

Practical Energy Tips for Energy Savings in HVAC Systems: Down to Earth Sustainability

ASHRAE TC 7.6

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ASHRAE Fellow and Distinguished Lecturer

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1

Learning Objectives

- Recognize the environmental and economic impacts of energy management
- Assess building energy performance and set energy usage goals
- Create an action plan for saving energy
- Prioritize multiple building projects
- Define accountability for a building's ongoing energy management

3

Sustaining our Future by Rebuilding our Past

“Energy Efficiency in Existing Buildings is Our Greatest Opportunity for a Sustainable Future”

Gordon Holness, ASHRAE Presidential Member

Our Greatest Opportunities

86% of Construction Dollars go into Existing Buildings

75% to 80% of All Buildings that will Exist in 2030 Exist Today!

Energy Management Potential

Building Reduction
33%



National Reduction
14%

In Other Words.....

- Green
- Sustainable
- Lowers Carbon Footprint
- Lowers CO₂ Emissions
- Reduces Global Warming
- Reduces Cost
- Improves Return on Investment

Emissions Factors and Energy Prices for the Cleaner and Greener Environmental Program
<http://www.cleanerandgreener.org/download/efactors.pdf>

14

Greener Pastures with Energy Savings Emissions Reduction at Madison Area Technical College

| Energy | Usage FY 01/02 | Usage FY 06/07 | Reduction! |
|-----------------|--------------------|--------------------|----------------|
| Electricity | 23,000,000 kWh | 18,000,000 kWh | 5,000,000 kWh |
| Natural Gas | 900,000 therms | 645,000 therms | 255,000 therms |
| Emissions | Emissions FY 01/02 | Emissions FY 06/07 | Reduction! |
| Carbon Dioxide | 30,500 tons | 23,000 tons | 7,500 tons |
| Sulfur Oxides | 138 tons | 106 tons | 32 tons |
| Nitrogen Oxides | 72 tons | 55 tons | 17 tons |

Source: MATC Engineering Manager – Wesley Marquardt – wmarquardt@matcmadison.edu

For 50 state emissions data, refer to “Emission Factors and Energy Prices”:
<http://www.cleanerandgreener.org/download/efactors.pdf>

15

GSA Energy Management Program

US Courthouse
Jacksonville, Florida
Constructed in 2005
Disappointing Energy Use

DOE-ORNL Report

17

2005 New Building Performance

- Floor area: 492,000 ft²
- EUI: 83 kBtu/SF predicted to be 45 kBtu/SF
- Energy Star rating: 41 predicted to be 79
- Utility costs: \$664,000/year predicted to be \$220,000/yr
- Far less efficient than design intent

More on this building later...

18

Energy Management Strategies

- Do Nothing
- Price Shopping
- Occasional O&M Projects
- Capital Projects
- **Sustained Energy Management**

Christopher Russel
www.energypathfinder.com

19

Energy Star Guidelines for Energy Management

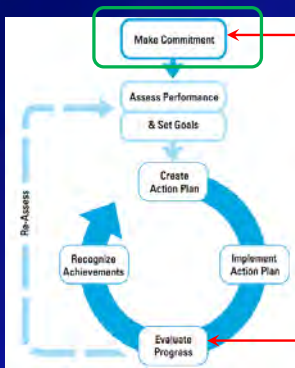
www.energystar.gov



27

Energy Star Guidelines for Energy Management

www.energystar.gov



28

Make Commitment

Top Management Commits to Continuous Improvement

The common element of successful energy management is commitment.

- Form a Dedicated Team
- Institute an Energy Policy

29

Energy Manager Job Description

Chapter 36, ASHRAE 2011 Handbook
"Energy Use and Management"

- Functions
 - Technical
 - Policy-related
 - Planning and purchasing
- Qualifications
 - General
 - Educational/Professional

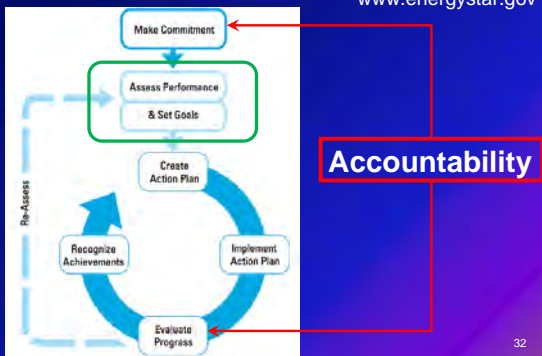
30

Job Description - Purchasing

- Lower-cost energy
- Other non-building utilities
 - Vehicle fuel
 - Water

31

Energy Star Guidelines for Energy Management
www.energystar.gov



32

Assess Performance & Set Goals

33

Assess Performance & Set Goals

- Annual Usage
 - Energy Cost Index (ECI)
 - Energy Utilization Index (EUI)
- Annual Profile of Monthly Data
- Daily Profile of 15-Minute Data

35

Indices

ECI: Energy Cost Index = \$/SF/yr

EUI: Energy Utilization Index = kBtu/SF/yr

$$\begin{aligned}
 & \text{(Annual kWh X 3.413)} = \text{___ kBtu} \\
 + & \text{(Annual Therms X 100)} = \text{___ kBtu} \\
 \hline
 & \text{Total Annual Energy} = \text{___ kBtu}
 \end{aligned}$$

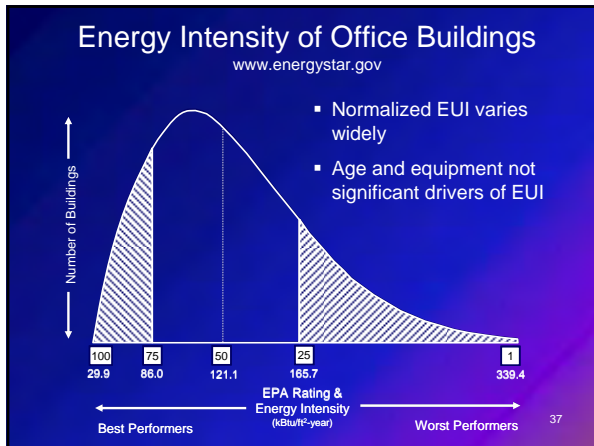
$EUI = \text{Total Annual Energy} \div \text{SF} = \text{kBtu/SF/yr}$

Example: Lowell Hall @ UW, 1996

$$\begin{aligned}
 & (1,209,319 \text{ kWh X } 3.413) = 4,127,000 \text{ kBtu} \\
 + & (83,642 \text{ Therms X } 100) = 8,364,200 \text{ kBtu} \\
 \hline
 & \text{Total Annual Energy} = 12,491,200 \text{ kBtu}
 \end{aligned}$$

$EUI = 12,491,200 \text{ kBtu} \div 117,600 \text{ SF} = 106.2 \text{ kBtu/SF/yr}$

36



Energy Star Benchmarking

www.energystar.gov/benchmark

38

39

40

41

42

Commercial and Corporate Real Estate Benchmarking Starter Kit

Get Started

[Quick Reference Guide \(PDF\)](#)

43

PORTFOLIO MANAGER + QUICK REFERENCE GUIDE

Rate Your Energy Performance

USE PORTFOLIO MANAGER STEP-BY-STEP

1. Access Portfolio Manager
2. Access your account
3. Specify property type
4. Enter property information
5. Enter energy use data
6. Review and export results

44

LEED Green Building

45

Energy Star Portfolio Facility Summary

| Facility Name | Energy Use (kBtu/sq ft) | Energy Star Rating | Score |
|---------------|-------------------------|--------------------|-------|
| Facility 1 | 12,345,678 | 4 | 85 |
| Facility 2 | 13,456,789 | 3 | 75 |

46

Target Page in Portfolio Manager

<http://www.energystar.gov/benchmark>

47

STATEMENT OF ENERGY PERFORMANCE

Sample Facility

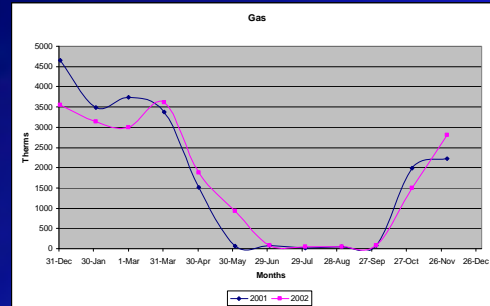
48

Assess Performance & Set Goals

- Annual Usage
 - Energy Cost Index (ECI)
 - Energy Utilization Index (EUI)
- Annual Profile of Monthly Data
- Daily Profile of 15-Minute Data

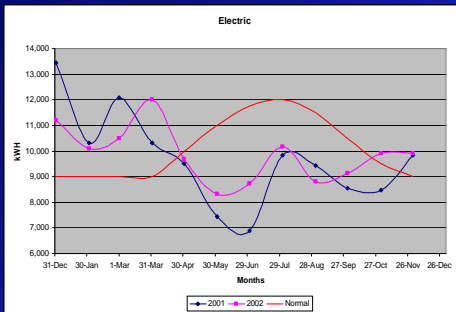
49

Annual Profile of Monthly Data Madison Church



50

Annual Profile of Monthly Data Madison Church



51

Assess Performance & Set Goals

- Annual Usage
 - Energy Cost Index (ECI)
 - Energy Utilization Index (EUI)
- Annual Profile of Monthly Data
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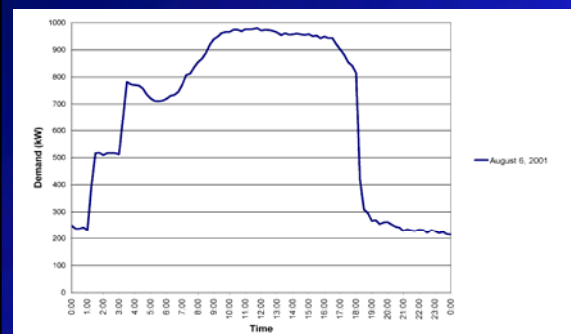
52

Honolulu Office Building: Using 15-Minute Data to Identify Opportunities



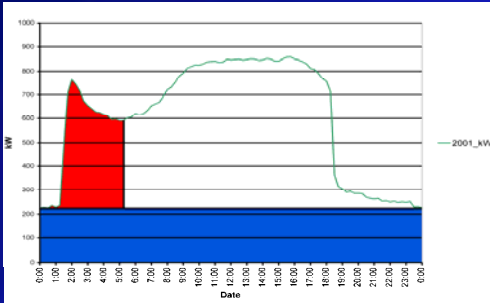
53

Daily Profile of 15-Minute Data



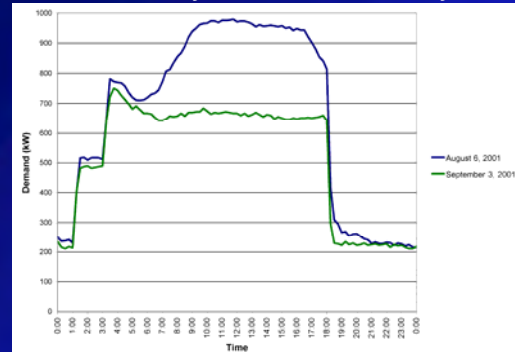
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Daily Profile of 15-Minute Data Honolulu Office Building



55

Monday versus Holiday



56

Energy Star Guidelines for Energy Management www.energystar.gov



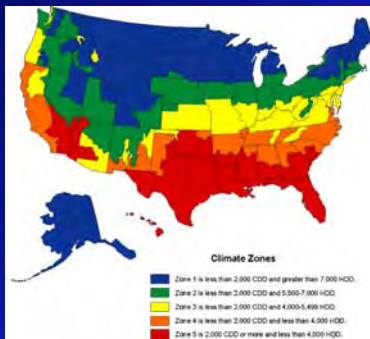
57

Create Action Plan

Where Do I Start Saving Energy?

58

Prioritizing Multiple Buildings



60

Action Plan: Evaluating Multiple Buildings

| Site | SF | Zone | Type | ECI | EUI | Current \$ |
|----------------------------|--------|------|------------|--------|-----|------------|
| 601-Tyson's Corner | 39,463 | 4 | Homestore | \$3.01 | 193 | \$118,823 |
| 510-Mission Viejo | 12,895 | 4 | Housewares | \$6.10 | 177 | \$78,685 |
| 503-Fashion Valley | 14,510 | 4 | Housewares | \$6.66 | 177 | \$96,579 |
| 412-Roseville | 34,372 | 4 | Homestore | \$4.13 | 176 | \$142,059 |
| 851-Lenox | 36,919 | 4 | Homestore | \$3.21 | 175 | \$118,325 |
| 855-Alpharetta | 29,282 | 4 | Homestore | \$2.52 | 156 | \$73,674 |
| 511-South Coast II | 36,417 | 4 | Homestore | \$6.02 | 154 | \$219,158 |
| 402-Corte Madera | 11,632 | 4 | Housewares | \$6.29 | 142 | \$73,119 |
| 404 a - Santana Row | 38,017 | 4 | Homestore | \$5.96 | 140 | \$226,467 |
| 507-University Town Centre | 12,678 | 4 | Housewares | \$5.33 | 137 | \$67,561 |
| 406-Walnut Creek | 37,552 | 4 | Homestore | 6.161 | 129 | 231357.872 |
| 505-Pasadena | 38,566 | 4 | Homestore | 4.257 | 128 | 164175.462 |
| 506-Topanga Plaza | 14,262 | 4 | Housewares | 3.112 | 121 | 44383.344 |
| 890-Crabtree Valley | 13,305 | 4 | Housewares | \$1.86 | 115 | \$24,751 |
| 411-Union Square Furniture | 43,167 | 4 | Homestore | \$4.91 | 114 | \$211,820 |
| 502-Century City(Closed) | 14,200 | 4 | Housewares | \$2.10 | 75 | \$23,753 |
| 407-Hillside | 15,238 | 4 | Housewares | \$3.24 | 71 | \$49,341 |
| 403-Palo Alto | 38,920 | 4 | Homestore | \$0.86 | 40 | \$33,588 |

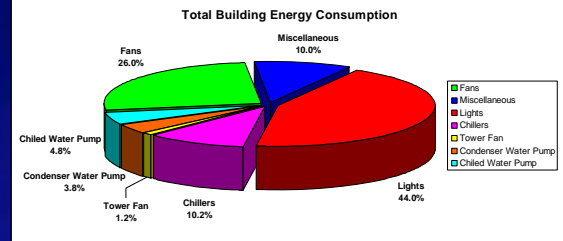
61

Action Plan: Evaluating Multiple Buildings

| Site | SF | Zone | Type | ECI | EUI | Current \$ | New \$ | Savings |
|----------------------------|--------|------|------------|--------|-----|-------------|-----------|-----------|
| 601-Tyson's Corner | 39,463 | 4 | Homestore | \$3.01 | 193 | \$118,823 | \$70,678 | \$48,146 |
| 510-Mission Viejo | 12,895 | 4 | Housewares | \$6.10 | 177 | \$78,685 | \$51,093 | \$27,592 |
| 503-Fashion Valley | 14,510 | 4 | Housewares | \$6.68 | 177 | \$96,570 | \$62,924 | \$33,655 |
| 412-Roseville | 34,372 | 4 | Homestore | \$4.13 | 176 | \$142,059 | \$92,740 | \$49,320 |
| 851-Lenox | 36,919 | 4 | Homestore | \$3.21 | 175 | \$118,325 | \$77,619 | \$40,707 |
| 855-Alpharetta | 29,282 | 4 | Homestore | \$2.52 | 156 | \$73,674 | \$54,176 | \$19,498 |
| 511-South Coast II | 36,417 | 4 | Homestore | \$6.02 | 154 | \$219,158 | \$164,146 | \$55,012 |
| 402-Corte Madera | 11,632 | 4 | Housewares | \$6.29 | 142 | \$73,119 | \$59,252 | \$13,867 |
| 404 a - Santana Row | 38,017 | 4 | Homestore | \$5.96 | 140 | \$226,467 | \$185,688 | \$40,781 |
| 507-University Town Centre | 12,678 | 4 | Housewares | \$5.33 | 137 | \$67,561 | \$56,700 | \$10,861 |
| 406-Walnut Creek | 37,552 | 4 | Homestore | \$6.16 | 129 | \$231,258 | | \$339,438 |
| 505-Pasadena | 38,566 | 4 | Homestore | \$4.26 | 128 | \$164,175 | | |
| 506-Topanga Plaza | 14,262 | 4 | Housewares | \$3.11 | 121 | \$44,383 | | |
| 860-Crabtree Valley | 13,305 | 4 | Housewares | \$1.86 | 115 | \$24,761 | Target | |
| 411-Union Square Furniture | 43,167 | 4 | Homestore | \$4.91 | 114 | \$211,820 | | |
| 502-Century City(Closed) | 14,200 | 4 | Housewares | \$2.10 | 79 | \$29,763 | | |
| 407-Hillsdale | 15,238 | 4 | Housewares | \$3.24 | 71 | \$49,341 | | |
| 403-Palo Alto | 38,920 | 4 | Homestore | \$0.89 | 40 | \$33,588 | | |
| | | | | | | \$2,003,639 | | |

64

Action Plan: Evaluating End-Use Within a Building



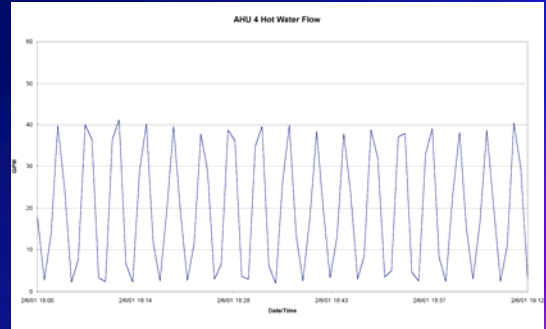
65

End-Use Evaluation

Use trend logs or portable data-loggers

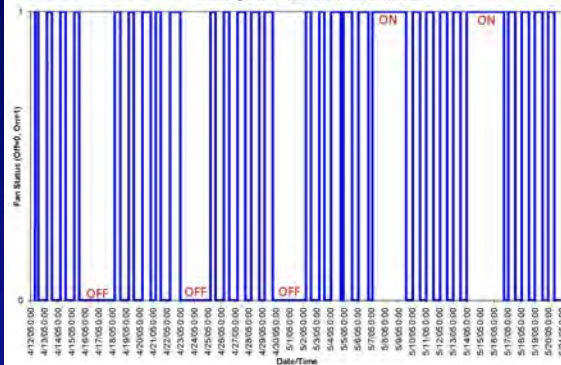
- Runtime
- Temperature fluctuations
- Electrical use
 - Amps
 - kWh

66



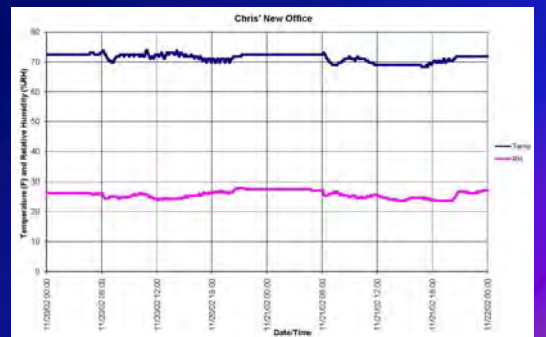
67

Monitoring Manual Control of Kitchen Exhaust Fan



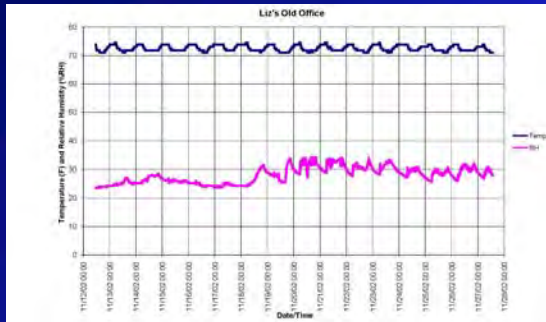
68

Office Temperature/RH - Verex



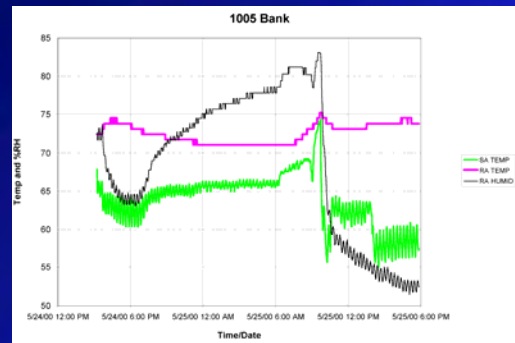
69

Office Temperature/RH - Verex



70

Bank Temperature/RH



71

Two Types of Action



- Discretionary Facility Operation
- Energy Audits and Capital Improvements

73



BREAK!

Wisconsin's Focus on Energy Best Practices Spreadsheets

- Air Handlers
- Boilers
- Chillers
- Cooking
- Domestic Hot Water
- HVAC
- Lighting
- Misc. Equipment
- Refrigeration



Available for download at:
<http://www.focusonenergy.com/business/commercial-business/cpem/sixsteps.aspx>

Air-Handlers Best Practices

- Install Variable Speed Controls on Air Handler Supply Fan
- Convert Air Handling system from Constant Volume to Variable Air Flow
- Convert Dual Duct or Multizone Air Handling System to Variable Air Flow
- Install Premium Efficiency Motors
- Install High Efficiency AC Units or RTUs
- Reduce Outside Air Intake
- Install Night Setback Controls (Heating season)
- Install Night Set Up Controls (Cooling season)

77

Air-Handlers Best Practices

Variable Speed Drive on an Air Handler

Converting an air handler from one type of control (constant volume to variable air volume) can save heating, cooling and fan energy. Fan energy savings only are calculated by this spreadsheet.

The heating and cooling energy savings are very dependent on type of air handling system, and how the system is operated. Therefore, those savings are not reflected in this spreadsheet.

78

Air-Handlers Best Practices

| EXISTING | | System 1 |
|------------------------|---------|----------|
| Motor Horsepower | 10.0 | 10.0 |
| Motor Efficiency | 87.0% | 90.0% |
| % Full Load | 75.0% | 75.0% |
| Annual Operation Hours | 2,000 | 2,000 |
| Conversion Factor | 0.746 | 0.746 |
| kW | 10.0 | 9.7 |
| kWh/yr | 18,000 | 17,500 |
| Average kWh Rate | \$0.100 | \$0.095 |
| Annual Energy Cost | \$1,800 | \$1,655 |

Annual Energy Cost: \$1,800 vs \$1,655

Annual Cost Savings: \$145

Project Cost Estimate: \$1,000

Payback: 6.9

Simple Payback: 6.9

[Install Variable Speed Controls on Supply Fan](#)

79

Air-Handlers Best Practices

Premium Efficiency Motors

Premium efficiency motors will generally require a larger up-front investment. However, the incremental cost can usually be recovered in less than 2 years. Additionally, it is typically less expensive to purchase equipment with the premium efficiency component already installed than it would be to retrofit the equipment at a later time.

80

Air-Handlers Best Practices

| Existing Motor | | Motor 1 |
|------------------------|---------|---------|
| Motor Horsepower | 10.0 | 10.0 |
| Existing Motor Eff | 87.0% | 90.0% |
| % Full Load | 75.0% | 75.0% |
| Annual Operation Hours | 2,000 | 2,000 |
| Conversion Factor | 0.746 | 0.746 |
| kW | 10.0 | 9.7 |
| kWh/yr | 18,000 | 17,500 |
| Average kWh Rate | \$0.100 | \$0.095 |
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Annual Energy Cost: \$1,800 vs \$1,655

Annual Cost Savings: \$145

Project Cost Estimate: \$1,000

Payback: 6.9

Simple Payback: 6.9

[Install Premium Efficiency Motors](#)

81

Air-Handlers Best Practices

Outside Air Reduction

Air handling units serve several functions including space heating, cooling and ventilation. Facility ventilation is generally accomplished by bringing in outside air, mixing it with "return air" at the air handler, and distributing the resulting "mixed air" throughout the facility. Bringing in outside air increases energy consumption during most times of year because the outside air needs to be conditioned. Therefore, it is important to make sure the correct amount of outside air is being supplied to the facility only when needed. Outside air is needed when the facility is occupied, or when large exhaust systems are being operated. The calculations below estimate gas savings associated with an outside air reduction. If the facility is cooled, and/or the shu fans are shut down during times of reduced ventilation, then there will also be electrical savings.

Dick's Tips

1. Turn off unneeded exhaust fans
2. Do not open O.A. dampers until occupancy

82

Air-Handlers Best Practices

| EXISTING | | System 1 |
|-----------------------|---------|----------|
| CFM of Outside Air | 1000 | 1000 |
| AHU Motor Horsepower | 10.0 | 10.0 |
| AHU Motor Load Factor | 0.75 | 0.75 |
| AHU Motor Efficiency | 87.0% | 90.0% |
| AHU% O.A. is Supply | 10.0% | 10.0% |
| AHU% O.A. is Exhaust | 0.0% | 0.0% |
| Heating Degree Hours | 1000 | 1000 |
| Cooling Degree Hours | 1000 | 1000 |
| Annual Energy Cost | \$1,800 | \$1,655 |

Annual Energy Cost: \$1,800 vs \$1,655

Annual Cost Savings: \$145

Project Cost Estimate: \$1,000

Payback: 6.9

Simple Payback: 6.9

[Reduce Outside Air Intake](#)

83

Air-Handlers Best Practices

Install Night Setback (heating) and Night Set Up (cooling) Controls

Setback Controls

Setback controls reduce the space temperature of an area during unoccupied hours. Reducing the temperature means less heat is lost to the outside through walls, roofs and air infiltration. Setback controls may be part of a facility-wide energy management system, or separate programmable thermostats may be used. Some setback controls employ "smart" features which determine when to start heating a building to make sure it is warm when occupancy starts. These "smart" controls look at both the outside air temperature and inside air temperature. Costs on controls can range from as low as \$40 for a programmable thermostat, to hundreds of thousands of dollars for complete energy management systems for facilities with multiple buildings.

Setup Controls

Set-Up controls allow the space temperature to float upward during unoccupied hours. Increasing the temperature means less heat needs to be removed from the building. Set-Up controls may be part of a facility-wide energy management system, or separate programmable thermostats may be used. Some controls employ "smart" features which determine when to start cooling a building to make sure it is at the correct temperature when occupancy starts. These "smart" controls look at both the outside air temperature and inside air temperature. Costs of controls can range from as low as \$40 for a programmable thermostat, to hundreds of thousands of dollars for complete energy management systems for facilities with multiple buildings. If the facility is assessed a demand charge, the setback period should end at least 15 minutes before the utility on-peak period.

84

Air-Handlers Best Practices

Install Night Setback (heating) and Night Set Up (cooling) Controls

| EXISTING | Example | Area 1 |
|---------------------------------------|----------|---------|
| Square Footage | 10,000 | 10,000 |
| Therms per year | 10,000 | 8,000 |
| Average Therm Rate | \$1,000 | \$1,000 |
| Annual Energy Cost | \$10,000 | \$8,000 |
| PROPOSED | | |
| Degrees of Temperature Setback | 10 | 20 |
| Hours per week of Setback | 100 | 100 |
| Constant Setback Hours per week | 100 | 100 |
| Adjustment Factor | 0.40 | 0.40 |
| Average Winter temperature difference | 30 | 20 |
| Percent Reduction | 8.0% | 8.0% |
| Average Therm/yr Use | 13,000 | 8,704 |
| Annual Energy Cost | \$13,000 | \$8,704 |
| SAVINGS | | |
| Th/yr | 5,000 | 300 |
| Annual Cost Savings | \$1,100 | \$767 |
| Project cost Estimate | \$1,000 | \$1,000 |
| Incentive | \$0 | \$100 |
| Simple Payback | 1.0 | 1.0 |

| EXISTING | Example | Area 1 |
|---------------------------------------|---------|---------|
| Square Footage | 10,000 | 10,000 |
| Cooling Balance Feet ² /yr | 100,000 | 100,000 |
| Cooling Degree Days | 100 | 1,000 |
| Cooling kWh/yr | 10,000 | 10,000 |
| Average kWh Rate | \$0.10 | \$0.10 |
| Annual Energy Cost | \$1,000 | \$1,000 |
| PROPOSED | | |
| Degrees of Temperature Setback | 10 | 20 |
| Hours per week of Setback | 100 | 100 |
| Constant Setback Hours per week | 100 | 100 |
| Effective Cooling Degree Days | 100 | 1,000 |
| Adjustment Factor | 0.40 | 0.40 |
| Percent Reduction | 10.0% | 10.0% |
| Average kWh/yr Use | 11,000 | 9,900 |
| Annual Energy Cost | \$1,100 | \$990 |
| SAVINGS | | |
| kWh/yr | 1,000 | 1,100 |
| Annual Cost Savings | \$100 | \$110 |
| Project cost Estimate | \$1,000 | \$1,000 |
| Incentive | \$0 | \$100 |
| Simple Payback | 1.0 | 1.0 |

85

Boilers Best Practices

- Test and Adjust Burners
- Replace Boiler with High Efficiency Unit
- Reduce Steam Pressure
- Steam Trap Repair/Replace
- Isolate Unused Boiler(s)
- Install Heat Recovery on the Boiler Stack (Flue Gas Economizer)
- Install Variable Speed Pumping
- Reset Boiler System Hot Water Temperatures

86

Boilers Best Practices

Test and Adjust Boiler Burners

Combustion efficiency is primarily a function of the fuel to air ratio at varying boiler loads. If the fuel to air ratio is too rich or too lean, efficiency is negatively impacted. A good way to keep boilers operating near an optimal fuel to air ratio, is to have the boilers tested and adjusted annually.

87

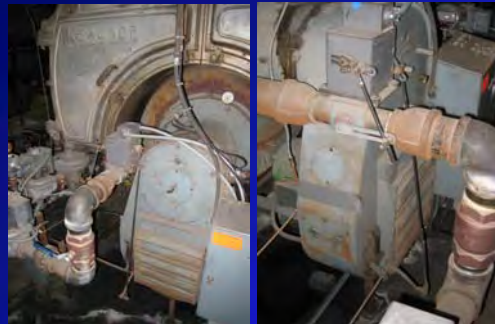
Boilers Best Practices

| EXISTING | Example | System 1 |
|-------------------------------|----------|-----------|
| Existing Boiler Efficiency | 80% | 80% |
| Average Current therm/yr Use | \$1,000 | \$1,000 |
| Average Therm Rate | \$0.900 | \$1,000 |
| Annual Energy Cost | \$90,000 | \$100,000 |
| PROPOSED | | |
| Est. % Increase in Efficiency | 2.0% | 2.0% |
| Proposed Efficiency | 82.0% | 82.0% |
| Proposed Therm Use: | \$9,548 | \$9,548 |
| Annual Energy Cost | \$85,908 | \$85,908 |
| SAVINGS | | |
| Th/yr | 1,834 | 1,834 |
| Annual Cost Savings | \$14,092 | \$14,092 |
| Project cost Estimate | \$750 | \$750 |
| Incentive | \$0 | \$110 |
| Simple Payback | 0.5 | 0.4 |

Test & Adjust Boiler Burners

88

Existing Burner showing linkages for gas and combustion air.



89

Linkageless Burner Characteristics

- Measures O₂ in flue gas
- Separately modulates gas valve to control load and matches speed of combustion air fan to maintain optimum efficiency at all loads.
- Estimated original turndown is 3:1
- Realistic new turndown is 6:1 (can be 8:1)
- Original peak efficiency is 78% to 80%
- New efficiency at all loads is 83% to 85%

90

Analysis of Linkageless Savings

- Apparent efficiency improvement: 78%/80% to 83%/85%. This is a 6% improvement at peak load.
- O₂ trim and separate modulation maintain peak efficiency at ALL LOADS.
- Burner turns down to lower loads without cycling off, this minimizes purging.
- An apparent 6% improvement results in an actual improvement of 20% or better.

91

Linkageless Economics

- Installed Cost \cong \$30,000
- Gas saved (15,600 therms @ \$1) \cong \$15,600
- Simple Payback \cong 1.9 years

92

Boilers Best Practices

Reduce Steam Pressure

Steam plants for heating and process needs can often operate at a range of pressures. It is often most efficient to operate these systems at the lowest possible pressures. When a system is operated at lower pressures, the temperature of the steam is lower. This leads to decreased heat loss from steam pipes. It also leads to more efficient operation of the boiler or steam generator, because the difference in temperature between the flame and the steam/hot water temperature is greater at lower pressures, resulting in greater heat transfer. In this analysis, only the savings due to increased boiler efficiency is estimated.

93

Boilers Best Practices

| | Example | Plant #1 |
|-------------------------------------|----------|----------|
| EXISTING | | |
| Boiler Plant Size (MMBtu/Hr) Input: | 1,000 | 1,000 |
| Average Boiler Load Factor | 20% | 25% |
| Steam Temperature (F) | 274 | 274 |
| Boiler Efficiency at 274F Steam | 78.9% | 80.0% |
| Boiler Efficiency at Steam Temp | 78.9% | 78.9% |
| Heat Rate (Btu/kWh) | 8,797 | 8,797 |
| Conversion Factor (MMBtu/Hr) | 100 | 100 |
| Average Existing (thyr) | \$1,800 | \$1,800 |
| Average Steam Rate | 81,507 | 81,507 |
| Annual Energy Cost | \$78,000 | \$78,000 |
| PROPOSED | | |
| Steam Temperature | 250 | 250 |
| Boiler Efficiency at New Steam T | 79.2% | 79.2% |
| Average Proposed (thyr) | \$1,500 | \$1,500 |
| Annual Energy Cost | \$50,473 | \$50,473 |
| SAVINGS | | |
| (thyr) | 300 | 300 |
| Annual Cost Savings | \$27,527 | \$27,527 |
| Project cost Estimate | \$17,220 | |
| Incentive | \$0 | |
| Simple Payback | 0.62 | |

Reduce Steam Pressure

94

Boilers Best Practices

Steam Trap Maintenance

The primary function of steam traps is to keep steam within the steam-using coils and appliances until the steam has condensed. The resulting condensate (water) flows out of the steam trap and into a condensate return. Steam traps are notorious for mechanical failure. Traps can either fail "closed" where no water or steam passes into the condensate system, or can fail "open" when both steam and water are allowed to pass into the condensate tank. This wastes energy and increases the amount of makeup water and chemical treatment needed. Routine checks and maintenance, and replacement of steam traps can reduce malfunctions and save energy.

95

Boilers Best Practices

| | Example | System 1 |
|---|---------|----------|
| EXISTING | | |
| # Traps in System | 20 | 20 |
| Steam Loss Rate | 15.0 | 15.0 |
| BTU/hr | 885 | 885 |
| Boiler Efficiency | 80.0% | 80.0% |
| % of Traps Filled Open | 70% | 70% |
| # Traps Filled | 3 | 3 |
| Boiler Operating Hours | 8,760 | 8,760 |
| Conversion Factor | 100,000 | 100,000 |
| Average Existing steam loss, thyr | 2,973 | 2,973 |
| \$/hr | \$0.190 | \$0.190 |
| Annual Energy Cost | \$2,064 | \$2,064 |
| PROPOSED | | |
| Adjusted Factor: the amount of steam loss that is actually wasted | 75% | 75% |
| Average Proposed thyr | 543 | 543 |
| Annual Energy Cost | \$819 | \$819 |
| SAVINGS | | |
| Savings thyr | 1,636 | 1,636 |
| Annual Cost Savings | \$1,245 | \$1,245 |
| Project cost Estimate | \$0 | \$1,200 |
| Incentive | \$0 | \$154 |
| Simple Payback | 0.0 | 0.8 |

Steam Trap Maintenance

96

Boilers Best Practices

Isolate Boilers

Most facilities that use boilers for space heat have at least two units to provide redundancy, and efficient operation during milder weather. Often these boilers are not easily isolated from one another when only one unit is operating. The result is that the standby unit has hot water or steam circulating through it. Because of this, the standby unit is effectively heated to the same temperature as the active unit, and therefore has significant shell heat loss. Automatic valves can be put in to isolate boilers, when only one unit is firing. Or, one boiler can be manually isolated during the mild periods of the heating season to reduce shell losses.

97

Boilers Best Practices

| | Example | System 1 |
|--------------------------------------|--------------|----------|
| EXISTING | | |
| Ave. Boiler Rating (MBtu/hr) | 1,870 | 1,870 |
| % Shell Losses at Ave. Boiler Rating | 2.2% | 2.2% |
| Boiler Steam or Water Temperature | 233 | 231 |
| Ave Temperature in the Boiler Room | 70 | 70 |
| Number of Boilers in the Plant | 2 | 2 |
| Hourly Boiler Plant Operates | 5,640 | 5,640 |
| Average Existing thyr | 4,808 | 4,808 |
| Average Steam Rate | \$0.280 | \$0.280 |
| Annual Energy Cost | \$4,248 | \$4,248 |
| PROPOSED | | |
| # of Boilers to be Isolated | 1 | 1 |
| Hourly Boilers will be Isolated | 1,680 | 1,680 |
| Proposed Thyr Used | 3,972 | 3,972 |
| Annual Energy Cost | \$2,948 | \$2,948 |
| SAVINGS | | |
| thyr | 1,287 | 1,287 |
| Annual Cost Savings | \$1,299 | \$1,299 |
| Project cost Estimate | \$0 | \$1,200 |
| Incentive | \$0 | \$154 |
| Simple Payback | Intermittent | 0.8 |

Isolate Unused Boilers

98

Boilers Best Practices

Variable Speed Drive Pump on Chilled or Hot Water Pumps

Many existing systems water pumping systems are constant speed. By going to a variable speed drive system, pumping energy can be saved. Often this will involve a constant temperature water supply, possibly some valving changes, and control changes.

99

Boilers Best Practices

| | Example | System 1 |
|------------------------|---------|----------|
| EXISTING | | |
| Motor Horsepower | 20 | 20 |
| Motor Efficiency | 88.4% | 88.4% |
| % Full Load | 80.0% | 80.0% |
| Control Factor | 100% | 100% |
| Annual Operation Hours | 8,760 | 8,760 |
| Conversion Factor | 3,745 | 3,745 |
| kWh | 413 | 413 |
| kWh/yr | \$6,804 | \$6,804 |
| Annual Energy Cost | \$7,689 | \$7,689 |
| PROPOSED | | |
| Motor Horsepower | 20 | 20 |
| Motor Efficiency | 89.2% | 89.2% |
| % Full Load | 80% | 80% |
| Conversion Factor | 3,745 | 3,745 |
| Control Factor | 95% | 95% |
| kWh | 413 | 413 |
| kWh/yr | \$6,804 | \$7,481 |
| Annual Energy Cost | \$7,689 | \$7,481 |
| SAVINGS | | |
| kWh | 0 | 0 |
| kWh/yr | \$6,804 | \$6,853 |
| Annual Cost Savings | \$4,200 | \$4,000 |
| Project cost Estimate | \$4,500 | \$4,500 |
| Incentive | \$0 | \$444 |
| Simple Payback | 1.0 | 0.8 |

Install Variable Speed Pumping

100

Boilers Best Practices

Hot Water Reset

Hot water heating systems are generally controlled to maintain a constant hot water temperature throughout the year. Therefore, the hot water temperature is set to the highest temperature required by the building. While the building may need very hot water in the winter to satisfy heating demand, during milder conditions lower water temperatures can often be used. Controls can be installed on most boiler systems to reduce the hot water set point based on the outside air temperature - the warmer the outside air temperature, the cooler the hot water temperature. Depending on the type of boiler being used, minor plumbing changes may need to be made to prevent the boiler from being shocked by cooler return water. The main energy savings associated with this best practice, is a reduced uncontrolled heat loss from the hot water pipes. In the winter months, the heat loss from the system may actually help to heat the building. However, during milder times of year, the heat loss can contribute to building overheating. This can be an especially significant problem for buildings that employ summer reheat, and therefore must circulate hot water in the summer time.

101

Boilers Best Practices

| | Existing | System 1 |
|--|----------|----------|
| EXISTING | | |
| # of Hot Pipes | 400 | 400 |
| Average Pipe Diameter (Inches) | 12 | 12 |
| Hot Water Temperature (F) | 180 | 180 |
| Hot Loss (Btu) | 1,700 | 1,700 |
| Hot Loss (MMBtu/yr) | 6,260 | 6,260 |
| Water Efficiency | 90% | 90% |
| % of Looses that Exceed Useful Heat | 47% | 47% |
| Is a CHW system used when the boiler is operating? | Yes | Yes |
| EER of Cooling System | 10.1 | 10.1 |
| Conversion Factor | 100,000 | 100,000 |
| Average Building Size | 140 | 140 |
| Average Hot Water | 30,710 | 30,710 |
| MMBtu/yr | 5,744 | 5,744 |
| Average kWh Rate | 0.100 | 0.100 |
| Annual Energy Cost | \$592 | \$592 |
| PROPOSED | | |
| Hot Water Temperature | 180 | 180 |
| Hot Loss (Btu) | 1,700 | 1,700 |
| Hot Loss (MMBtu/yr) | 6,260 | 6,260 |
| Average Proposed Hot Water | 303 | 318 |
| MMBtu/yr | 2,484 | 2,484 |
| Annual Energy Cost | \$453 | \$453 |
| SAVINGS | | |
| Hot Water | 137 | 137 |
| MMBtu/yr | 3,226 | 3,226 |
| Annual Cost Savings | \$139 | \$139 |
| Project cost Estimate | \$1,000 | \$1,000 |
| Investment | \$1 | \$1 |
| Simple Payback | 0.0 | 0.0 |

Hot Water Reset

102

Chillers Best Practices

- High Efficiency Chillers
- Chilled Water Reset
- Chilled Water Pump VFD

103

Chillers Best Practices

Chilled Water Reset

Chilled water temperature is often kept at a fixed set point. However, chillers tend to operate more efficiently, and have more cooling capacity if they are operated at higher chilled water temperatures. To increase chiller efficiency, chilled water temperature can be adjusted automatically based on the outside air temperature.

Dick's Tips

1. Increase chilled water temp: save 1.5% power per 1°F
2. Decrease condenser water temp: save 1.5% power per 1°F

Extreme Example

Increase chilled water temp from 42°F to 48°F AND decrease condenser water temp from 78°F to 75°F:

SAVE 13.5% POWER

104

Chillers Best Practices

| | Existing | System 1 |
|---|----------|----------|
| EXISTING | | |
| Existing Air Conditioner Size | 30 | 30 |
| Chilled Water Temperature | 42 | 42 |
| Existing Air Conditioner Efficiency (EER/FUEER) | 10.7 | 10.7 |
| Efficiency | 100 | 100 |
| Unit Conversion (Btu/kWh) | 3,412 | 3,412 |
| Unit Conversion (kWh/Btu) | 0.293 | 0.293 |
| kWh | 21.8 | 21.8 |
| MMBtu/yr | 24,136 | 24,136 |
| Average kWh Rate | 0.100 | 0.100 |
| Annual Energy Cost | \$1,134 | \$1,134 |
| PROPOSED | | |
| Air Chilled Water Temp. | 48 | 48 |
| Proposed Air Conditioner Efficiency (EER/FUEER) | 10.7 | 10.7 |
| Unit Conversion (Btu/kWh) | 3,412 | 3,412 |
| Unit Conversion (kWh/Btu) | 0.293 | 0.293 |
| kWh | 23.4 | 22.4 |
| MMBtu/yr | 25,487 | 24,487 |
| Annual Energy Cost | \$1,415 | \$1,415 |
| SAVINGS | | |
| kWh | 8.6 | 8.6 |
| MMBtu/yr | 963 | 963 |
| Annual Cost Savings | \$276 | \$276 |
| Project cost Estimate | \$1,000 | \$1,000 |
| Investment | \$1 | \$1 |
| Simple Payback | 3.6 | 3.6 |

Chilled Water Reset

105

Chillers Best Practices

Variable Speed Drive Pump on Chilled Water Pumps

Many existing systems water pumping systems are constant speed. By going to a variable speed drive system, pumping energy can be saved. Often this will involve a constant temperature water supply, possibly some valving changes, and control changes.

Chillers Best Practices

| | Existing | System 1 |
|------------------------|----------|----------|
| EXISTING | | |
| Motor Horsepower | 20 | 20 |
| Motor Efficiency | 84.4% | 84.4% |
| % Full Load | 43.0% | 43.0% |
| Control Factor | 0.70 | 0.70 |
| Annual Operating Hours | 7,760 | 7,760 |
| Conversion Factor | 0.746 | 0.746 |
| kWh | 11.0 | 11.0 |
| MMBtu/yr | 12,483 | 12,483 |
| Annual Energy Cost | \$1,160 | \$1,160 |
| PROPOSED | | |
| Motor Horsepower | 20 | 20 |
| Motor Efficiency | 84.4% | 84.4% |
| % Full Load | 68% | 68% |
| Control Factor | 0.746 | 0.746 |
| Conversion Factor | 0.70 | 0.70 |
| kWh | 11.0 | 11.0 |
| MMBtu/yr | 12,483 | 12,483 |
| Annual Energy Cost | \$1,160 | \$1,160 |
| SAVINGS | | |
| kWh | 0.0 | 0.0 |
| MMBtu/yr | 0.0 | 0.0 |
| Annual Cost Savings | \$0.00 | \$0.00 |
| Project cost Estimate | \$1,000 | \$1,000 |
| Investment | \$1 | \$1 |
| Simple Payback | 0.0 | 0.0 |

Chilled Water Pump VFD

107

Lighting Best Practices

- Compact Fluorescents
- LED Exit Lights
- Reduced Hours of Operation
- Occupancy Sensors
- Vending Machines
- T12 to High Performance T8s
- Metal Halide to High Performance T8s or T5s
- Task Lighting

108

Lighting Best Practices



Miscellaneous Equipment Best Practices

- EnergyStar Computers & Monitors
- Replace Windows
- Vending Machine Occupancy Sensors
- Add Roof Insulation
- Reduce Infiltration

110

Miscellaneous Equipment Best Practices

Computers and Monitors

Many computers and monitors today are "Energy Star Compliant." This means that the units have the ability to operate in a low power mode after a certain amount of inactivity. The computer and/or monitor will power up to its normal operational power at the press of a key or movement of the mouse. Many computers, especially those produced after July of 2000, can sleep "intelligently" on networks, such that they can be awoken by a command placed over the network. Often the energy star features of computers and monitors are not enabled leading to no savings. The process to enable the features is simple, and can lead to substantial savings for facilities with a large number of computers.

111

Miscellaneous Equipment Best Practices

| | Existing | Proposed |
|------------------------------|-----------|-----------|
| Number of Computers | 100 | 100 |
| Number of Monitors | 100 | 100 |
| Avg Computer Operating Hours | 1,000 | 1,000 |
| Avg Monitor Operating Hours | 1,000 | 1,000 |
| Avg Computer Cost (\$) | 1,000 | 1,000 |
| Avg Monitor Cost (\$) | 1,000 | 1,000 |
| % Cooling Energy | 10% | 10% |
| Subtotal Total | \$100,000 | \$100,000 |
| Annual Energy Cost | \$10,000 | \$10,000 |
| Annual Savings | \$0 | \$0 |
| Payback Period | N/A | N/A |

| | Existing | Proposed |
|------------------------------|-----------|-----------|
| Number of Computers | 100 | 100 |
| Number of Monitors | 100 | 100 |
| Avg Computer Operating Hours | 1,000 | 1,000 |
| Avg Monitor Operating Hours | 1,000 | 1,000 |
| Avg Computer Cost (\$) | 1,000 | 1,000 |
| Avg Monitor Cost (\$) | 1,000 | 1,000 |
| % Cooling Energy | 10% | 10% |
| Subtotal Total | \$100,000 | \$100,000 |
| Annual Energy Cost | \$10,000 | \$10,000 |
| Annual Savings | \$0 | \$0 |
| Payback Period | N/A | N/A |

[EnergyStar
Computers &
Monitors](#)

112

Miscellaneous Equipment Best Practices

Install Occupancy Sensors on Vending Machines

Vending machines typically operate 24 hours a day, seven days a week. There are a number of products available that turn off the vending machine using an occupancy sensor. When no one is near the machine for a preset amount of time, the unit turns off. When someone walks by, the unit turns on. These devices are also set up to make sure the machine maintains beverages at a low temperature. Occupancy sensor units for vending machines typically cost ~\$180 per unit.
Rule of Thumb: Installing an occupancy sensor device on a vending machine can typically save \$50-\$120/machine/year depending on the type of unit and amount of people traffic by the unit. Simple payback range, 1.5 - 4 years.

113

Miscellaneous Equipment Best Practices

| EXISTING | Climate Area 1 | |
|-----------------------------------|-------------------|-------------------|
| | B | F |
| Number of Heating Machines | 8 | 8 |
| % Loads Fixed | 80% | 80% |
| % AC Savings | 15% | 15% |
| \$/hr saved per machine | 2,800 | 2,800 |
| kW | | |
| kW/yr | 11,400 | 11,400 |
| Average with Fuel | 22,700 | 22,700 |
| Gas Use (MMBtu) | 275 | 275 |
| Average Therm Rate | 10,500 | 10,500 |
| Annual Energy Cost | \$715 | \$715 |
| PROPOSED | | |
| kW | | |
| kW/yr | 0 | 0 |
| Gas Use (MMBtu) | 0 | 0 |
| Annual Energy Cost | \$0 | \$0 |
| SAVINGS | | |
| kW | | |
| kW/yr | 11,400 | 11,400 |
| Gas Use (MMBtu) | 275 | 275 |
| Annual Cost Savings | \$715 | \$715 |
| Project cost/Estimated Incentives | \$1,000 / \$1,000 | \$1,000 / \$1,000 |
| Simple Payback | 1.4 | 1.4 |

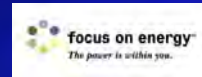
Vending
Machine
Occupancy
Sensors

114

Wisconsin's Focus on Energy Best Practices Spreadsheets

Available for download at:

<http://www.focusonenergy.com/business/commercial-business/cpem/sixsteps.aspx>



115

Sample Discretionary Action Plan - Lighting

- Match operating hours to activities
 - Unoccupied Lighting
 - Existing Custodial Lighting
- Add Occupancy Sensors
- Assure Footcandles Appropriate for Tasks
- Install Efficient Light Sources
- Use lamps with higher Kelvin temperature ratings (recommended: 4100°K- 6500°K)

116

Sample Discretionary Action Plan – Air Systems

- Match running time to activities
- Lower hot air temperatures
- Raise cold air temperatures
- Lower fan pressure in ducts
- Adjust static pressure setpoints
 - Manual reset
 - Dynamic reset using damper positions
- Minimize outside air quantities
- Minimize exhaust quantities
- Match ventilation to number of occupants
- De-energize exhaust fans and close dampers when unoccupied

117

Sample Discretionary Action Plan – Air Systems

- Make best use of economizer operation
- Eliminate simultaneous heating and cooling
- Reduce airflow in constant volume (CV) systems
- De-energize nonessential loads
- Seal leaky ducts
- Convert CV systems to VAV

118

Sample Discretionary Action Plan – Pumping Systems

- Convert CV system to variable flow
- Install variable frequency drives
- Match running time to activities
- Verify proper flow
 - Throttle balance valves
 - Trim pump impellers
- Lower pressure setpoint to optimize variable flow
 - Manual reset
 - Dynamic reset
- De-energize nonessential loads

119

Sample Discretionary Action Plan – Boilers

- Lower hot water temperatures
- If steam, lower steam pressure
- Install modulating burners (linkage-less)
- Optimize boiler sequencing
- Minimize losses in de-energized boilers

120

Sample Discretionary Action Plan – Chillers

- Match running time to activities
- Raise chilled water setpoints
- Reduce condenser water temperature
- Optimize cooling tower fan speed
- Optimize chiller staging
- Minimize chiller cycling
- Reduce chilled water speed

121

| ENERGY AUDIT CHECKLIST | | | | |
|--|--------------------------|---|------------------|-----|
| C. HVAC – CONTROLS | Does this problem exist? | | Response needed? | |
| | Y | N | Y | N |
| 13. Control devices are not responded as a single item. | | | | |
| Required ICM | | | | |
| a. Review check of these checks and other control equipment for proper operation. Perform fine-tuned adjustments. | | | 1.1 | 1.1 |
| Required ICM | | | | |
| a. Use an advanced energy management system. | | | 1.1 | 1.1 |
| 14. Building temperatures are not adjusted for unoccupied periods. | | | 1.1 | 1.1 |
| Required ICM | | | | |
| a. Review thermostat settings for a minimum of 2°F at night, for weekend and holiday occupancy levels, for seasonal variations. | | | 1.1 | 1.1 |
| b. Make sure air conditioning units at night, on weekend and holiday. | | | 1.1 | 1.1 |
| Required ICM | | | | |
| a. Reset automatic controls such as fan clocks or setback management systems. | | | 1.1 | 1.1 |
| 15. Thermostat setpoints are based on seasonal adjustments. | | | 1.1 | 1.1 |
| Required ICM | | | | |
| a. Review thermostat settings in 2°F increments. | | | 1.1 | 1.1 |
| b. Make periodic, back-off heating systems if building is above load limit. | | | 1.1 | 1.1 |
| c. Use space heaters to keep spaces with low occupancy. | | | 1.1 | 1.1 |
| d. Review system thermostat settings, or unoccupied areas if possible. | | | 1.1 | 1.1 |
| Required ICM | | | | |
| a. Reset system controls to reduce heating/cooling of unoccupied spaces. | | | 1.1 | 1.1 |
| 16. Heating/cooling equipment is not scheduled to operate on or near its operating design load of occupancy. | | | 1.1 | 1.1 |
| Required ICM | | | | |
| a. Coordinate with other trades and division of operations to determine whether loads from the adjacent building are not being met and working during the hot/cold of occupancy, affecting the building in "load". | | | 1.1 | 1.1 |
| Required ICM | | | | |
| a. Review operation of an advanced energy management system that will allow heating and/or cooling. Monitor conditions daily. | | | 1.1 | 1.1 |

Available at: <http://www.energy.wsu.edu/ftp-ep/pubs/rem/energyaudit/OMchecklists.pdf>

122

| ENERGY AUDIT CHECKLIST | | | | |
|--|--------------------------|---|------------------|-----|
| C. HVAC – COOLING | Does this problem exist? | | Response needed? | |
| | Y | N | Y | N |
| 46. Multiple air conditioning compressors start simultaneously. | | | 1.1 | 1.1 |
| Required ICM | | | | |
| a. Check controls to stage compressors. | | | 1.1 | 1.1 |
| Required ICM | | | | |
| a. Reset automatic controls and reset, per base and model. This will allow compressor 11 to start at three compressors if system design model uses condensing head. | | | 1.1 | 1.1 |
| 48. Chiller sequencing and condensing temperatures are not optimized. | | | 1.1 | 1.1 |
| Required ICM | | | | |
| a. Monitor chiller condensing temperature following manufacturer's recommendations. | | | 1.1 | 1.1 |
| b. Determine chiller condensing temperature following manufacturer's recommendations. | | | 1.1 | 1.1 |
| 51. Chiller is operating during cool weather to provide air conditioning. | | | 1.1 | 1.1 |
| Required ICM | | | | |
| a. Provide a water temperature control strategy setting lower condenser water directly into the cooling coil and/or cooling tower. Check for proper set points for the condenser. Also provide for cooling. Special care must be taken in heating and cooling condenser water. | | | 1.1 | 1.1 |
| b. If system is based on using DX coils and air cooled condensers, install economizer coils to reduce the cooling. | | | 1.1 | 1.1 |
| 52. Return coils are used to maintain room temperatures. | | | 1.1 | 1.1 |
| Required ICM | | | | |
| a. Control to restrict air volume to coils if the return coils are not necessary to supply heat during the heating season. | | | 1.1 | 1.1 |
| 55. Building utilizes a dual flow or multistage system. | | | 1.1 | 1.1 |
| Required ICM | | | | |
| a. Control dual flow or multistage systems to restrict air volume, if building has a constant heating season. | | | 1.1 | 1.1 |
| b. Reset controls to automatically meet hot and cold deck temperatures. | | | 1.1 | 1.1 |

123

Additional Discretionary Opportunities

- Chapter 36, ASHRAE 2011 Handbook “Energy Use and Management”
- Washington State University Checklist <http://www.energy.wsu.edu/ftp-ep/pubs/rem/energyaudit/OMchecklists.pdf>
- Advocate EM Operational Checklist (handout)

124



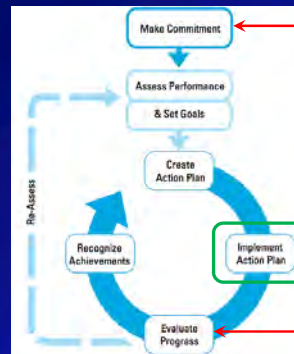
BREAK!

Exercise #9 Discussion

126

Energy Star Guidelines for Energy Management

www.energystar.gov



130

Disincentives for the Building Engineer

- Risk of occupant discomfort
- Risk of equipment failure
- Experimentation can be terrifying

131

Incentives for the Building Engineer

- Regular monitoring by the manager
- Managerial encouragement to experiment
 - Occasional, brief discomfort is OK
- Teamwork

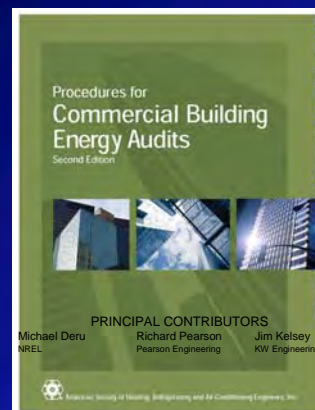
132

Two Types of Action



- Discretionary Facility Operation
- Energy Audits and Capital Improvements

133



A LEED EB Reference

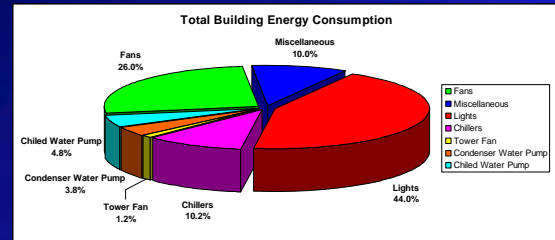
134

Levels of Effort

- Preliminary Energy Use Analysis
- Level I – Walk-Through Analysis
- Level II – Energy Survey and Analysis
- Level III – Detailed Analysis of Capital-Intensive Modifications

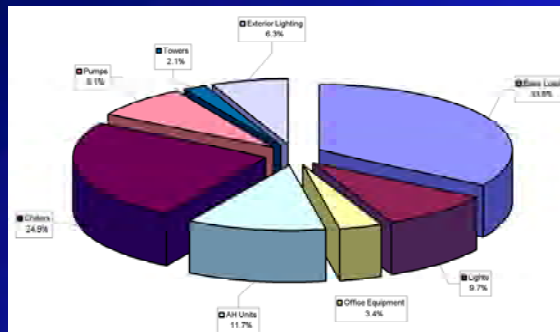
140

“Typical” Office Building End-Use



146

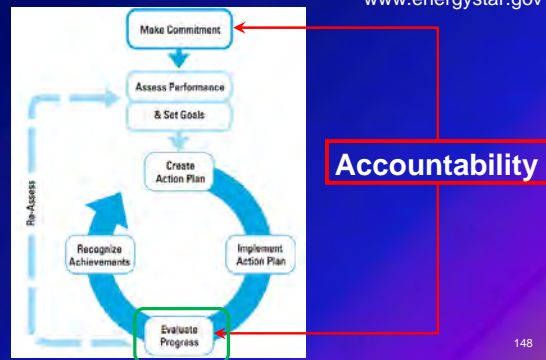
Honolulu Office Building Actual End-Use



147

Energy Star Guidelines for Energy Management

www.energystar.gov

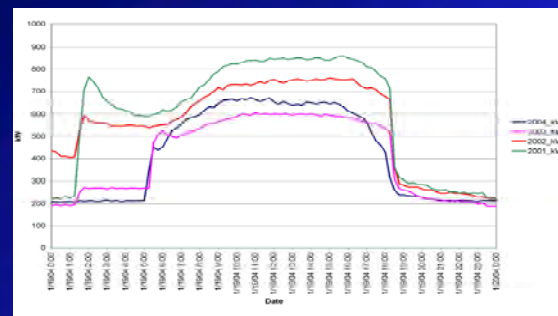


148

Evaluate Progress

149

Honolulu Office Building After



150

What We Did

- Capital – more efficient chillers, pumps, towers; new building automation system to integrate equipment operation
- Operational changes – matched schedules to occupancy
- Simple Payback: 5 years

151

Honolulu Office Building: Energy Management Results



- 20% energy savings
- Savings per year
 - \$100K
 - 750 tons CO₂
 - 2.3 tons NO_x
 - 2.0 tons SO₂

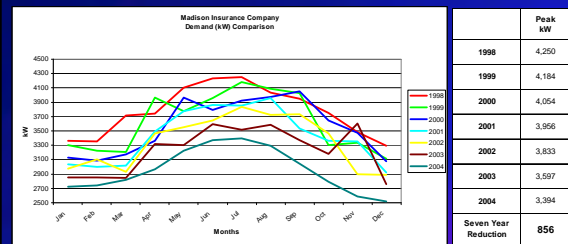
152

Madison Insurance Company



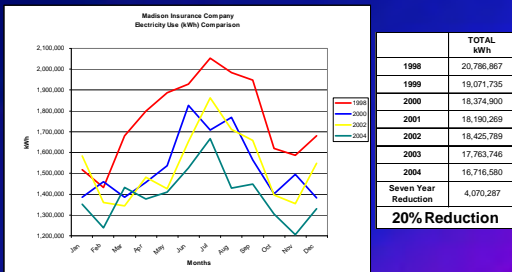
153

Madison Insurance Company Evaluate Progress



154

Madison Insurance Company Evaluate Progress



4.1 Million kWh per year
provides electricity for 586 new homes!

155

GSA Energy Management Program: The Rest of the Story

US Courthouse
Jacksonville, Florida
Energy Improvements

DOE-ORNL Report

156

2005 New Building Performance

- Floor area: 492,000 ft²
- EUI: 83 kBtu/SF – predicted to be 45 kBtu/SF
- Energy Star rating: 41 – predicted to be 79
- Utility costs: \$664,000/year – predicted to be \$220,000/yr
- **Far less efficient than design intent**

157

ECMs Implemented

- VAV minimum settings reduced to 10%
- Boilers turned off in summer
- Duct static pressure setpoints reduced from 1.5 in. to 0.7 in.

158

Results of Control Modifications

- EUI: 45 kBtu/SF – Reduced from 83
- Energy Star rating: 79 – Improved from 41
- Energy Savings: 11.7 trillion Btu/year
- Cost savings: \$220,000/year

Energy Star Plaque is now in the lobby!

159



Downtown Chicago Energy Star Building



Uninsulated concrete
Single pane glass

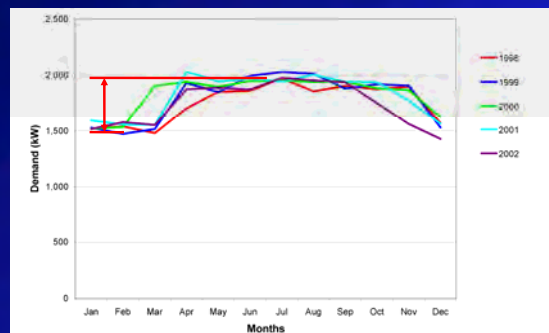
160

Madison Bank



161

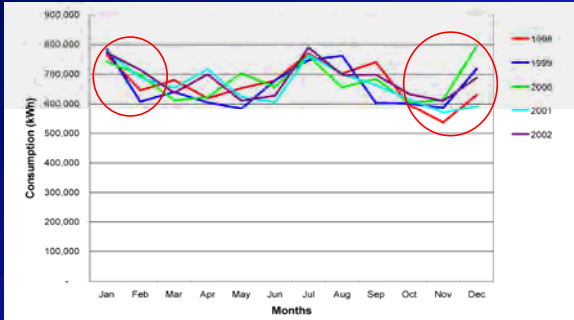
Annual Profile of Monthly Peaks (kW)



Chillers add 500 kW in summer

162

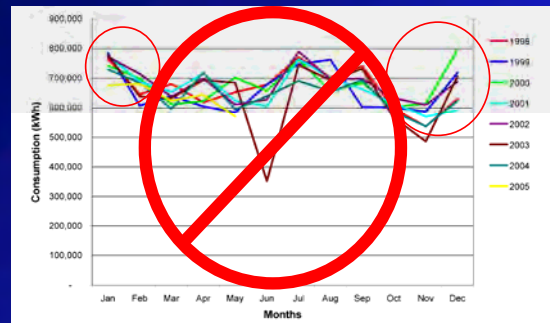
Annual Profile of Monthly kWh



Fans waste energy in winter!

163

Evaluate Progress 3 Years Later



Energy Management Did Not Work!

164

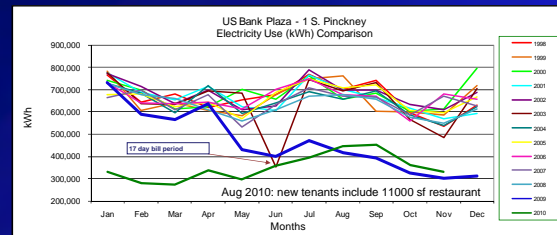
Explanation of the failure to see progress at Madison Bank

- The high electrical energy use in colder months results from decision to maintain fans "on 24/7:
- No commitment to improve energy use
- No accountability

Therefore, NO CHANGE.

165

But Things Have Changed!

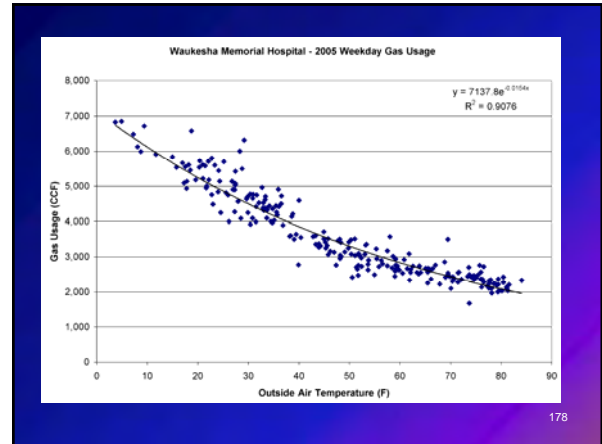
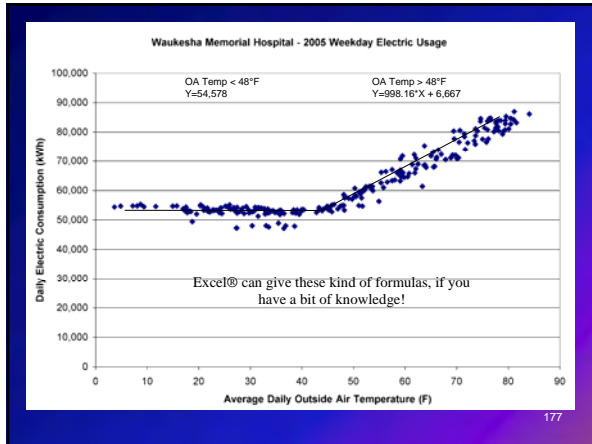


BREAK!

Unique Process using daily energy data

- Collect one year's utility data
 - Electric interval data (15 min or 30 min)
 - Daily natural gas (or steam) consumption
- Plot daily consumption versus Outside Air Temperature
 - Establish a model of each building normalized for weather
 - Weekend usage slightly different than weekday usage

176



7% savings in 12 months: \$89K and 530 Tons CO₂

| Date | OA Temp | OA Dew Point | Actual Boiler CCF | Predicted CCF | Percent | Savings CCF | Actual Electric kWh | Predicted kWh | Percent | Savings kWh |
|---------------|---------|--------------|-------------------|------------------|--------------|---------------|---------------------|-------------------|---------------|-----------------|
| 1/1/2006 | 33.6 | 33.6 | 3.958 | 4.141 | 95.6% | 183 | 47,058 | 49,045 | 97.8% | 1,987 |
| 1/2/2006 | 38.6 | 38.6 | 3.891 | 3.939 | 98.8% | 48 | 49,774 | 54,578 | 91.2% | 4,804 |
| 1/3/2006 | 38.3 | 38.3 | 3.699 | 3.957 | 93.5% | 258 | 53,456 | 54,578 | 97.9% | 1,122 |
| 1/4/2006 | 38.9 | 38.9 | 4.189 | 3.921 | 106.8% | -268 | 53,936 | 54,578 | 98.8% | 642 |
| 1/5/2006 | 34.5 | 33.3 | 4.943 | 4.196 | 117.8% | -747 | 54,140 | 54,578 | 99.2% | 438 |
| 1/6/2006 | 28.3 | 24.6 | 4.768 | 4.618 | 103.3% | -150 | 52,441 | 54,578 | 96.1% | 2,137 |
| 1/7/2006 | 31.5 | 30.7 | 4.545 | 4.273 | 106.4% | -272 | 48,894 | 49,045 | 99.7% | 151 |
| 1/8/2006 | 34.2 | 33 | 4.492 | 4.104 | 109.4% | -388 | 48,255 | 49,045 | 98.4% | 790 |
| 1/9/2006 | 34.1 | 33.1 | 4.832 | 4.222 | 114.5% | -610 | 53,842 | 54,578 | 98.3% | 736 |
| 1/10/2006 | 24.6 | 23.3 | 4.303 | 4.687 | 88.1% | 384 | 54,025 | 54,578 | 99.0% | 553 |
| 12/21/2006 | 37.6 | 35.7 | 4.323 | 4.000 | 108.1% | -323 | 54,332 | 54,578 | 99.6% | 246 |
| 12/22/2006 | 42.7 | 42.3 | 3.378 | 3.698 | 91.4% | 319 | 53,468 | 54,578 | 98.0% | 1,110 |
| 12/23/2006 | 37.3 | 35 | 3.970 | 3.919 | 101.3% | -51 | 48,980 | 49,045 | 99.8% | 85 |
| 12/24/2006 | 33.6 | 25.5 | 3.796 | 4.141 | 91.7% | 342 | 48,222 | 49,045 | 98.3% | 823 |
| 12/25/2006 | 33.8 | 30.1 | 3.969 | 4.241 | 94.3% | 243 | 47,189 | 54,578 | 86.5% | 7,389 |
| 12/26/2006 | 29.6 | 23.5 | 4.234 | 4.525 | 93.6% | 291 | 52,071 | 54,578 | 95.4% | 2,507 |
| 12/27/2006 | 31.4 | 24.7 | 3.741 | 4.401 | 85.0% | 660 | 52,698 | 54,578 | 96.6% | 1,880 |
| 12/28/2006 | 37.6 | 32.8 | 3.357 | 4.000 | 83.9% | 643 | 53,081 | 54,578 | 97.3% | 1,497 |
| 12/29/2006 | 38.7 | 37.1 | 3.503 | 3.633 | 89.1% | 430 | 52,887 | 54,578 | 96.9% | 1,691 |
| 12/30/2006 | 34.7 | 33.9 | 3.236 | 4.074 | 79.4% | 838 | 49,211 | 49,045 | 100.3% | -166 |
| 12/31/2006 | 43 | 41 | 3.243 | 3.600 | 90.1% | 357 | 49,071 | 49,045 | 100.1% | -26 |
| Totals | | | 1,168,973 | 1,258,127 | 92.9% | 89,214 | 21,25,821 | 21,602,617 | 101.5% | -323,204 |

179

Extra Benefit:
An Energy Management Breakthrough

| Day | Outside Air Temp | Gas | | | Electric | | | Comment |
|-----------|------------------|----------------------|------------------|--------------|----------------------|------------------|--------------|------------------------------|
| | | Calculated Usage CCF | Actual Usage CCF | Difference % | Calculated Usage kWh | Actual Usage kWh | Difference % | |
| 1/9/2006 | 81.3 | 2,749 | 2,301 | 83.7 | 62,230 | 63,894 | 102.7 | Sun |
| 1/10/2006 | 61.0 | 2,753 | 2,300 | 83.7 | 62,137 | 64,325 | 103.5 | Sun |
| 1/11/2006 | 60.8 | 2,789 | 2,328 | 83.7 | 61,354 | 70,286 | 104.4 | Rained all day |
| 1/12/2006 | 84.5 | 2,644 | 2,129 | 79.8 | 61,545 | 74,922 | 105.5 | |
| 1/13/2006 | 69.7 | 2,803 | 2,343 | 83.6 | 61,255 | 68,504 | 103.8 | |
| 1/14/2006 | 62.7 | 2,718 | 2,374 | 87.3 | 60,251 | 70,119 | 101.3 | |
| 1/15/2006 | 65.3 | 2,610 | 2,846 | 109.1 | 71,885 | 73,333 | 102.0 | Sat |
| 1/16/2006 | 69.9 | 2,410 | 2,823 | 117.1 | 71,141 | 71,128 | 100.0 | |
| 1/17/2006 | 72.3 | 2,325 | 2,324 | 117.6 | 73,558 | 73,584 | 99.7 | Sun |
| 1/18/2006 | 69.8 | 2,842 | 3,134 | 110.3 | 66,346 | 66,540 | 100.3 | Correct chiller problem |
| 1/19/2006 | 52.0 | 3,205 | 2,345 | 73.2 | 58,571 | 55,413 | 94.6 | Chillers off most of the day |
| 1/20/2006 | 51.9 | 3,224 | 2,384 | 74.3 | 55,181 | 51,429 | 93.7 | |
| 1/21/2006 | 55.5 | 3,035 | 2,389 | 78.9 | 62,104 | 61,892 | 99.7 | |
| 1/22/2006 | 62.0 | 2,747 | 2,273 | 82.7 | 68,362 | 69,437 | 101.3 | |
| 1/23/2006 | 62.1 | 2,710 | 2,495 | 91.8 | 63,213 | 65,918 | 104.3 | |
| 1/24/2006 | 58.1 | 2,876 | 2,470 | 85.9 | 59,176 | 60,878 | 102.9 | Sun |
| 1/25/2006 | 58.1 | 2,817 | 2,357 | 83.7 | 64,859 | 62,718 | 97.0 | |

180

Applying the Process

Aurora Health Care – 2009

- 17 facilities
- 7 million sq. ft.
- Each facility joined the Portfolio Manager® system
- President of Aurora Healthcare signed an EnergyStar® commitment to reduce energy 12% in 3 years
- Each facility utilizes the spreadsheet and records energy consumption daily
- Monthly summaries distributed to all
- Monthly energy initiative meeting to share successful ideas

181

Aurora Health Care 2009-2010 Utility Summary

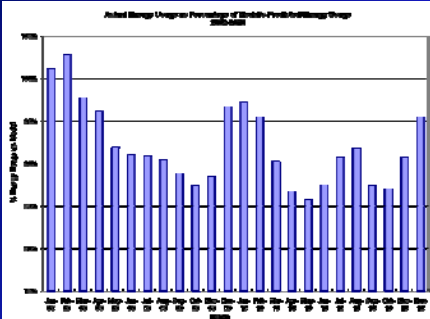
| Facility | Sq Ft | 2009-2010 Total | | | |
|------------------------|------------------|-----------------|-------------------|----------------------|----------------------|
| | | % | CO2 (lbs) | 2009 EUI (kBtu/sqft) | 2010 EUI (kBtu/sqft) |
| Shenandoah | 278,000 | 85.6% | 2,589,873 | 209.8 | 204.2 |
| Northbrook | 150,000 | 85.7% | 1,448,872 | 296.5 | 278.1 |
| Two Rivers | 183,000 | 87.0% | 1,507,041 | 282.3 | 268.4 |
| West Allis Memorial | 848,600 | 82.8% | 5,803,605 | 277.5 | 268.2 |
| BayCare Clinic | 810,716 | 86.2% | 1,678,950 | 273.8 | 268.1 |
| St. Luke's South Shore | 380,565 | 82.9% | 4,189,934 | 242.8 | 227.9 |
| South Medical Center | 884,000 | 82.0% | 11,216,115 | 226.8 | 214.2 |
| Rockingham | 220,000 | 87.0% | 1,188,295 | 178.4 | 203.5 |
| St. Luke's | 1,746,988 | 91.1% | 14,162,628 | 204.8 | 203.0 |
| Admetra | 334,000 | 84.9% | 1,614,930 | 201.4 | 194.7 |
| Carleboro | 478,000 | 84.0% | 4,589,209 | 220.0 | 207.4 |
| Sumner | 790,000 | 88.7% | 3,293,173 | 169 | 155.8 |
| Sumner | 265,280 | 87.3% | 1,831,033 | 178.2 | 146.8 |
| West Allis Memorial | 1,715,000 | 84.4% | 9,818,881 | 283.2 | 266.4 |
| Sumner | 91,200 | 89.0% | 2,790,003 | 254.0 | 193.2 |
| Carleboro Building | 21,782 | 81.3% | 134,265 | 110.5 | 104.2 |
| BayCare Clinic | 209,074 | 82.4% | 82,380 | 91.8 | 89.4 |
| Sumner | 139,000 | 89.2% | 4,046,170 | 133.0 | 140.0 |
| Total | 7,687,954 | 82.4% | 62,567,801 | 207.8 | 207.8 |

★ Achieved EnergyStar Award!

183

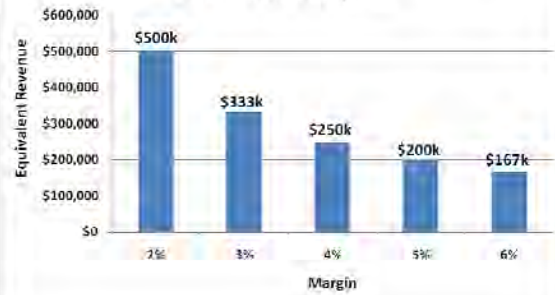
Aurora Health Care 2009-2010

- 7.6% reduction in energy consumption
- 67.6 million pound reduction in CO₂
- Two facilities achieved ENERGY STAR



184

Equivalent Revenue per \$10,000 savings for Acute Care Hospitals



Source: Corporate Realty, Design, & Management Institute

185

Energy Management Strategies Taken

- Chiller operations
- H.W. reset schedules
- Run schedules (occ./unocc., day/night, summer/winter)
- D.A. temperature reset schedules
- Steam pressures
- Installation of variable speed drives
- Isolation dampers for unoccupied areas
- Steam trap survey
- Shutting off air handling units in unoccupied areas.
- Maintaining modified space temperatures
- Promoting the energy message at department meetings

186

Reverse Energy Audit Process

- Low cost actions decrease utility costs first
- First steps reveal specific needs for future capital improvements
- In-depth audit and capital improvements follow

189



Energy Management at Monona Terrace Convention Center

Jeff Griffith
Building Maintenance Supervisor

- Action Plan
- Monitoring
- Benchmarking
- Accountability

191

Action Plan

- Initial commissioning by staff
- No compromise in customer comfort
- Eliminate simultaneous heating and cooling
- Adapt operation to daily schedule
- Eliminate energy use in unoccupied spaces
- Regular reminders to entire staff

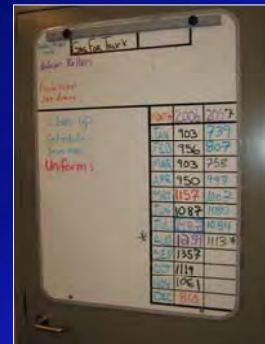
192

Regular Monitoring

- Weekly energy review by engineering staff
- BAS alarms to pagers
 - Demand exceeds 1,100 kW
 - Chilled water exceeds 50°F
- Personal attention by one engineer on peak days

193

Monitoring and Benchmarking



194

Benchmarking

| | Square Footage | Electricity (kbtu/sqft) | Nat Gas (kbtu/sqft) | Steam (kbtu/sqft) | Chilled Water (kbtu/sqft) | Total Energy (kbtu/sqft) |
|----------------------|----------------|-------------------------|---------------------|-------------------|---------------------------|--------------------------|
| Rochester, NY | 200,000 | 55.76 | 0.00 | 0.00 | 0.00 | 55.76 |
| Pittsburg, PA | 1,500,000 | 24.05 | 0.00 | 32.25 | 108.46 | 162.75 |
| Collinsville, IL | 72,500 | 102.42 | 69.39 | 0.00 | 0.00 | 171.81 |
| Rochester, MN | 191,531 | 79.90 | 4.77 | 89.96 | 0.00 | 174.65 |
| Milwaukee, WI | 667,475 | 65.23 | 2.16 | 80.06 | 0.00 | 147.45 |
| Madison, WI | 303,000 | 51.08 | 9.51 | 4.91 | 0.00 | 65.50 |
| Sarasota Springs, NY | 52,500 | 66.23 | 89.61 | 0.00 | 0.00 | 156.04 |
| Toledo, OH | 325,000 | 39.72 | 73.74 | 0.00 | 0.00 | 113.46 |
| Davenport, IA | 154,215 | 45.26 | 81.37 | 0.00 | 0.00 | 126.62 |
| Totals | 3,466,221 | | | | | |

195

Accountability

- Jeff is personally accountable to the facility manager
- Engineering staff is accountable to Jeff and to each other
- Entire staff maintains an energy conscious culture
- Weekly staff review of energy use

196



Monona Terrace LEED EB Silver Certification

- Significant energy savings
- Non-toxic cleaning products
- Use of clean energy
- High recycling rates

197

Accountability: A Management Challenge



198

Defining Accountability

- Is a person answerable for the results?
- A building or a department can't be!

199



- Headquarters in Fond du Lac, Wisconsin
- Manufacturing and sales organization
- Multiple facilities across the US
- Multi-million dollar utility bill
- Jerry Eaton – Energy Manager
- >\$1 million annual savings

200

Jerry Eaton's Discoveries

- Utility cost was an overhead item – not a manageable expense
- Stickers on light switches – no impact on expense or consumption

201

Jerry Eaton's Parallel Activities

Developed a corporate-wide chain of accountability:

- ✓ Begin with buildings (each with a meter)
- ✓ Then departments within buildings (each with a meter)
- ✓ Appoint a person in each location to be responsible for proven results

202

Jerry Eaton's Parallel Activities

Developed an accountability process in which results are reviewed and discussed on a regular basis:

- ✓ In this context, "regular basis" is not defined as every 12 months. That feedback interval is too long.
- ✓ A monthly interval is reasonably functional.
- ✓ Some type of weekly review has proven to be very effective.

203

Jerry Eaton's Parallel Activities

Found waste and inefficiencies

Found ways to be more efficient

Developed a significant sub-metering program

Developed procedures to monitor the meters on a regular basis

204

Jerry Eaton's Success Story

- The cost of energy ceased to be an overhead item.
- Buildings and departments learned that their annual budgets had increased by approximately the amount of the cost of energy attributable to each entity.
- Energy teams were developed in each entity, coordinated by the energy manager.
- The "buck" stops at one person in each entity, who receives regular data from ongoing monitoring and measuring performed by the energy manager.
- Annual savings of over \$1 million.

205

Meters and Sub-Meters

- Meters by themselves do not save anything
- No direct payback on the purchase of a meter
- That is not the basis for their justification as an energy conservation investment
- Question: How can you manage it if you can't measure it?

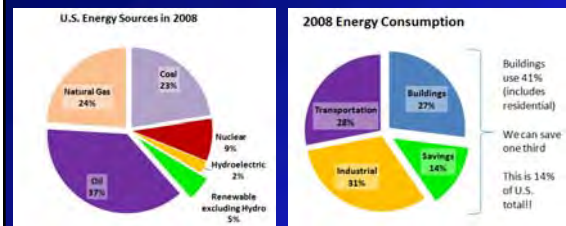
206

Measurement Technology

- Measurement technology is continuously improving, and becoming more affordable
- More than one way to develop measurements which are useful in an Energy Management program
- Creative thinking and competitive bidding can produce surprising results

207

Energy Management is the Quickest, Cheapest, Cleanest Way to Extend World Energy Supplies



Energy management can provide three times the environmental impact of renewable energy

208

Successful Energy Savings Are Within Your Reach!

- Personal, regular attention of a single person
- Team-oriented atmosphere tends to ensure conservation
- Consider tying success to department perks or bonuses

209

Prepare for Culture Change — What You Can Do...

- Collect 24 months of utility bills
- Enter utility information into Energy Star Portfolio Manager and get your score as a baseline
- Review the Discretionary Action Plans (slides 116-124)
- Try one change — save some energy, reduce climate impact and build your confidence to deploy on-going Energy Management

210

Remember to Monitor!!



211

References

Text and on-line references are listed in the References supplement

212

About the Speaker

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Procedures for Commercial Building Energy Audits, Second Edition (2011)
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213

Questions?

215