Overview of Energy Technologies and Energy Efficiency (solar, wind, net metering, and energy efficient buildings and infrastructure)

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Energy Efficiency then Renewable Energy (EERE)

- All new buildings should be as efficient as possible with the goal of net zero annual energy.
- Determine the energy use and energy cost of existing buildings and infrastructure.
- Reduce energy use by installing EE lighting, HVAC and controls and reducing plug loads.
- Install RE (Solar, Wind, Biofuels) to meet remaining energy needs.
Step 1 – Compile monthly electricity and heating fuel bills

- Where do you go for the data?
  - Finance department
  - Facilities reports
  - Environmental Management Systems
  - Leases

- What are you looking for?
  - Electricity consumption (kWh) and rates ($/kWh)
  - Natural Gas consumption (CCF, Therms, Btu or MMBtu) and rates ($/unit)
  - On-peak and off-peak rates
  - On-peak start time and stop time
  - Utility provider

- Not sure how to read the bills?
  - Ask the finance department
  - Contact the Utility company directly (they’re often really really helpful)
Background

- Lighting accounts for 25% of the total electricity used in the federal sector
- Electric lighting accounts for more than a third of all electricity consumed for commercial use in the United States

General Energy Saving Strategies

1. Optimize use of natural daylight
2. Replace lamps and ballasts with modern, efficient lamps / ballasts
3. Replace incandescent lamps with compact fluorescent lamps (CFLs)
4. Implement task lighting
5. Install state-of-the-art lighting controls
Energy Conservation Measures (ECM’s)

- **Fluorescent Lights and Electronic Ballasts**
  - Replace T-12 lamps and Magnetic Ballasts with Low Wattage T-8 Lamps and Electronic Ballasts
  - Replace Standard T-8 Lamps with Low Wattage T-8 Lamps and Low Ballast Factor Ballasts
  - Install Perimeter Dimming Ballasts
  - Optimize Interior Security Lighting

- **Compact Fluorescent Lights (CFL)**
  - Screw-in Lamp Retrofit

- **Light Emitting Diodes (LED)**
  - Replace Standard Exit Signs with LED Exit Signs
  - Install LED Task Lighting
  - Replace Incandescent and HID/HPS Fixtures with LED Fixtures
ECM’s - Continued

- Lighting Controls
  - Install Occupancy Sensors in Bathrooms, Conference Rooms and Private Offices
  - Install Central Lighting Controls

Lighting Projects by Year and Type
HVAC Overview

- Convert CV to VAV
- Convert 3 Way Valves to 2 Way Valves w/VFDs
- Install Dedicated OA AHU
- Install Static Pressure Sensor and VFD on Small CV AHU
- Install Energy Recovery
Convert CV to VAV

• Constant Volume Configurations:
  – Most constant volume systems have electric or hot water heating elements serving as terminal units

• Variable Air Volume System Components:
  – Each VAV system will have a central air handling unit with a variable speed supply fan (VFD on supply fan)
  – The AHU will contain a cooling coil, controls, mixing box, possibly a return air fan
  – AHU’s should be located as close to end loads as possible
  – Existing AHU can be used or it might need to be replaced

http://www.betterbricks.com/graphics/assets/images/Building_Ops/BOpTIsCmnOps_3W.png
Energy Recovery

- Factors that improve energy recovery economics include:
  - Colder climates (e.g. more than 3,000 heating degree-days)
  - High exhaust rates
  - High utility rates
- Consider impact of increase pressure drop due to energy recovery devices in airflow.
Heating Background

• Space heating and water heating accounts for 45% of the energy used in commercial buildings.¹

**General Energy Saving Strategies**

1. Install high efficiency equipment
2. Turn equipment down or off as load decreases
3. Install biofuel (typ wood) heating systems

Install Condensing Gas Furnace

- Small condensing furnaces have efficiencies 92% - 96%
- Great application for smaller facilities
- PVC exhaust stack reduces installed cost
• Condensing boiler benefits:
  – High efficiencies ~ 98%, low Nox
  – Good part load efficiencies

• Condensing boiler issues:
  – Most common problem is high return water temperatures
  – Typical heating coils are 180 F/150 F
  – Won’t work if the building is heated with only perimeter baseboard heaters

• Condensing remedies:
  – Install 180/120 F cooling coils (60 deg delta) w/ supply water temp reset
  – Set them up with two return water steams
HVAC Control Overview

- Install Programmable Thermostats
- Replace Pneumatic Sensors with Electronic Sensors
- Reduce OA and EA Flow Rates per ASHRAE 62
- Enable Air-side Enthalpy Economizer Operation
- Optimize Supply and Exhaust Air Duct Work

Static Pressure
Background

• HVAC Control system improvements typically produce considerable energy savings with minimal capital investments

General Energy Saving Strategies

1. Match HVAC schedules to occupancy schedules
2. Optimize current control strategies for improved efficiency and comfort
Install Programmable Thermostats

• **Programmable Thermostat Applications:**
  - Control of zone
  - Control of system such as a packaged air handling unit

• **Programmable Thermostat Requirements:**
  - Commercial building unit
  - Minimum of 7 day scheduling capability
  - EASY TO PROGRAM
  - Able to turn zone or unit on-off based on time and temperature
  - Adjustable dead-band (differential where thermostat remains neutral – no heating or cooling)

• **Programmable Thermostat Optional:**
  - Occupied/unoccupied control
  - Heating only
  - Cooling only
  - Ventilation only

Plug Loads Overview

• Definition of Plug Loads
• Energy conservation measures to reduce plug loads
  – Activate power management on computers and monitors
  – Replace desktop computers with laptop computers and a docking station
  – Replace desktop computers with low energy desktop computers or thin clients
  – Replace CRT monitors with LCD monitors
  – Install vending machine misers on refrigerated vending machines and de-lamp advertising lighting
  – Install occupancy sensor controlled surge protectors in offices
  – Replace appliances with Energy Star appliances
  – Others
    • Network printers to reduce the number of personal printers
    • Replace task lighting with LED task lighting
    • Replace office equipment with Energy Star models
Plug Loads

• Plug loads are devices that plug into a building’s electrical system. They include:
  – Office equipment (fax machines, computers, printers, and copiers)
  – Appliances
  – Soda machines
  – Drinking fountains
  – TVs
  – VCRs

• Plug loads account for 9% of a building’s total electrical use
ECM: Activate Power Management on Computers and Monitors

- Technical Specifications
  - Activate power management settings on all computers through built-in Windows tools
    - “Turn off monitor” set to 15 minutes
    - “System Standby” set to 30 minutes
    - “Hibernation” set to 45 minutes
  - Limit screen-saver use

- Cost Guidelines
  - Power management settings are already built in to Windows at no additional cost
  - Average labor time per computer should be 15 minutes
ECM: Replace Appliances with Energy Star Appliances

- Refrigerators
  - Specify refrigerators at least 20% more energy efficient than the minimum federal government standard (NAECA)

- Clothes washers
  - Specify modified energy factor (MEF) ≥1.72
    - MEF equals washer capacity divided by total energy consumption per cycle
  - Specify water factor (WF) ≤8.0
    - WF is the water consumption per cycle divided by the washer capacity

Lifetime or Levelized Costs of Renewables

- Wind, Onshore
- Wind, Offshore
- Solar Photovoltaic
- Concentrating Solar Power
- Geothermal Hydrothermal
- Hydropower
- Biopower

Levelized cost of energy, $/kWh
Renewable Portfolio Standards Policies

www.dsireusa.org / March 2013

29 states, Washington DC, and 2 territories have Renewable Portfolio Standards (8 states and 2 territories have renewable portfolio goals).
Net Metering of Renewable Energy

Energy consumed immediately: retail rate

Excess energy used to \textit{offset} consumption at another time: retail rate

Net excess energy (determined monthly or annually): retail rate, avoided cost, or given to the utility
43 states & 4 territories have adopted a net metering policy

Note: Numbers indicate individual system capacity limit in kilowatts. Some limits vary by customer type, technology and/or application. Other limits might also apply. This map generally does not address statutory changes until administrative rules have been adopted to implement such changes.
43 States and Puerto Rico have adopted an interconnection policy.

Notes: Numbers indicate system capacity limit in kW. Some state limits vary by customer type (e.g., residential versus non-residential). “No limit” means that there is no stated maximum size for individual systems. Other limits may apply. Generally, state interconnection standards apply only to investor-owned utilities.
PV Technology Overview

- Direct conversion of sunlight into DC electricity
- DC converted to AC by inverter
- Solid-state electronics, no-moving parts
- High reliability, warranties of 20 years or more
- PV modules are wired in series and parallel to meet voltage and current requirements
<table>
<thead>
<tr>
<th>Technology</th>
<th>Efficiency Range</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single Crystal</td>
<td>14 to 23%</td>
<td>Most efficient. Rigid.</td>
</tr>
<tr>
<td>Multi-Crystal</td>
<td>13 to 17%</td>
<td>Efficient. Most Common. Less area per watt. Rigid.</td>
</tr>
<tr>
<td>CIGS</td>
<td>12% to 14%</td>
<td>Uses no Silicon. Can be made flexible.</td>
</tr>
<tr>
<td>Cadmium Telluride</td>
<td>10% to 11%</td>
<td>Uses no Silicon. Rigid.</td>
</tr>
<tr>
<td>Thin Film Si</td>
<td>6 to 11%</td>
<td>Uses relatively little Silicon. Can be made flexible.</td>
</tr>
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**PV Watts**

- **PV Watts** Photovoltaic Analysis
  
  - Select default values or input customized system parameters for size, electric cost, array type, tilt angle, and azimuth angle

  - Typical Meteorological Year weather data for the selected location (TMY files) used to calculate incident solar radiation and PV cell temperature for each hour of the year

- **Benefits**
  
  - Easy to use
  - Very Quick
  - Useful for users of all technical levels
  - Widely accepted tool
Price of PV Modules

Source: EIA 2005 data
Costs

• Use PPA or PERFORMANCE SPECS (kWh/year) not specific manufacture or kW.
• Provide clear requirements and evaluation criteria
• Costs depend on:
  – Size – bigger is better:
  – Balance of system costs including structures, inverters, electrical and interconnection.
• Lowest cost is large (5 MW+) ground mount, $2/W (6-14)
• Ballasted or Direct roof attachment such as standing seam metal roof – Installed approx. $3/Wdc for 100kW
• Single axis tracking (over 300 kW in SW) – add $0.1/W
• Carports – add $0.6/W (careful w/ snow and ice)
• High efficiency modules (GT 17%) add $0.3/W
• Annual Energy use = 6000 kWh
• PV on south facing roof sloped at 20 degrees produces 1458 kWh/kW Annual with 0.8 derate factor
• 6000 kWh/1458 kWh/kW = 4.1 kW
• Expected cost at $4/W = $16.4K before incentives
• Area required = 4100 W/11W/sq ft = 373 sq ft.
SHW - Active, Closed-loop (antifreeze), Indirect System

- Excellent freeze protection
- Good hard water tolerance
- High maintenance requirements
Locating Windy Sites

- Wind maps – check for updated state maps
- Regional wind atlases
- Biological indicators
- Environmental monitoring data
- Local knowledge
- Geographic/social references
- Proprietary localized wind maps

- Measure, measure, measure!
  - Essential for large investments
  - 1yr. dataset is typical
  - “It’s really windy here” isn’t bankable
Sizes and Applications

Small (≤10 kW)
- Homes
- Farms
- Remote Applications
  (e.g. water pumping, telecom sites, icemaking)

Intermediate (10-250 kW)
- Village Power
- Schools, businesses
- Hybrid Systems
- Distributed Power

Large (660 kW - 2+MW)
- Central Station Wind Farms
- Distributed Power
- Community Wind
Importance of “Micro-Siting”
Questions?
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