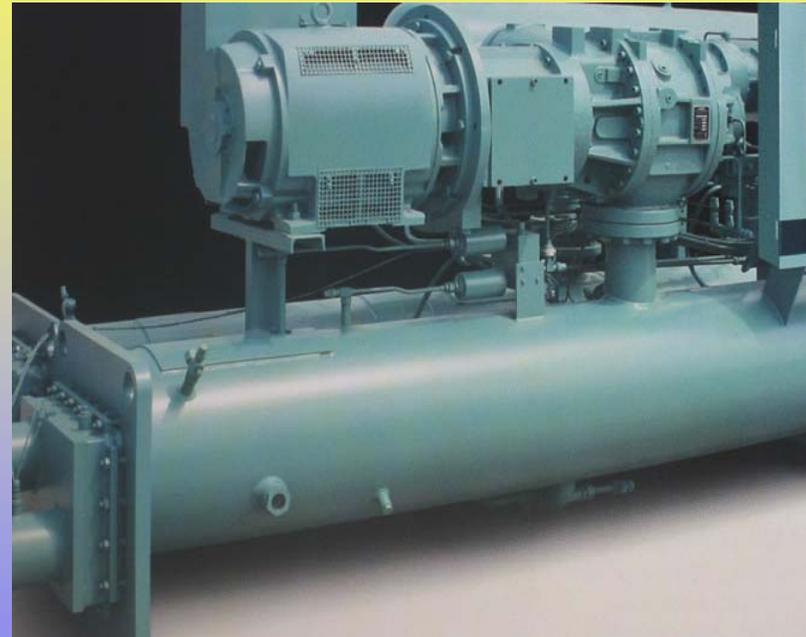
- Less efficiency improvement
- Less expensive if inaccessible location
- Consider Downsizing
- Recent Example:
800 Ton to 600 Ton
0.345 kW/Ton @ 600 Ton, 70 CW
0.253 kW/Ton @ 300 Ton, 60 CW





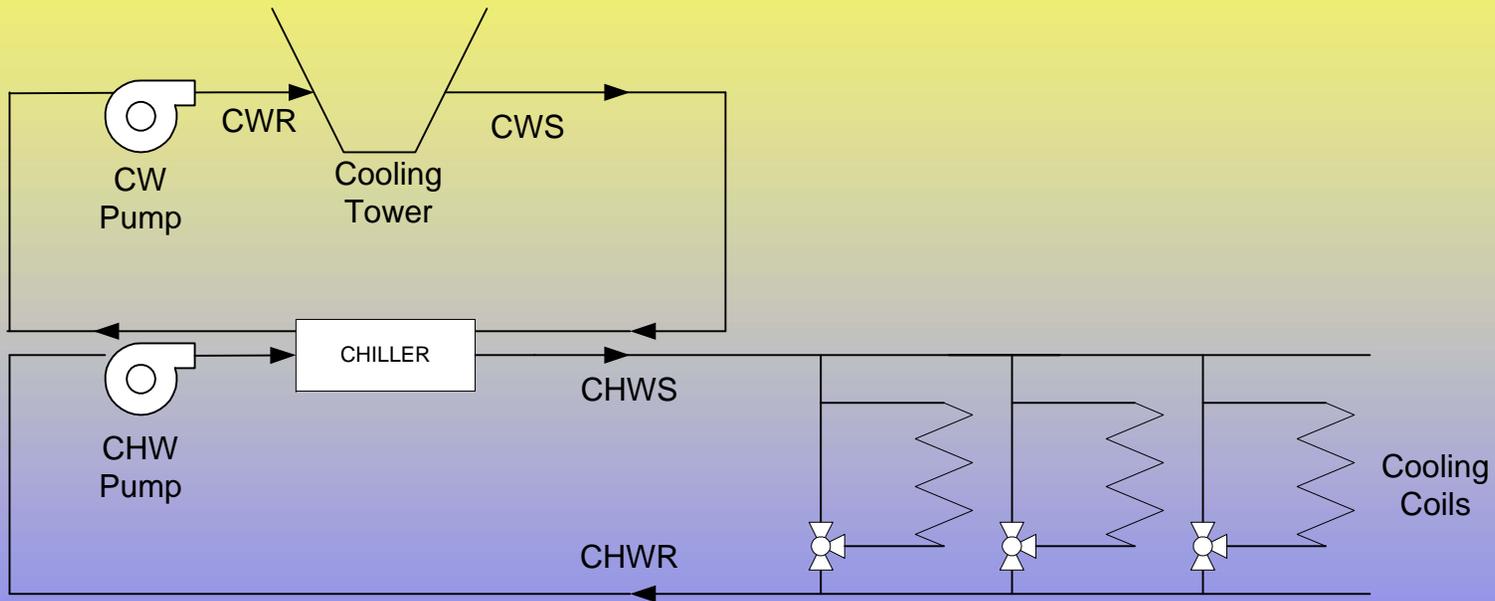
Chillers - Replacement

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



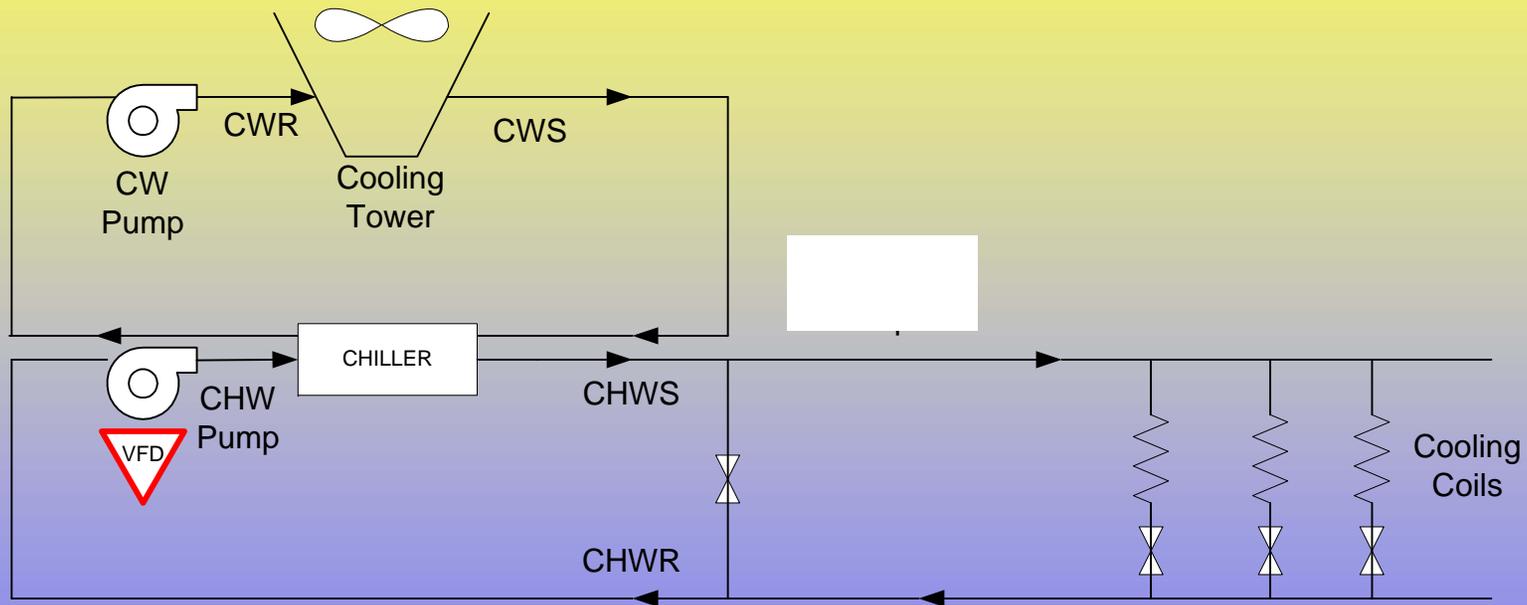


Chillers: Primary Pumping



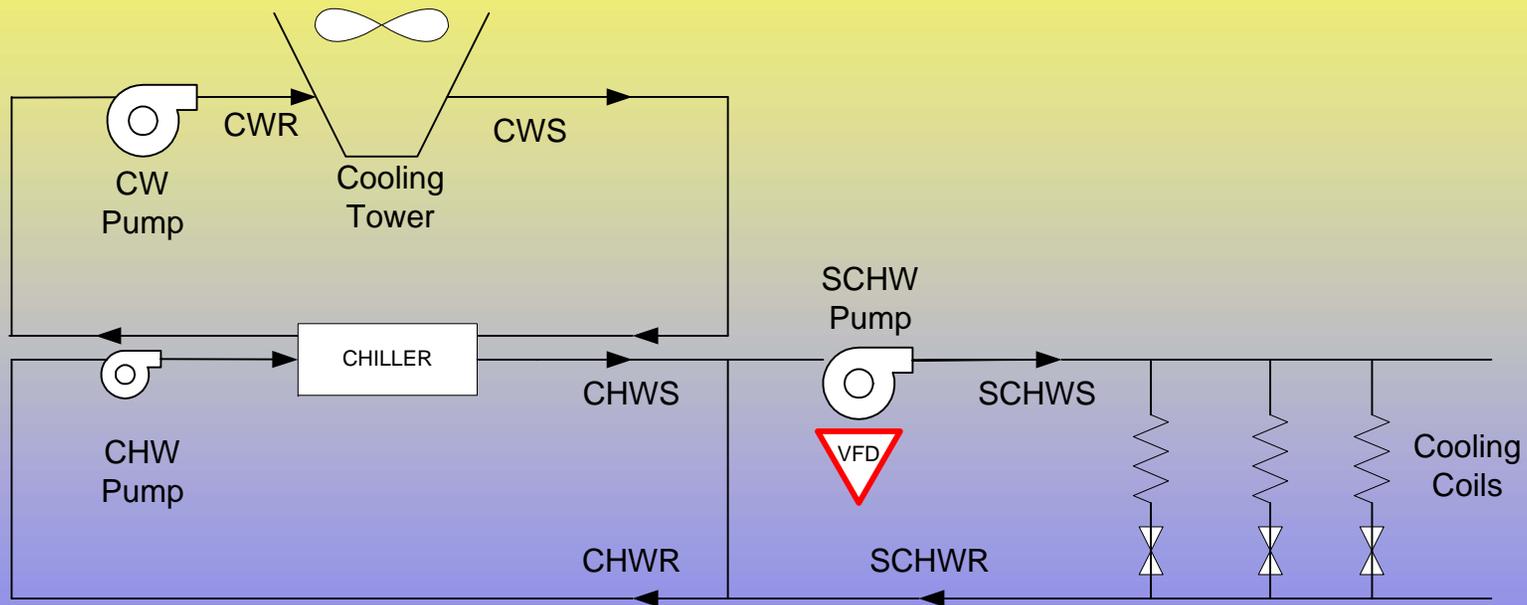


Chillers: Variable Primary Pumping





Chillers: Primary-Secondary Pumping





Cooling Towers

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





Water Side Economizer



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2003 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





Pumps, Fans, and Motors

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





2003 Motor Efficiencies

NOMINAL FULL LOAD EFFICIENCIES FOR EPACT AND NEMA PREMIUM™ MOTORS

Covered Equipment: 1-200 horsepower NEMA design A and B, three phase, low voltage, general purpose motors
ODP and TEFC, 1200, 1800, and 3600 RPM

Initiative Web Page: www.cee1.org/ind/motrs/motrs-main.php3

Motor Decisions Matter Web Page: www.motorsmatter.org

For more information, contact: Ilene Mason, 617-589-3949 ext 225, e-mail: imason@cee1.org

Open Drip-Proof (ODP)							Totally Enclosed Fan-Cooled (TEFC)						
HP	1200 RPMs		1800 RPMs		3600 RPMs		HP	1200 RPMs		1800 RPMs		3600 RPMs	
	EPACT Efficiency Standard*	NEMA PREMIUM Efficiency**	EPACT Efficiency Standard*	NEMA PREMIUM Efficiency**	EPACT Efficiency Standard*	NEMA PREMIUM Efficiency**		EPACT Efficiency Standard*	NEMA PREMIUM Efficiency**	EPACT Efficiency Standard*	NEMA PREMIUM Efficiency**	EPACT Efficiency Standard*	NEMA PREMIUM Efficiency**
1	80	82.5	82.5	85.5	N/A	77	1	80	82.5	82.5	85.5	75.5	77
1.5	84	86.5	84	88.5	82.5	84	1.5	85.5	87.5	84	86.5	82.5	84
2	85.5	87.5	84	88.5	84	85.5	2	86.5	88.5	84	86.5	84	85.5
3	86.5	88.5	86.5	89.5	84	85.5	3	87.5	89.5	87.5	89.5	85.5	86.5
5	87.5	89.5	87.5	89.5	85.5	86.5	5	87.5	89.5	87.5	89.5	87.5	88.5
7.5	88.5	90.2	88.5	91	87.5	88.5	7.5	89.5	91	89.5	91.7	88.5	89.5
10	90.2	91.7	89.5	91.7	88.5	89.5	10	89.5	91	89.5	91.7	89.5	90.2
15	90.2	91.7	91	93	89.5	90.2	15	90.2	91.7	91	92.4	90.2	91
20	91	92.4	91	93	90.2	91	20	90.2	91.7	91	93	90.2	91
25	91.7	93	91.7	93.6	91	91.7	25	91.7	93	92.4	93.6	91	91.7
30	92.4	93.6	92.4	94.1	91	91.7	30	91.7	93	92.4	93.6	91	91.7
40	93	94.1	93	94.1	91.7	92.4	40	93	94.1	93	94.1	91.7	92.4
50	93	94.1	93	94.5	92.4	93	50	93	94.1	93	94.5	92.4	93
60	93.6	94.5	93.6	95	93	93.6	60	93.6	94.5	93.6	95	93	93.6
75	93.6	94.5	94.1	95	93	93.6	75	93.6	94.5	94.1	95.4	93	93.6
100	94.1	95	94.1	95.4	93	93.6	100	94.1	95	94.5	95.4	93.6	94.1
125	94.1	95	94.5	95.4	93.6	94.1	125	94.1	95	94.5	95.4	94.5	95
150	94.5	95.4	95	95.8	93.6	94.1	150	95	95.8	95	95.8	94.5	95
200	94.5	95.4	95	95.8	94.5	95	200	95	95.8	95	96.2	95	95.4

Energy 2003 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





Time Clock Inside Unit





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





Unit Heater in Garage



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Other Opportunities

- Lighting upgrade (T8s, Premium T8s, HQT5, 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



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



Benchmarking Resource

http://208.254.22.6/index.cfm?c=evaluate_performance.bus_portfoliomanager

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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)



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



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

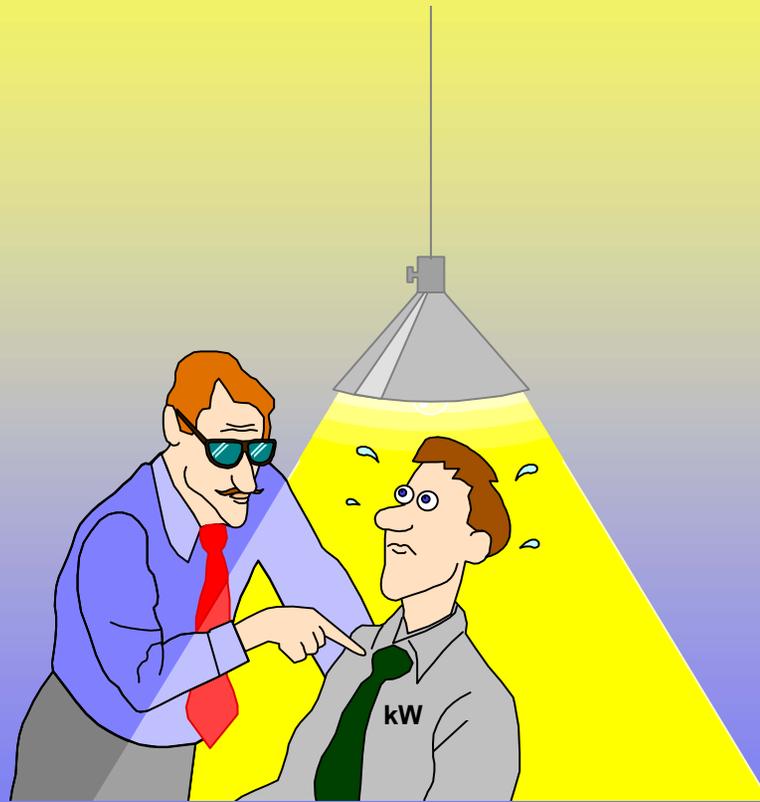


Data Collection

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



Energy 2003 Questions?



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