Strategies for Building Energy Efficiency

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How Buildings Use Energy

- Building Envelope (Walls, Roof, Windows, Floors)
- Lighting
- Heating, Ventilating, and Air Conditioning (HVAC)
- Internal and Process Loads (cooking, hot water, swimming pools, manufacturing, etc.)
Envelope
Increase Wall and Roof Insulation

- Insulate Walls to at least R-13
- Insulate Roofs to at least R-20, Attics to R-38. Floors over unconditioned spaces to R-30.
- Highly Efficient Buildings will have values which exceed these.
Window Characteristics

- Five key parameters:
  - U-Factor
  - Solar Heat Gain Coefficient (SHGC)
  - Visual Light Transmittance (VLT)
  - Air Leakage (cfm/sf)
  - Condensation Resistance

- www.nfrc.org
The magic of “Low-E”

- The “E” stands for emissivity
- Absorptivity and Emissivity describe how materials respond to radiation.
- The properties are wavelength dependent.
- This allows a material to transmit light but block heat.
Longer-wave heat energy is reflected, keeping summer heat out.

Shorter-wave visible light passes to the interior.

Low-E glass reflects heat to the interior.

Visible light is absorbed by the interior and reradiated as heat.
Why Low-E works...

Source: Kreith and Kreider
Tailoring the Window

- Lower U values almost always the best choice.
- Solar Heat Gain Coefficient can be selected to block less heat in Northern Climates more in Southern.
- VLT can be chosen to maximize daylighting or to eliminate glare.
### Some Window Rules-of-Thumb

<table>
<thead>
<tr>
<th></th>
<th>Cold Climate</th>
<th>Mixed Climate</th>
<th>Hot Climate</th>
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</thead>
<tbody>
<tr>
<td><strong>U-Value</strong></td>
<td>&lt;0.33 all climates: low U not quite as important in hot climates</td>
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<tr>
<td><strong>VT</strong></td>
<td>&gt;60%</td>
<td>&gt;50%</td>
<td>&gt;50%</td>
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<tr>
<td><strong>SHGC</strong></td>
<td>&gt;0.55</td>
<td>0.40-0.55</td>
<td>&lt;0.40</td>
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<tr>
<td><strong>Spacer</strong></td>
<td>warm-edge spacers for all climates</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Frame</strong></td>
<td>Thermally broken frames for all climates</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Air Leakage</strong></td>
<td>&lt;0.30 cfm/sf for all climates</td>
<td></td>
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</tr>
</tbody>
</table>
Insulating Window Shades

- High R-Value Window Shades, while expensive, may also be a viable option.
Interior Window Films

- If acceptable by building management, window films may be a useful option. Choose film tailored for climate.
Air Sealing

- Air Sealing is just as important in a commercial or municipal building as it is in your home – maybe even more!
- Wind and Stack effects are greater in multi story construction.
Lighting
Compact Fluorescent
Super T8 and Low Wattage T8

- **Super T8** systems can produce energy savings as **high as 40 percent** over standard T8.
- To identify a Super T8, look for lamps that are at least 3100 initial lumens [as opposed to 2850 for a standard T8] and have a barrier coat design and high lumen maintenance.
- Super T8 lamps include the SYLVANIA "Xtreme," Philips "Advantage" and GE "HL." Ballasts include the SYLVANIA "Xtreme," Advance "Optanium," Universal Triad "HE" and GE "UltraMax."
Occupancy Sensors

- Use them for office lighting
- Restroom lighting
- Storage Areas
- Mechanical Rooms
- Warehouse Aisles - Fluorescent
- Get creative – use for HVAC in individual rooms or zones.
Isole – Personal Occupancy Sensor
LED Exit Signs

- Payback is quick
- Rebates available
- Very basic lighting energy savings measure
- Chicago approved
HID to Fluorescent Retrofit

- **Existing System:**
  - 400watt High Pressure Sodium and 400watt Metal Halide.
  - Each fixture uses 455 watts (400 for lamp, 55 for ballast)

- **Retrofit**
  - Each fixture uses 234 watts (lamps and ballast combined)
  - Light levels increased 10-20%
Street and Parking Lot Lighting

- Probe Start HID to Pulse Start HID a typical retrofit.
- Fluorescent Induction, and LEDs making moves into market
Probe vs. Pulse Start

Figure 3: Arc tube construction

- Probe-start arc tube
  - Operating electrodes
  - Starting probe
  - Bi-metal switch

- Pulse-start arc tubes
LED Traffic Signals

- Application is very popular
- Energy savings 50 to 75 percent
- Good LED application: directed light and switched on and off
The LED luminaires offered a conservative 13% energy savings relative to the baseline HPS system.

Simple payback was found to be quite long at current luminaire pricing.

Overall public reaction to the LED bridge lighting has been very positive, with “positive” comments outweighing “negative” comments by about five-to-one.
Other DOE Gateway Results

http://www1.eere.energy.gov/buildings/ssl/

Oakland Street lighting – 15 year payback

Supermarket Parking Lot 70 percent savings – 5 year payback
HVAC
Programmable Thermostats

- They work when you use them.
Thermostat Set-Back and Set-Up

- Set Heating to 68 F, set-back to at least 60 during unoccupied periods. Let condensation be your guide.
- Set cooling to 74, set-up to 80 during unoccupied periods. Developing morning recovery schedule based on demand charges or system capacity.
- Easy to do on systems without reheat.
System Shutdown During Breaks

- HVAC – turn off exhaust fans
- HVAC – place air handling units in unoccupied or holiday schedule
- HVAC – place temperature control into unoccupied mode setbacks
- Lighting – turn off sections, and go to minimum levels if bi-level switching available
- Plug loads – turn off as possible
Variable Frequency Drives

- Variable Frequency Drives can save 20 percent or more in electrical usage.
- Often there are additional benefits in process control and quality.
- Look for pump and fan systems which have bypass or valve control. Chilled Water, Hot Water, AHU Fans, Pool Sand Filter Pumps are typical applications.
Demand Control Ventilation

Energy Savings & CO₂ Control

Excess Ventilation Over Design Levels

Excess Ventilation Over Occupancy Need

Actual Ventilation Based On Occupancy With CO₂

6 AM  12 PM  6 PM
Unit Ventilators – great opportunities to save
$\text{CO}_2$ and Occupancy Sensor Control for Unit Ventilators
VAV Supply Air Temp. Reset

- Saves cooling energy
- Saves reheat energy
- Increases hours when economizer can be utilized.
VAV Fans

- Static Pressure Reset on VAV Systems.
  - Provides significant fan energy savings since system is often at part load
  - Reduces fan noise
VAV Control Deadband

“Variable air volume (VAV) terminal units shall be programmed to operate at the minimum airflow setting without addition of reheat when the zone temperature is within the set deadband.”

To meet this requirement, the control system must allow separate heating and cooling setpoints that are at least 5°F apart. If, for example, the cooling setpoint is 75°F, then the control system cannot enable the reheat coil until the space temperature drops to 70°F or below.
Radiator Valves

- For spaces that tend to overheat, and don’t have thermostats for control of radiators or hot water convectors.
Boilers, Chiller, Etc.

- Don’t start boilers until OA temperatures are below 50 consistently.
- Consider shutting down boilers used for AC reheat in the summer or resetting the supply water temperature.
- Shut down chillers when OA temperatures are consistently below 50, and use economizer.
Reset Boiler Water and Chilled Water Supply Temps.

- Lower boiler water supply temperature in mild weather.
- Raise chilled water supply temperature in mild or dry weather.
Use Modular Boilers

- Modular boilers can follow load more closely with greatly improved efficiency
- Can mix modular boilers with existing large boiler system.
Isolate Off-Line Chillers

- Depending on plant arrangement and offline chiller can act as a bypass between supply and return water.
- This reduces system delta T, and wastes pumping energy.
Try Refrigerant Migration
Free Cooling

- Some centrifugal chillers can provide free cooling at reduced capacity during periods when low temperature condenser water is available.
Reduce Boiler Blowdown Rate

- Review your blowdown practices to identify energy saving opportunities.
- Examine operating practices for boiler feedwater and blowdown rates developed by the American Society of Mechanical Engineers (ASME). Considerations include operating pressure, steam purity, and deposition control.
- Consider an automatic blowdown control system
- Fact Sheet Available at http://www1.eere.energy.gov/industry/bestpractices/pdfs/steam9_blowdown.pdf
Computers and Office Equipment
Vending Energy Management

- Vending Misers can be used to control Snack and Cold Drink Machines
Water Savings Measures

- Faucet Aerators
- Low Flow Shower Heads
- Low Flow Water Closets
- Low Flow Urinals
- Reduced cooling loads reduce cooling tower water usage
- Eliminate once-through cooling systems where possible
## Water Saving Fixture Data

<table>
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<tr>
<th>Fixture Type</th>
<th>EPAAct 1992 Usage Limit</th>
<th>Water Efficient Fixture</th>
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<tbody>
<tr>
<td>Water Closet</td>
<td>1.6 GPF</td>
<td>1.1 to 0.8 GPF</td>
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<tr>
<td>Urinal</td>
<td>1.0 GPF</td>
<td>0.5 to 0.0 GPF</td>
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<td>Faucet</td>
<td>2.5 GPM</td>
<td>1.8 GPM</td>
</tr>
<tr>
<td>Shower</td>
<td>2.5 GPM</td>
<td>1.8 GPM</td>
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Lower Water Heater Temperature

- Set domestic water heater temperature to 130 F. Use gas fired booster heater where higher temp is required.
Retro-Commissioning
Typical Findings from RCx

- Missing or broken equipment/components
- Incorrect thermostat settings and control sequences
- Incorrect or missing BAS schedules for fans, pumps, lights, and other key components
- Malfunctioning control sensors such as outside air temperature sensors, supply air temperature sensors, damper position, etc.
- Heating and cooling systems fighting each other (excessive reheat).
Excessive Reheat
## Incorrect Schedule

### Fan System

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<tr>
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<th>2A</th>
<th>2B</th>
<th>ERF2 A</th>
<th>ERF2 B</th>
<th>3A</th>
<th>3B</th>
<th>5A</th>
<th>5B</th>
<th>7A</th>
<th>7B</th>
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Incorrect Control Sequence

February 17, Inside Temperature and Heating Valve Pressure

- Temp (F)
- Pressure (PSIG)

<table>
<thead>
<tr>
<th>Time</th>
<th>Temp (F)</th>
<th>Pressure (PSIG)</th>
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<td>PM</td>
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</table>

Graph showing temperature and pressure variation throughout the day from 12 AM to 10 PM.
Opportunity for Tighter Demand Control

![Graph showing CO2 ppm, Rel. Humidity, and Temperature over time. The graph highlights Sept. 3 with an arrow.]
Control of Baseboard Heaters
To Apply for SEDAC Assistance

- Call 1-800-214-7954 or,
- Visit the SEDAC web site at www.sedac.org and download an application.