Retrocommissioning & Energy Retrofits

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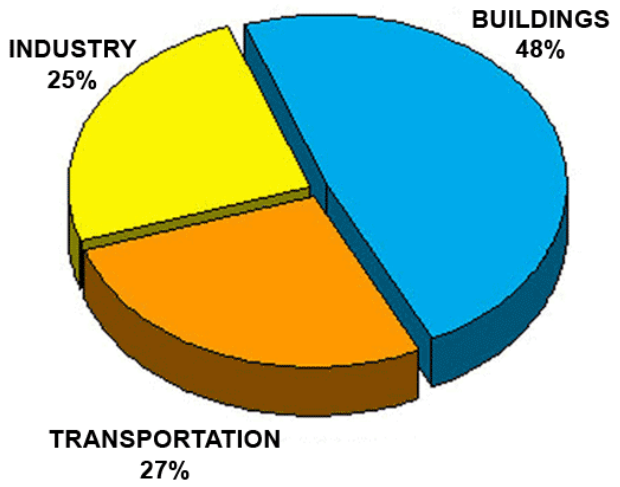
Drivers

Buildings account for:

- **38%** of CO2 emissions
- **48%** of total energy use
- **76%** of U.S. electrical consumption

-AIA Sustainable Design Factsheet (architecture2030.org)



US ENERGY CONSUMPTION

We will build as many buildings in next 50 years as in last 5,000

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Drivers

- Energy Independence and Security Act of 2007 (EISA 2007) <– EO 13514
  - Goal of net zero energy for all new commercial buildings by 2030
  - Specifies a zero-energy target for 50% of U.S. commercial buildings by 2040
  - Net zero for all U.S. commercial buildings by 2050
- ASHRAE Vision 2020 report (ASHRAE 2008) sets out requirements for developing the tools by 2020
- The AIA 2030 Challenge (AIA 2009) calls for incrementally reducing energy use, starting with a 50% reduction over existing buildings' 2010 energy use and increasing savings up to 2030

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Drivers

Buildings Technologies Program

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President Obama Announces Nearly $4 Billion in Building Energy Upgrades

December 7, 2011

President Obama announced on December 2 nearly $4 billion in combined federal and private sector energy upgrades to buildings over the next two years. These investments will save billions in energy costs, promote energy independence, and, according to independent estimates, create tens of thousands of jobs in the hard-hit construction sector. The $4 billion investment includes a $2 billion commitment, made through the issuance of a presidential memorandum, to energy upgrades of federal buildings using long-term energy savings to pay for up-front costs, at no cost to taxpayers. In addition, 60 Chief Executive Officers, mayors, university presidents, and labor leaders committed to invest nearly $2 billion of private capital into energy efficiency projects. They also pledged to upgrade energy performance by a minimum of 20% by 2020 in 1.6 billion square feet of office, industrial, municipal, hospital, university, community college, and school buildings.

Workers like this one putting insulation into a wall will help transform public and private sector buildings through energy upgrades.
Credit: Dennis Schroeder, NREL

The commitments were announced by President Obama and former President Clinton along with representatives from more than 60 organizations as part of DOE's Better Buildings Challenge. The challenge is part of the Better Buildings Initiative launched in February by the president. President Clinton is spearheading the effort along with the President's Council on Jobs and Competitiveness to support job creation by catalyzing private sector investment in commercial and industrial building energy upgrades to make buildings 20% more efficient over the next decade. Such improvements would reduce energy costs for U.S. businesses by nearly $40 billion. Last year, commercial buildings consumed roughly 20% of all energy used by the U.S. economy.

Among those pledging to reduce energy consumption were the District of Columbia, which is committed to a multi-pronged action plan to reduce energy consumption in more than 90 million square feet of city- and privately held buildings in the downtown core by at least 20% by 2020. And Prologis, a global leader in industrial real estate, has made it a key priority to work with its customers to reduce energy consumption in 100 million square feet by 20% by 2020. See the White House press release.

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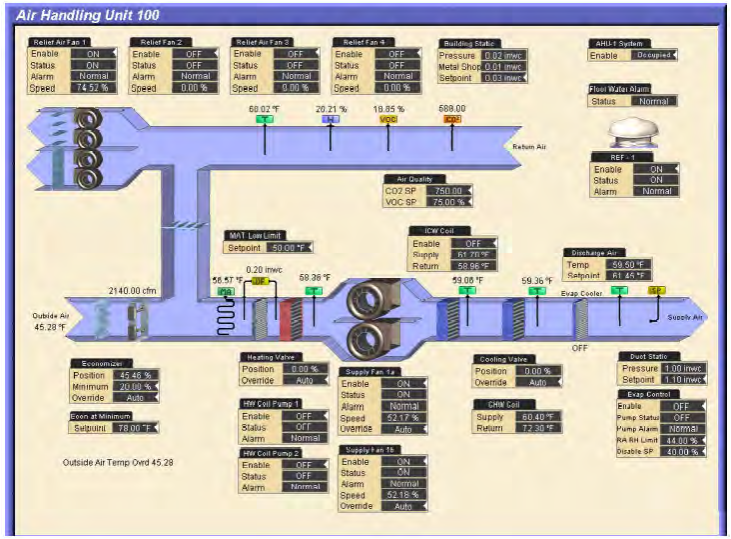
What is Existing Building Cx & Tune-Up?

Applying the commissioning process to improve the current conditions/operations of an existing building



Typically focuses on

low cost improvements to:

- HVAC Systems
- HVAC Controls
- Lighting Controls

Evaluates building operation:

- What were the building systems originally designed to do?
- What are the building systems doing now?
- How can the building systems be optimized for current needs?

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Why Commission?

"The results demonstrate that commissioning is arguably the single-most cost-effective strategy for reducing energy, costs, and greenhouse-gas emissions in buildings today."

Building Commissioning: A Golden Opportunity for Reducing Energy Costs and Greenhouse Gas Emissions" –

Lawrence Berkeley National Laboratory July 2009

Typical Costs and Benefits

Commissioning Analysis of 643 Buildings	Cost $/Sq. Ft.	Benefit $/Sq. Ft.	Return on Your Investment %	Simple Payback Period Years	Whole Building Energy Savings
Existing Building Cx	$ 0.30	$ 0.27	91%	1.1	16%
New Building Cx	$ 1.16	$ 0.28	23%	4.2	13%

332 EBCx + 77 NBCx projects = 643 buildings

- Mills, E., et al, 2009, Building Commissioning

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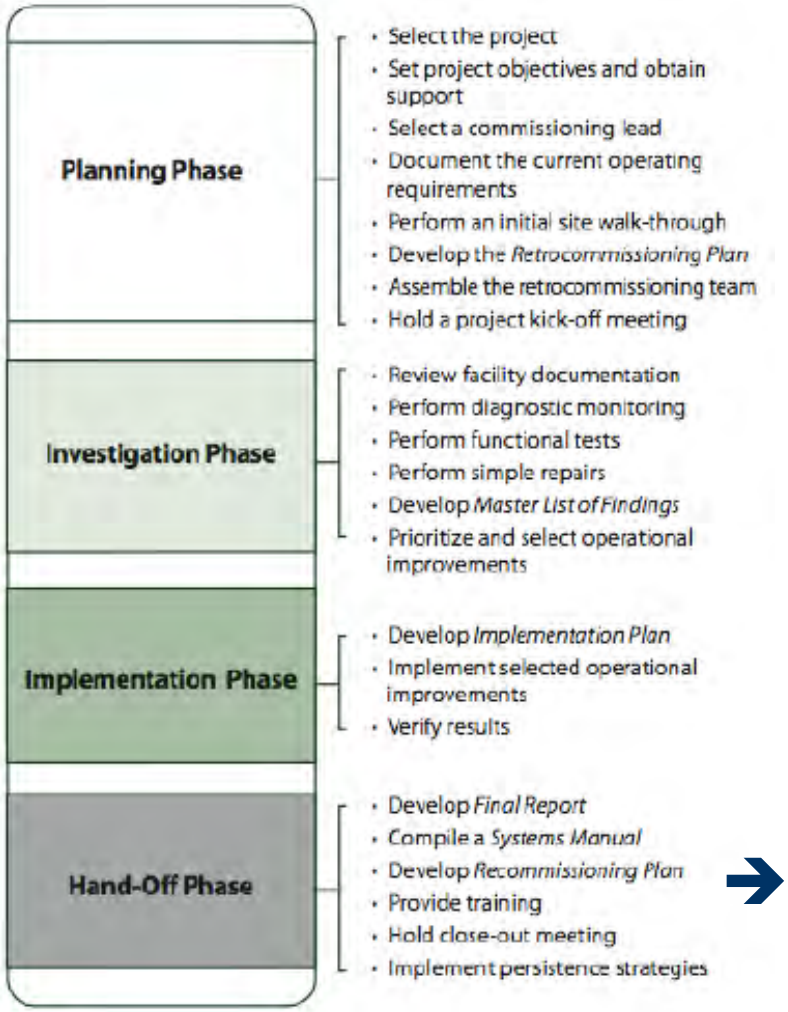
The Tune-Up Process



Source: California Commissioning Collaborative

(BCA and NEBB list similar processes)

➔ **Persistence**

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Planning
Good Candidates for Tune-Ups

- Unjustified high energy use
- Frequent failure of energy systems
- Excessive occupant comfort complaints
- Buildings with energy management systems
- Motivated owners / operators
- Outdated building documentation, lack of training on systems
- Building staff knows problems, but lacks time to fix

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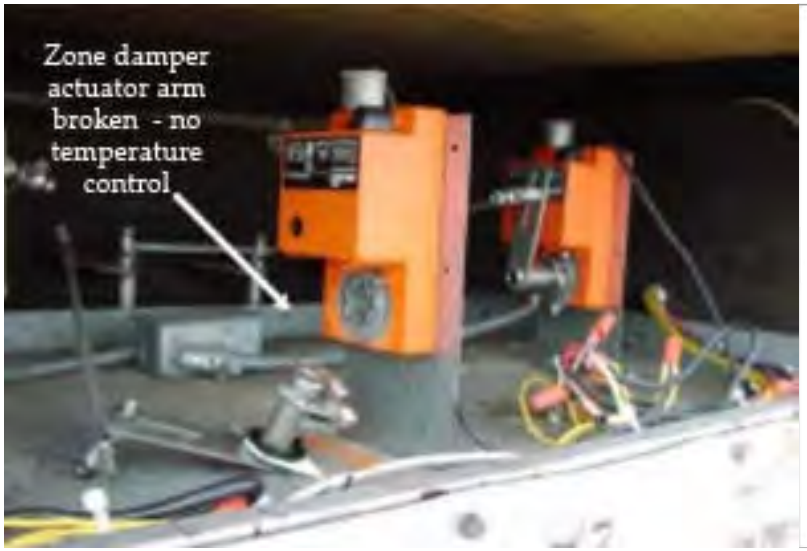
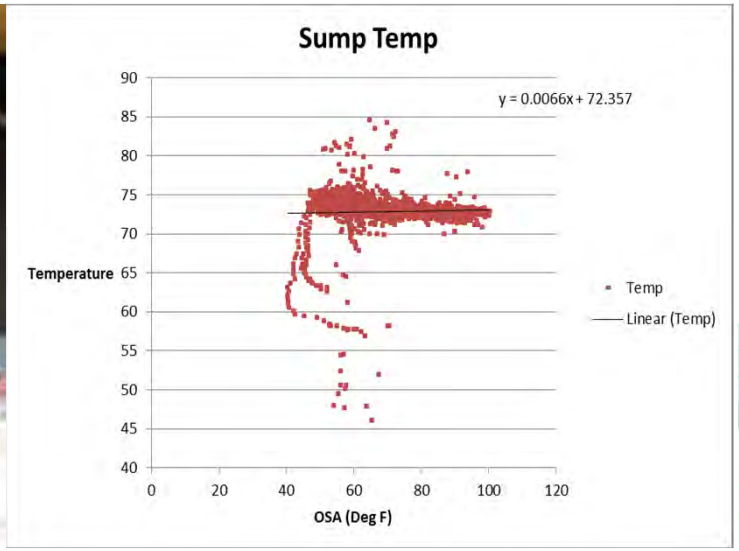
Investigation – Sources of Issues

- Overrides due to other issues (warm-up time, poor comfort, etc.)
- Hardware issues –actuator operation, controls linkage, sensor calibration
- Improper control sequence, changes in space use

New Buildings Institute: 64% of economizers tested required adjustment





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Top Opportunities RCx

1. Optimize equipment scheduling
2. Optimize outside airflow control (free-cooling & minimum ventilation)
3. Reset/reduce supply air static pressure
4. Reset air and water temperatures
5. Return VFDs to variable speed operation – Restoring Auto Control
6. Repair inoperable controls hardware (dampers & valves)
7. Optimize plant sequencing (including lockout control)
8. Calibrate sensors
9. Fix leaks
10. Clean heat transfer surfaces

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Investigation – Inspection hall of fame

Restricted flow

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Investigation – Inspection hall of fame

When freezing isn't cold enough

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Investigation – Inspection hall of fame

When all else fails,
put it in ‘hand’!!!

EO 13423 -Reduce use of ‘hand’ by 30% by 2015

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Persistence – Strategies for Success

- PO&M Plan
  - Equipment Lists
  - O&M and Systems Manuals
  - Points List and Sequence of Operation
  - System Diagrams
  - Equipment life and expected/documented efficiency
  - Maintenance schedule and task descriptions
  - Form for data tracking and collection
- Training – plan and execute and periodic refreshers
- Ongoing discussion with occupants and O&M personnel
- Performance tracking

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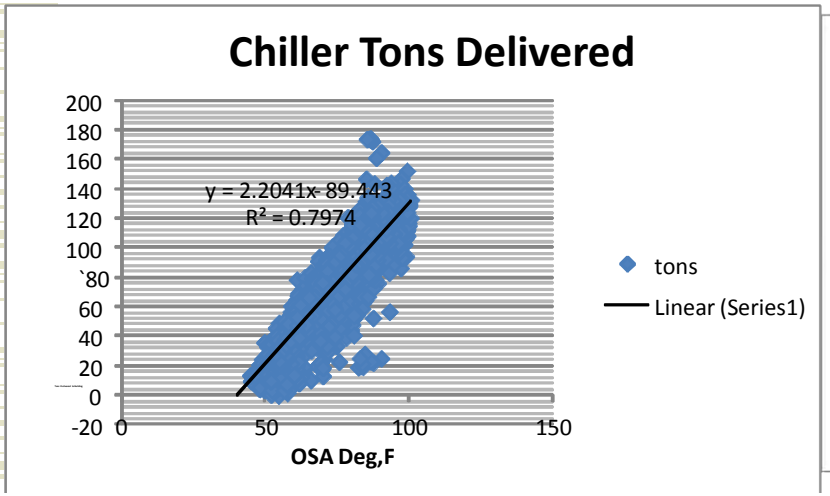
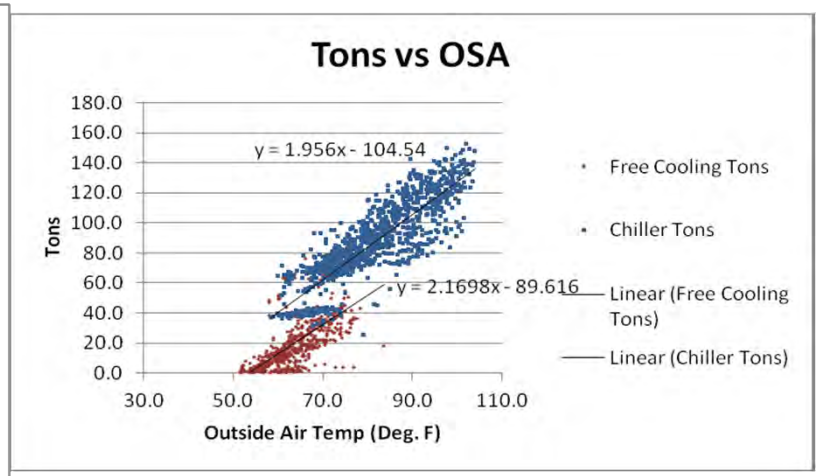
Persistence – Performance Tracking

- Benchmark energy use (i.e. Energy Star or Utility Tracking Software)
- Performance and End-Use Monitoring
- Trend key system parameters (chiller efficiency, system pressure, run-time, etc)
- Diagnostic and Reporting Software





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Case Study (Tune-Up)

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PROJECT PROFILE

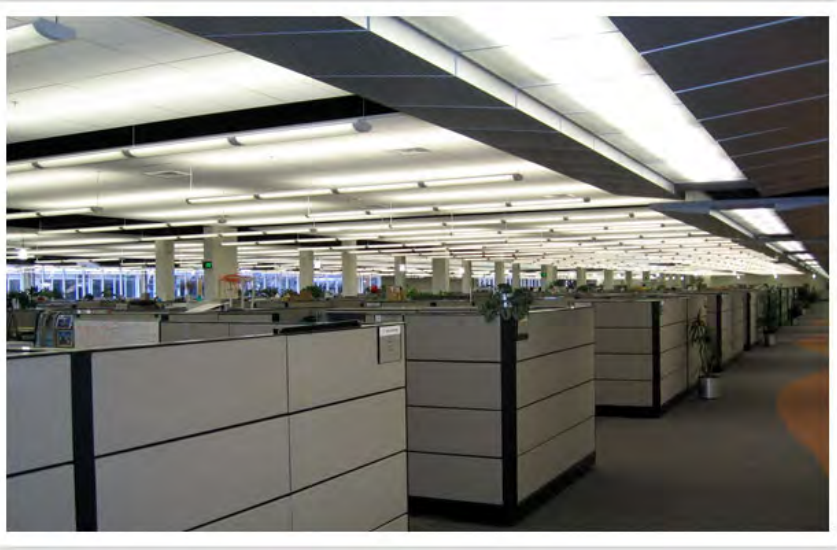
Millrock Park Campus
Salt Lake City, UT
Buildings 1, 2 and 3
Re-Commissioning

Total Square Feet Re-commissioned: 370,000
Annual Energy Saving Estimated: $23,495
Annual Energy Saving Verified: $19,360
Customer Cost: $14,228
Project Simple Payback: 9 months
Annual CO_2 Reduction Achieved: 259 Metric Tons

- Optimize equipment scheduling
- Duct static pressure reset
- Supply air temperature reset
- Optimize OA economizer
- Hot water temperature reset
- Optimize ventilation volume

Case Study (Tune-Up)

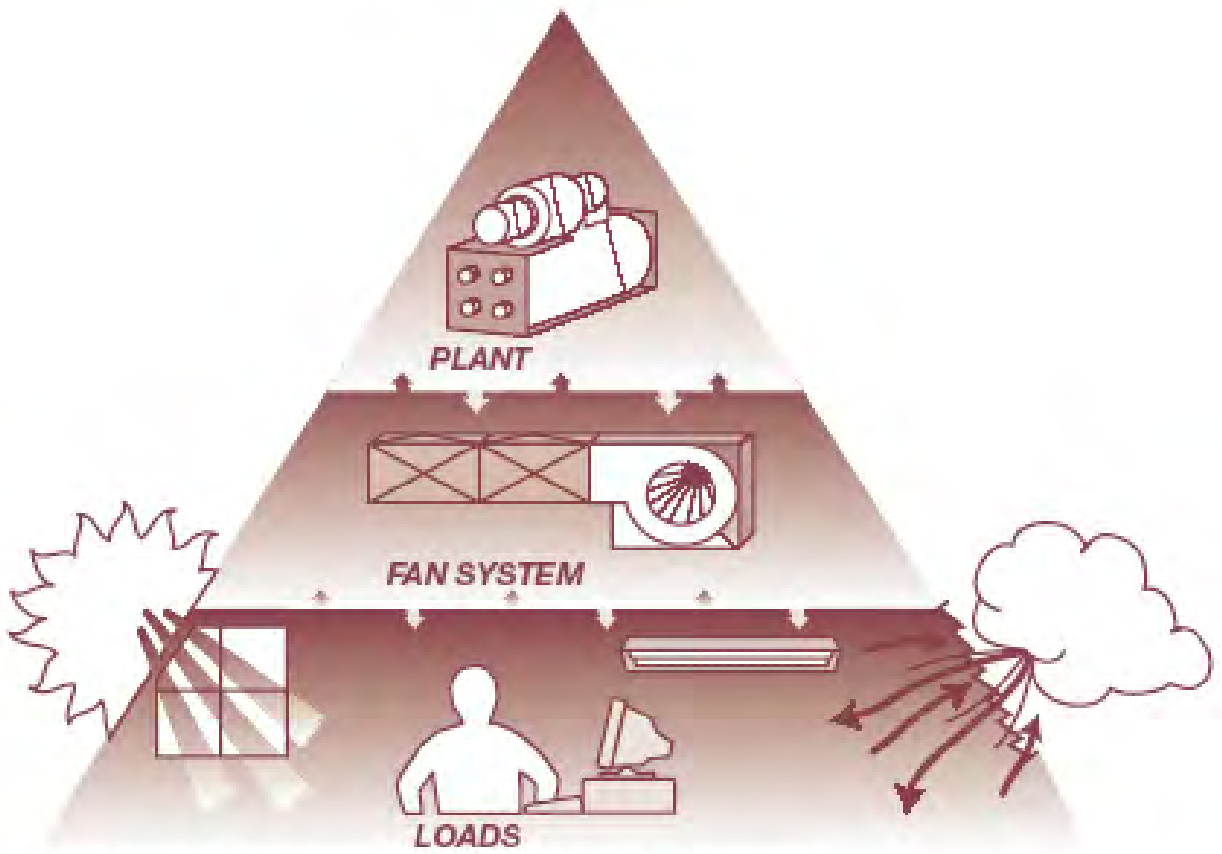
Agilent Technologies
Loveland, CO



$16,400 Implementation Cost
$23,000 Savings
133,000 Square Feet

- Reduce VAV box min. settings
- Turn off exhaust fans at night
- Static pressure/Temperature resets
- Optimize IDEC system
- Fix data center air distribution
- Obviate chiller spiking

Strategies for Success



Heat Flow In Buildings: Building Systems Interactions

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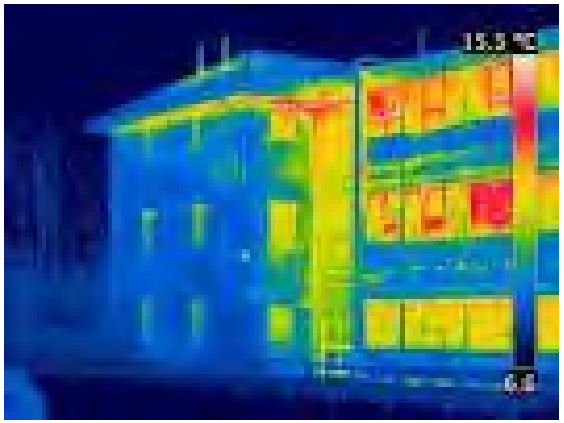
Loads

- Tune-up measures
- Reducing air infiltration
- Increased insulation
- Better windows
- Shading
- Equipment purchasing



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Systems

- Tune-Ups
- CAV->VAV conversion
- Right-size fans/pumps
- Premium efficiency motors
- Heat recovery

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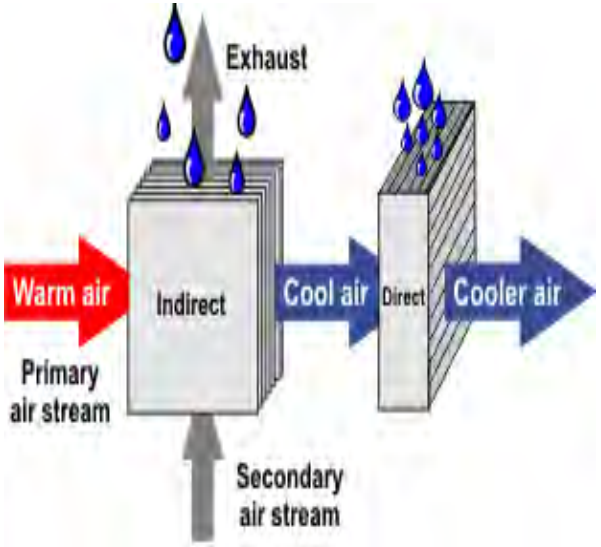
Plant

High-Efficiency

- Tune-Ups
- Two-Stage Evaporative Cooling
- Ground Source Heat Pumps
- Thermal Energy Storage
- Dedicated Outdoor Air System
- Displacement Ventilation
- Radiant Cooling
- Variable Refrigerant Flow Systems
- Top it off with Renewables



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Case Study – Tune-Up & Retrofit

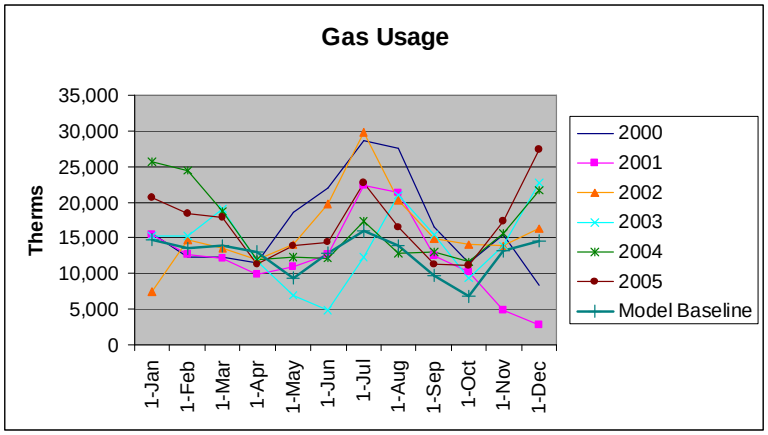
U.S. Army
Fort Bragg, NC

1M Square Feet (33 buildings)

- Optimize ventilation volume
- Optimize equipment scheduling
- Temperature resets
- CAV to VAV MZU conversion
- Chiller replacements
- Boiler retrofit

Boulder County Justice Center

- 250,000 SF
- Saves ~$125,000 annually (40%)
- 1973 Central plant overhaul
- Thermal storage option
- ~9 year payback
- 500 tons chiller, 20,000 MBH?



Resources

Building Commissioning Association
http://www.bcxa.org/

CA Commissioning Collaborative
http://www.cacx.org/

Procedural Standards for Retro-Commissioning of Existing Buildings
http://www.nebb.org

Energy Star Building Upgrade Manual
http://www.energystar.gov/index.cfm?c=business.bus_upgrade_manual

ASHRAE Advanced Energy Design Guides – 50%
http://www.ashrae.org/publications/page/aedg50pct

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Net Zero Energy

- Yet, how realistic is this vision?
- How close do NZEBs come to realizing their design goals?
- How much does it cost to design and build a net zero energy building?

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ZEB Database

- 9 projects
- <20,000 SF
- 1 or 2 story commercial

http://zeb.buildinggreen.com/

High performance buildings database

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Defining Net Zero Energy

- Zero net site energy use – (US)
  - Site renewable energy = building energy
- Zero net source energy use–
  - Includes transport energy
- Net zero energy emissions– (outside US)
  - Includes carbon emissions from fossil fuel use
- Net zero cost–
  - Good Luck!

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Getting There (Demand – Supply)

- Build Tight…Ventilate Right
- Daylighting
- Insulation 10/20/40/60
- Passive solar heating / control gain
- Energy reuse
- Natural ventilation / ‘Free’ cooling
- Evaporative cooling
- High-efficiency HVAC equipment
- Ground-source heat pumps
- Renewable Energy

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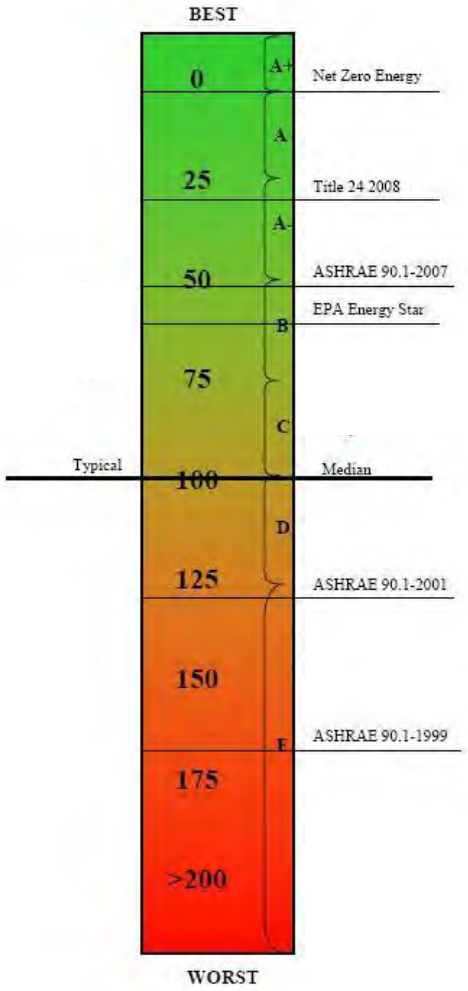
Getting There



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City of Denver – DHA
Block 5B

- LEED-H Platinum
- Building 50%+ better than 90.1
- Advanced lighting design and controls
- GSHP, Heat Recovery
- PV handles 22% of electric usage

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Mapleleaf Orthopedics

- 8,000 SF medical office, completed Dec 2007
- Southern Colorado's 1st LEED Building – *LEED 2.2 Gold*
- CRES award winner www.cres.org

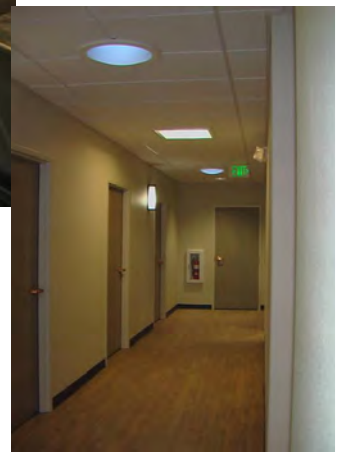
Mapleleaf Orthopedics

- 30kW PV System
  - meets 90%+ of energy needs
- Ground source heat pumps (GSHP)
  - 350%+ heating efficiency
  - 23 EER cooling
- Energy recovery ventilator (ERV)
  - reduces ventilation load by 75%
- 90% of spaces are daylit, Dimming and occupancy based lighting controls

GSHP

ERV

Lighting



Mapleleaf Orthopedics – Performance Metrics

Period March 2008 - August 2008 Extrapolated	
kWh Used/Year	51,360
kWh Produced/Year	47,854
Net kWh Used/Year	3,506
Energy Use Intensity (Btu/Square Foot/Year)	16.5
CBECS: Office US 1990-2003*	88.0
CBECS: West Mountain Region 1990-2003*	81.2
Mapleleaf Orthopedics Performs 80% Better Than a Typical Building	
$/Year	$ 5,187
$/SF/Yr	$ 0.65

Source: EIA CBECS 2003: Table C.12 Consumption and Gross Energy Intensity by Year Constructed for Sum of Major Fuels for Non-Mall Buildings, 2003

Hyland Village Community Center

Designed to net-zero energy

- Solar thermal (radiant floor and pool)
- Solar PV
- Trombe Wall
- Natural Ventilation
- DOAS

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Movement Climbing Gym

"Carbon Neutral"

- Daylighting
- DOAS
- Air source heat pumps
- Indirect evaporative cooling
- Solar Thermal - DHW
- Solar PV – 100 kW, 70% of energy

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Thank You

Questions?

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