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The Premier Energy Training Workshop
and Trade Show for Federal Agencies

A River of Energy Solutions

Transforming Ordinary Buildings into High Performance Buildings Inexpensively !

‘Gearing Up for Energy Savings’

Presentation Outline

- What is Driving High Performance Buildings?
- Challenges toward Optimizing Building / System Performance
- Identifying Opportunities for Improvement
- Sample Measures to be Employed and Typical Results
- Case Studies
- How To Start

Energy Needs, Codes, Standards

→ High Performance Buildings

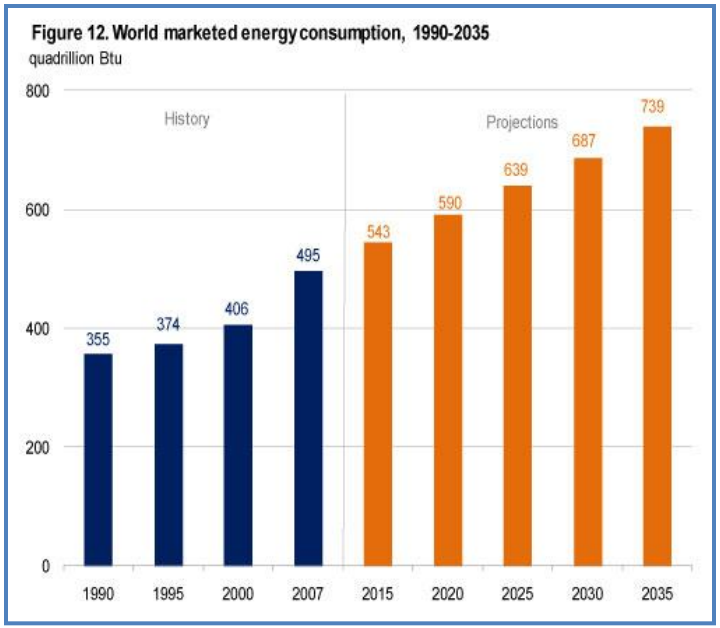
Statistics - Projected Growth in Energy Demand

Energy Consumption Grows by 49% from 2007 to 2035

Consumption increases by 84% in Non-OECD (Organization for Economic Co-operation and Development) nations

By 2020, bulk of middle class is outside of USA and Europe

In the U.S., buildings account for 70% of electrical consumption, and 40% of all energy consumed



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Energy Needs, Codes, Standards

→ High Performance Buildings

- Energy Independence and Security Act of 2007
- ASHRAE Standard for the Design of High Performance Green Buildings (189.1-2009)
- ASHRAE Energy Standards for Building (2010)
- California Green Building Standards Code (2008)
- North Carolina Code on Sustainability and Energy Efficiency

Building Labeling

- DOE / EPA Energy Star Certification
- European Union (EU) Directive 2002/91/EC Energy Performance Certificate – since Jan. 2006, BER – Building Energy Rating
- ASHRAE Building Energy Quotient (EQ) Labeling Program

Challenges Toward Optimizing Building / System Performance

- Limited staff – focus on 'fire drills'!!!
- Limited capital – priority given to 'mission related' items
- Limited data – limited information available (M&V, sub-metering, etc.) for analysis (either due to limited system capability or limited interest in tracking same)
- Limited training and knowledge base – understanding impact of various operations and sequences!!!
- Cultural Challenges
  - Generation of qualified facility managers – aging baby boomers
  - Lack of qualified replacement O&M personnel
  - Defined (or interpreted) job duties (lack of pro-active approach)

Identifying Opportunities for Improvement

- Auditing vs. Retro-Commissioning – what is the difference?
- Retro-Commissioning Process
- Assimilating and analyzing utility data
- Trend logging – through BAS or separate (temporary) dataloggers
- Use of independent (third party) energy engineer / RetroCx Agent
- Identifying Key Areas of Opportunity
- Top Ten RetroCx Findings

Auditing vs. Retro-Commissioning

Energy Audit – meant to inform building manager on how well a building is performing with respect to energy consumption

- Perform utility analyses
- Create energy use index (EUI)
- Identify energy conservations measures (ECMs)
- Provide report with estimated costs, savings and payback

RetroCx Process – systematically analyzes and fine tunes an existing building's systems, as well as O&M procedures

- Energy reduction, not sole goal
- Improved comfort and IAQ
- Extend life of equipment
- Improve effectiveness of O&M
- Provide additional Training, as required

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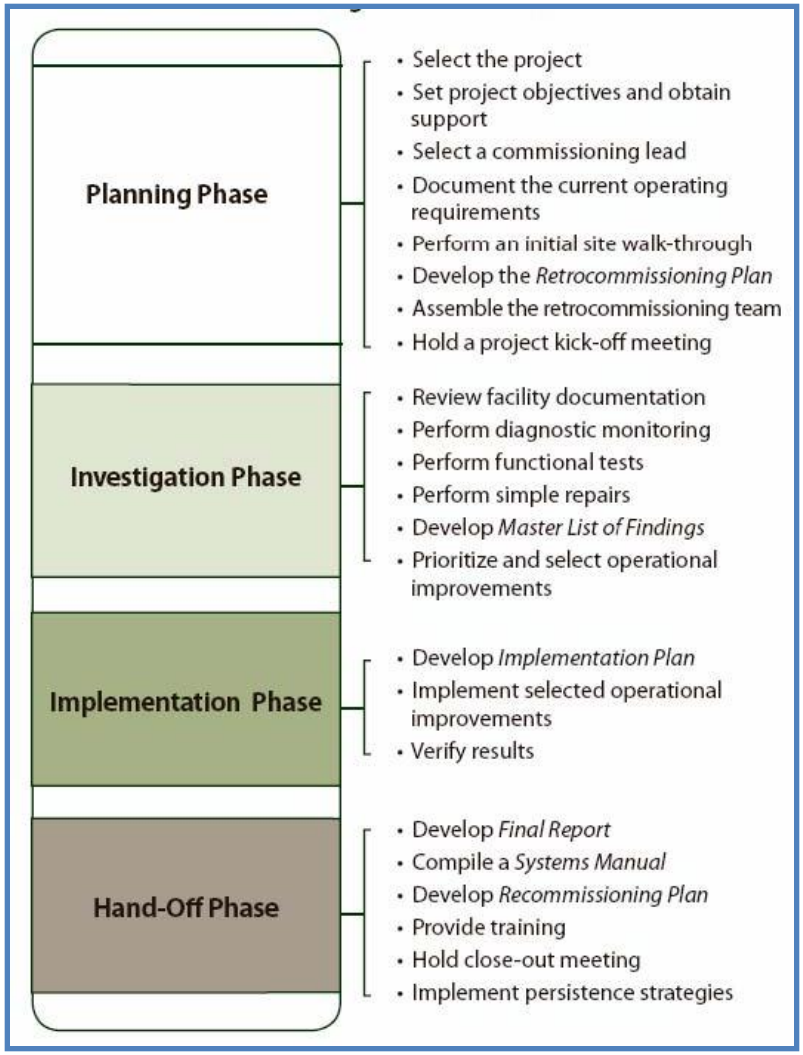
The Retro-Commissioning Process



Assimilating and Analyzing Utility Data

Analysis:

- Calculate benchmark numbers, kWh / SF, MBtu/SF, $ / SF, etc.
- Look for trends and/or unusual consumption
- Compare to national averages (Energy Star, etc.)
- Establish weighted unit costs for utilities

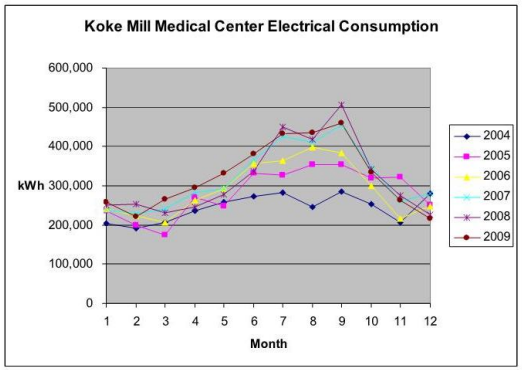
KOKE MILL MEDICAL CENTER
3136 OLD JACKSONVILLE ROAD
Account Number: 106184604

MEMORIAL HEALTHCARE SYSTEM
701 NORTH FIRST STREET
SPRINGFIELD, IL 62702

Meter #: 105546
ELECTRIC RATE: E46 - General Service Medium Electric
TURN ON DATE: 2/4/1999
MULTIPLIER: 960

latest 12 month monthly average
$35,432.43

Service	Read Date	Read Type	Meter Reading	Days	kWh Usage	Actual kW Demand	Customer Charge	kWh Charge	kW Demand Charge	Fuel Adj. Factor	Utility Tax	Total Electric Bill	Load Factor
Electric	01/14/10	Actual	37321	34	269,760	480.00	$120.00	$15,349.34	$4,944.00	$4,482.33	$863.23	$25,758.91	68.9%
Electric	12/11/09	Actual	37040	28	216,960	460.80	$120.00	$12,345.02	$4,746.24	$4,562.02	$694.27	$22,467.55	70.1%
Electric	11/13/09	Actual	36814	30	264,000	710.40	$120.00	$15,021.60	$7,317.12	$4,634.26	$844.80	$27,937.78	51.6%
Electric	10/14/09	Actual	36539	33	335,040	768.00	$120.00	$19,380.54	$8,081.69	$7,458.66	$1,072.13	$36,113.02	55.1%
Electric	09/11/09	Actual	36190	32	458,880	931.20	$120.00	$29,689.54	$11,304.77	$11,231.09	$1,468.42	$53,813.81	64.2%
Electric	08/10/09	Actual	35712	31	435,840	854.40	$120.00	$28,198.85	$10,372.42	$8,170.26	$1,394.69	$48,256.21	68.6%
Electric	07/10/09	Actual	35258	29	433,920	940.80	$120.00	$28,074.62	$11,421.31	$10,322.52	$1,388.54	$51,327.00	66.3%
Electric	06/11/09	Actual	34806	29	380,160	864.00	$120.00	$24,391.85	$10,379.32	$10,842.16	$1,216.51	$46,949.85	63.2%
Electric	05/13/09	Actual	34410	28	333,120	816.00	$120.00	$18,954.53	$8,404.80	$6,328.28	$1,065.98	$34,873.59	60.8%
Electric	04/15/09	Actual	34063	34	295,680	624.00	$120.00	$16,824.19	$6,427.20	$5,857.72	$946.18	$30,175.28	58.1%
Electric	03/12/09	Actual	33755	31	265,920	585.60	$120.00	$15,130.85	$6,031.68	$4,815.28	$850.94	$26,948.75	61.0%
Electric	02/09/09	Actual	33478	27	221,760	508.80	$120.00	$12,618.14	$5,240.64	$3,277.61	$709.63	$21,966.03	67.3%
Electric	01/13/09	Actual	33247	33	258,240	460.80	$120.00	$14,693.86	$4,746.24	$2,155.27	$826.37	$22,541.74	70.8%
Electric	12/11/08	Actual	32978	28	225,600	499.20	$120.00	$12,836.64	$5,141.76	$2,505.29	$721.92	$21,325.61	67.3%
Electric	11/13/08	Actual	32743	30	276,480	720.00	$120.00	$15,731.71	$7,416.00	$4,089.42	$884.74	$28,241.86	53.3%
Electric	10/14/08	Actual	32455	29	341,760	700.80	$120.00	$19,446.14	$7,218.24	$4,316.09	$1,093.63	$32,194.10	70.1%
Electric	09/15/08	Actual	32099	39	505,920	844.80	$156.00	$32,733.02	$13,332.63	$8,526.78	$1,618.94	$56,367.38	64.0%
Electric	08/07/08	Actual	31572	29	418,560	921.60	$120.00	$27,080.83	$11,188.22	$9,258.13	$1,339.39	$48,986.58	65.3%
Electric	07/09/08	Actual	31136	33	450,240	873.60	$120.00	$29,130.53	$10,605.50	$9,756.25	$1,440.77	$51,053.05	65.1%
Electric	06/06/08	Actual	30667	29	336,000	854.40	$120.00	$21,106.60	$9,992.94	$11,276.83	$1,075.20	$43,571.57	56.5%
Electric	05/08/08	Actual	30317	27	278,400	691.20	$120.00	$15,840.96	$7,119.36	$1,606.37	$890.88	$25,577.57	62.2%
Electric	04/11/08	Actual	30027	29	246,720	652.80	$120.00	$14,038.37	$6,723.84	$2,423.53	$789.50	$24,095.24	54.3%
Electric	03/13/08	Actual	29770	29	230,400	480.00	$120.00	$12,810.24	$4,828.80	$1,968.77	$737.28	$20,465.09	69.0%
Electric	02/13/08	Actual	29530	32	253,440	499.20	$120.00	$14,091.26	$5,021.95	$2,533.39	$811.01	$22,577.61	66.1%
Electric	01/12/08	Actual	29266	32	249,600	595.20	$120.00	$13,877.76	$5,987.71	$5,023.45	$798.72	$25,807.64	54.6%
Electric	12/11/07	Actual	29006	34	279,360	604.80	$120.00	$15,532.42	$6,084.29	$4,233.70	$893.95	$26,864.36	56.6%
Electric	11/07/07	Actual	28715	28	261,120	643.20	$120.00	$14,518.27	$6,470.59	$4,164.08	$835.58	$26,108.53	60.4%
Electric	10/10/07	Actual	28443	29	345,600	816.00	$120.00	$19,577.64	$8,411.55	$6,271.26	$1,105.92	$35,486.38	60.9%
Electric	09/11/07	Actual	28083	33	456,000	921.60	$120.00	$27,952.80	$10,607.62	$5,861.42	$1,459.20	$46,001.04	62.5%
Electric	08/09/07	Actual	27608	30	411,840	940.80	$120.00	$25,245.79	$10,828.61	$4,289.31	$1,317.89	$41,801.60	60.8%
Electric	07/10/07	Actual	27179	32	425,280	912.00	$120.00	$26,069.66	$10,497.12	$2,112.37	$1,360.90	$40,160.05	60.7%
Electric	06/08/07	Actual	26736	30	366,720	787.20	$120.00	$21,937.19	$8,786.73	$5,295.07	$1,173.50	$37,312.49	64.7%
Electric	05/09/07	Actual	26354	28	293,760	720.00	$120.00	$15,833.66	$7,034.40	$1,883.30	$940.03	$25,811.39	60.7%
Electric	04/11/07	Actual	26048	30	283,200	624.00	$120.00	$15,264.48	$6,096.48	$748.50	$906.24	$23,135.70	63.0%



Annual Energy Consumption for the Past Six (6) years

Exhibit D-2

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Trend Log Analysis

- Review equipment status (On /Off) to see if it aligns with schedules
- Identify analog readings that are outside of anticipated range (improper setpoints, bad sensors?)
- Review readings to see if they align with sequence of operation (temp. setback of decks, dampers closed during warm-up, coils inactive during economizer operation, etc.)
- Identify suspicious trends to be examined further during functional performance testing

MHS Data Center
2401 West Jefferson

TREND DATA REPORT

Sept. 2nd thru 7th, 2010

DATE	TIME	BLRHWR-T (deg F)	BLRHWS-T (deg F)	BLRR1-C	CD-TEMP (deg F)	CD-DASP	Cooling Load Command	HD-TEMP (deg F)	SF2-STAT
9/2/10	1:30:00 PM	147.875	158.875	On	59.34375	60.0	91.125	128	On
9/2/10	2:00:00 PM	145.375	157.125	On	59.6875	60.0	91.375	126.9375	On
9/2/10	2:30:00 PM	144.75	159.625	On	59.5	60.0	91.25	126.4375	On
9/2/10	3:00:00 PM	142.875	157.25	On	60.09375	60.0	91.4375	125.625	On
9/2/10	3:30:00 PM	144.125	158.625	On	59.8125	60.0	91.375	126.25	On
9/2/10	4:00:00 PM	141.125	164	On	59.5625	60.0	91.25	125.4375	On
9/2/10	4:30:00 PM	141.75	157.375	On	59.21875	60.0	91.5	122.5625	On
9/2/10	5:00:00 PM	144.125	159.5	On	60.15625	60.0	91.4375	124.1875	On
9/2/10	5:30:00 PM	143.625	159.25	On	61.1875	60.0	92.375	124.5	On
9/2/10	6:00:00 PM	146	153.375	On	60.625	60.0	95.1875	127.3125	On
9/2/10	6:30:00 PM	143.625	158.5	On	60.84375	60.0	95.5	123.875	On
9/2/10	7:00:00 PM	141.125	167.75	On	60.375	60.0	95.0625	123.4375	On
9/2/10	7:30:00 PM	144.125	160.5	On	60.90625	60.0	95.5	124.75	On
9/2/10	8:00:00 PM	143.625	159.25	On	60.71875	60.0	95.5	123.9375	On
9/2/10	8:30:00 PM	144.75	162.125	On	60.5625	60.0	95.3125	123.0625	On
9/2/10	9:00:00 PM	142.375	158.75	On	60.4375	60.0	95.0625	123	On
9/2/10	9:30:00 PM	143.625	159.5	On	60.71875	60.0	95.3125	123.4375	On
9/2/10	10:00:00 PM	144.125	159.625	On	60.5625	60.0	95.4375	123.875	On
9/2/10	10:30:00 PM	140.625	149.75	On	59.03125	60.0	94.375	122.8125	On
9/2/10	11:00:00 PM	141.125	152.875	On	58.5	60.0	94.0625	120	On
9/2/10	11:30:00 PM	140.375	152.5	On	56.75	60.0	93.5625	118.875	On
9/3/10	12:00:00 AM	140.125	153.125	On	55.46875	60.0	91.625	118.25	On
9/3/10	12:30:00 AM	135.375	148.75	On	55.34375	60.0	91.8125	115.8125	On
9/3/10	1:00:00 AM	139.875	154.125	On	54.40625	60.0	91.5	116.8125	On
9/3/10	1:30:00 AM	133.625	147.75	On	53.9375	60.0	90.8125	114.125	On
9/3/10	2:00:00 AM	138	153	On	53.0625	60.0	90.4375	115.375	On
9/3/10	2:30:00 AM	135.25	149.5	On	56.65625	60.0	84.625	114.4375	On
9/3/10	3:00:00 AM	133.875	148.125	On	57.6875	60.0	85.625	113.5	On
9/3/10	3:30:00 AM	133	148.875	On	58.5	60.0	85.9375	112.875	On
9/3/10	4:00:00 AM	136.125	150.75	On	59.21875	60.0	86.5	114.4375	On
9/3/10	4:30:00 AM	134.875	149.125	On	58.34375	60.0	85.9375	113.5	On
9/3/10	5:00:00 AM	136.875	155.5	On	57.625	60.0	85.4375	112.875	On
9/3/10	5:30:00 AM	136.75	153.5	On	56.59375	60.0	84.5	112.625	On
9/3/10	6:00:00 AM	132.375	147.625	On	55.8125	60.0	84.3125	111.9375	On
9/3/10	6:30:00 AM	131.25	146	On	55.71875	60.0	84.3125	110	On
9/3/10	7:00:00 AM	131.5	146.625	On	55.9375	60.0	84.3125	111.5	On
9/3/10	7:30:00 AM	143.625	168.5	Off	62.25	60.0	0	108.5625	OFF
9/3/10	8:00:00 AM	109.25	155.25	On	62.46875	60.0	42.34375	94.75	On
9/3/10	8:30:00 AM	107.4375	166.25	On	63	60.0	42.71875	94.9375	On
9/3/10	9:00:00 AM	108.0625	174.625	On	63.34375	60.0	42.9375	95.5625	On
9/3/10	9:30:00 AM	110.5625	154.125	On	65.125	60.0	44.125	98.25	On
9/3/10	10:00:00 AM	113.3125	173.125	On	65.4375	60.0	44.34375	101.875	On
9/3/10	10:30:00 AM	115.9375	166.625	On	66.0625	60.0	44.71875	105.5625	On
9/3/10	11:00:00 AM	118.25	169.125	On	67.125	60.0	45.40625	106.75	On
9/3/10	11:30:00 AM	119.375	156	On	66.375	60.0	50.0625	107.4375	On
9/3/10	12:00:00 PM	120	158.5	On	67.125	60.0	69.0625	106.9375	On
9/3/10	12:30:00 PM	116.875	169.125	On	62.875	60.0	82.375	104.8125	On
9/3/10	1:00:00 PM	115.625	156	On	65.625	60.0	84.25	104	On
9/3/10	1:30:00 PM	115.625	156.375	On	65.4375	60.0	84.125	103.1875	On

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Identifying Key Areas of Opportunity

(i.e. "low hanging fruit")

- Develop energy use index (EUI) – Where is energy being consumed?
- 'Operation' vs. 'Performance' – What's the difference?
- Oversized equipment / systems – Planning for future growth?
- Most new and upgraded EMS are not fully checked and verified
- Use of "canned" sequences of operation – are these appropriate for all occupancies and seasons?
- Full time facility energy manager <u>should be able to save several times his salary each year</u> through energy/ utility cost avoidance

Top 10 Findings – Retro-Commissioning

1. Schedule HVAC Systems
2. Adjust Outdoor (Ventilation) Air to Proper Demand
3. Mitigate Simultaneous Heating and Cooling
4. Reduce Flow from Oversized Pumps
5. Reset Supply Air Temperatures
6. Enable Economizer Controls
7. Reset Static Pressures/Optimize VFD Operation
8. Stage Chillers Properly
9. Lower Condenser Water Setpoints
10. Correct Lighting Control Operation

Source: SERVIDYNE and PECI

Sample Measures to be Employed

• Scheduling – nothing saves more energy than turning equipment 'OFF' – do schedules correspond with current occupancy and usage?

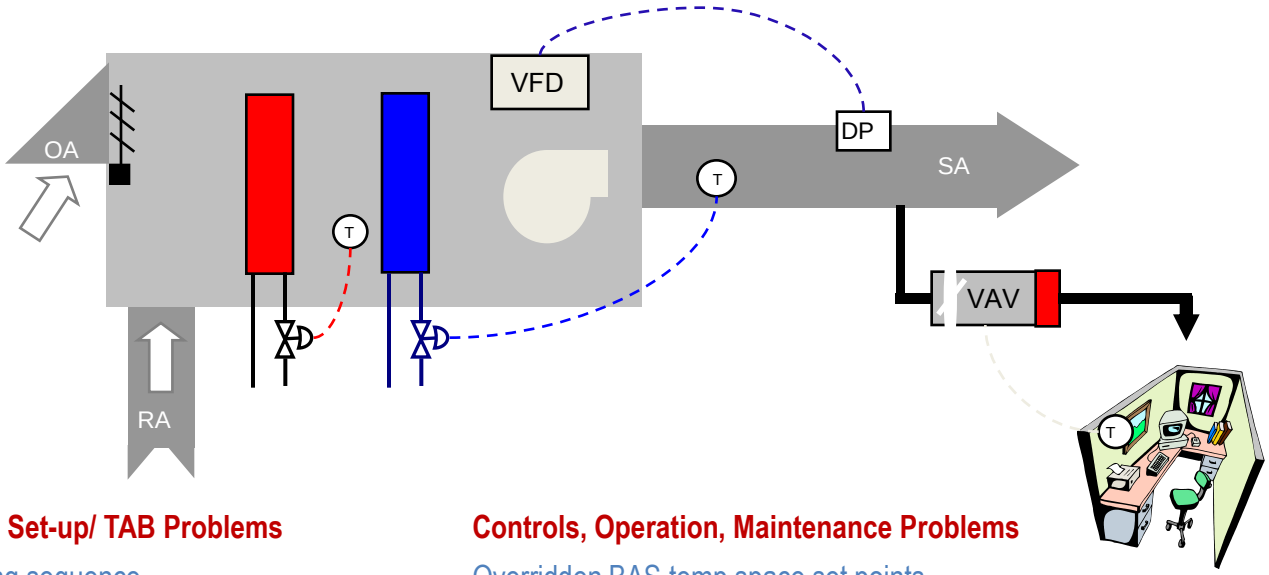
• Setback (or set-up) space temperature setpoints during unoccupied periods.

• Reset discharge air temperature setpoints depending upon zone needing most heating or cooling – avoid simultaneous heating and cooling

•Reset heating water and/or chilled water setpoints, depending upon outdoor ambient temperature and/or need for humidity control.

• BAS programming does not match desired (actual) sequence of operation

Potential Problems – Air Handling Systems



Design, Installation, Set-up/ TAB Problems

Improper programming sequence

Coils piped backwards

OA damper occupied / unoccupied set points

VAV damper actuator / calibration

Service access restricted

Space thermostat calibration

Sensors in wrong location

VFD / fan sheave sized for 'max concurrent' operation

Controls, Operation, Maintenance Problems

Overridden BAS temp space set points

Increased VAV airflow set points

High duct static DP set point

Disabled duct static DP reset logic

Decreased cooling coil setpoint

Preheat and Cooling coil fighting

Disable supply air temp reset logic

Actual OA damper position

Dirty filters

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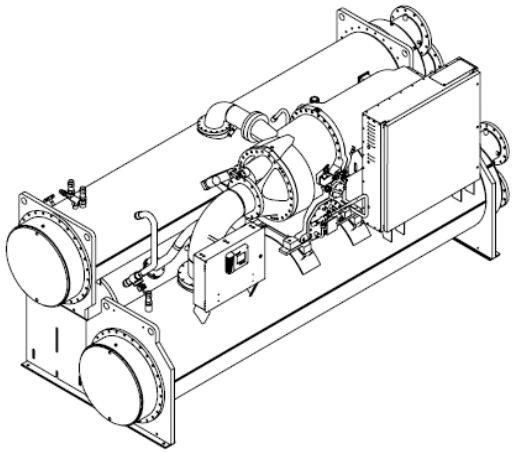
Other Considerations …

- Building envelope – how much energy is being lost through the 'shell'? (air barrier test and thermography survey)
- Has System Zoning been compromised – change in usage or occupancy?
- Ventilation Control – consider use of demand control ventilation (DCV), but ensure positive building pressurization
- Lighting controls – Use of scheduled lighting sweeps, occupancy sensors and daylighting controls
- Study equipment staging and sequencing of central plant equipment – chillers, pumps, boilers, etc.

Potential Problems – Central Plants

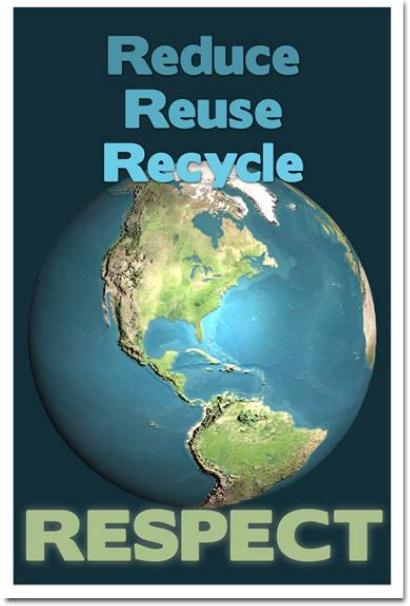
- Sequencing (Add / Subtract) Logic
- Incorrect Setpoints – Chilled and/or condenser water
- Poor water treatment – excessive fouling
- Chillers, pumps, tower fans in ‘manual’ operation
- Controlling sensor calibration
- Isolation valves – chillers / towers

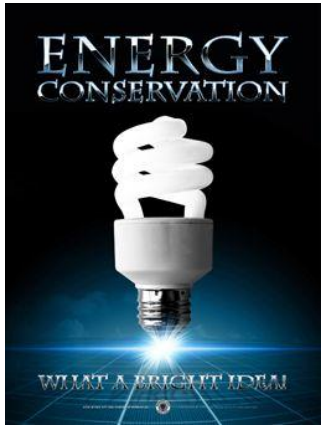


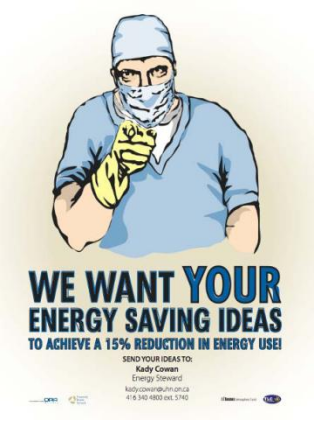
Ensuring Persistence of Savings

Employee Engagement / Social Marketing

- Solicitation of energy saving ideas from staff
- Pre- and Post-implementation surveys
- Identifies barriers to change
- Monitors changes in behavior







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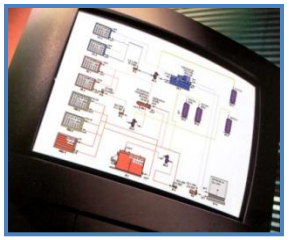
Ensuring Persistence of Savings

Building Operator Training

- Engage Facility staff
- Explain roles and responsibilities related to energy use
- Not only M&O procedures, but also energy basics and 'spotting energy saving opportunities'
- Discuss progress during future training sessions
- Train Senior operators and managers to be 'future trainers'

Ensuring Persistence of Savings



- **Good Documentation**

  Implemented measures, RetroCx findings, energy and demand savings estimates, and operations & maintenance procedures

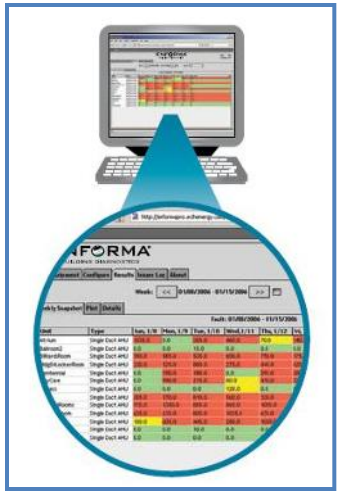
- **Performance Monitoring**

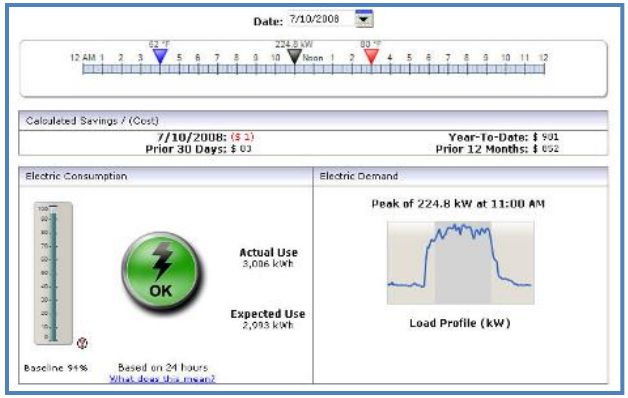
  Benchmarking, tracking monthly utility bills, using installed EMS, detected anomalies may be referred to the RetroCx provider

- **Train Personnel to do Energy Auditing & Re-commissioning**

M&V – "What gets measured, gets improved"

- Verify implemented modifications to systems perform as expected
- Compare energy consumption and costs against models and historical database benchmarks
- Needed to document compliance for various legislative requirements and for programs
- Critical in evaluating ESCO performance contracts





GovEnergy
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Case Study No. 1 – Medical Office Building

- Medical Center – 12 years old
- Nine ECMs identified – annual energy savings 829,220 kWh and a utility cost savings of $102,877
- Corresponded to a 21.1% reduction in annual electrical energy usage and 24.1% reduction in electrical utility costs
- Implementation cost $196,130 – simple payback 1.9 years

Case Study No. 2 – Campus AHU RetroCx

- University campus – 52 AHUs in 11 buildings
- Various physical deficiencies / numerous control issues identified – annual energy cost savings from correction and implementation of recommendations is $183,882.
- Implementation cost $33,707.27 – simple payback 0.183 years
- Future work includes additional 9 AHUs.

Market Potential for RetroCx

- Existing building commissioning industry has reached about $200 million / year in the U.S. (still in its infancy)
- If one establishes a goal to commission each building every five (5) years, the potential size is approximately $4 billion per year
- To achieve the goal of keeping existing buildings in the U.S. commissioned, it will require an increase in the workforce from approx. 1,500 to 25,000 F.T.E. workers
- While a challenge, it appears realistic given number of workers in related trades

Getting Started

- Evaluate internal resources and budgets
- Research available funding assistance – State, Utility incentives, and Performance Contracting (ESCO)
- Develop internal plan and set goals – Obtain “buy in” by all
- Identify ECMs, Analyze & Select, Implement, Train / Hand-off
- Measure & Verify, then adjust as necessary
- Lessons Learned

Thank You !

Robert J. Knoedler, P.E., CEM, CxA

Vice President – Principal-in-Charge – Energy and Cx Services

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