High Efficiency Heating and Cooling Systems for Community Colleges

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Principal
Learning Objectives for this Session

- Get acquainted with typical systems used in the Community College setting
- Understand what comprises a high efficiency system
- Get to know what supplemental funding sources are available
- Understand why a central ground source system has cost and operational advantages
Building Owner Expectations

- Simplicity
- Low maintenance
- Efficiency
- Cost Effectiveness
- Environmentally Green
Current Systems

- Variable Air Volume Systems with reheat zone control
- Single Zone Air Handling Systems
- Multi-zone systems
- Fan Coils / Heat Pumps
- Variable Refrigerant Flow
VAV Systems

- Standard Large building system from late 1970’s
- Generally oversized to meet building warm up / cool down needs
- Claims to take advantage of diversity within the areas served
- Generally dehumidifies all of the air delivered to the building
- Controls comfort by adding heat to the dehumidified air
- Generally consists of
  - A main air handler
  - Chiller
  - Boiler
  - Large distribution duct
  - Variable Air Volume boxes
- Controls are key to system operation
System Complexity

= Reduced Efficiency

\[ \text{kW} = 1.1 + 0.07 + 0.07 + 0.15 + 0.3 + 0.16 = 1.85 \]
\[ \text{tons} = 1.0 - 0.03 - 0.02 - 0.09 - 0.05 = 0.81 \]
\[ \frac{\text{kW}}{\text{ton}} = 2.27 \]
\[ \text{EER} = 5.3 \]
Single Zone Systems

- Multiple air handlers serving multiple spaces
- Each unit can heat or cool as necessary
- Chilled water or Direct expansion
- Hot water / steam boilers
- Simple controls, can make single units Variable air Volume to serve variable needs
Fan coil /heat pump

- Generally a compilation of smaller systems
- Can be chiller or boiler driven
- Simple controls
- Outside air managed through a separate system
- Fan coils require 4 pipes for simultaneous heating and cooling
- Heat pumps can accommodate 1 pipe for heating and cooling
Variable Refrigerant Flow

- Refrigerant based fan coil system
- Newer technology from the Pacific rim
- Needs separate outside air system
- Complicated refrigerant management controls
- 25 tons maximum sizing per system
- Refrigerant safety concerns
Ground Source

- Best thought of as a heating or cooling source
- Is a method to recycle energy from the summer to the winter and winter to summer
- House Bill 4850 may designate as a renewable sustainable resource
- Is designed based on campus energy needs
- Is best delivered with high efficiency mechanical systems
Geoexchange Renewable Energy Concept

1 kW electricity

3-4 kW of Geothermal Energy moved from the Earth

4-5 kW Heat Delivered
Buildings in the Midwest are heating dominated.

- Heat pumps dump 50% more energy (per delivered ton) during cooling than is removed for heating.
- Occupied buildings need cooling to temperatures for 30-40°F. (<25% of the total hours are below these conditions)

ARE THEY?
Building Energy Profile

Heat Rejection VS Bldg load

Chart Area

- HVAC Energy
- HK Loading

KBTU

TOA (F)
One Pipe Loop

distributed primary secondary loop

Attributes
- Demand Fluid Control
- Secondary pump flow control
- Little loop temp control
- Unit by unit diversity
- No flow regulators
- Low system pump head
- Primary pump can be sized for BLOCK load CONDITIONS
- No drive/pump/static control head inefficiency

Challenges
- Temperature control
- Pipe Length/ pressure loss
- Last Heat pump will have warmer/cooler water
Heat Recovery
Anyone????

Attribute
One pipe loop allows heat pumps to recover energy from the other units on the system.

Cooling units add heat to the loop, heating units extract heat…

It doesn’t take VRF to have heat recovery.
The Lake Land Concept

Central Loop system
1. Take advantage of Building diversification
2. Loop pumps, back up heat and cooling located in power house
Design Considerations

- Major Advantage to central systems: Diversity
- Effective use of Ground Coupling
- Pumping efficiency
- Utility flexibility
  - Central pumping or diversified
  - Central heat rejection/addition or diversified
- Heating and cooling generation efficiency
  - COP and EER considerations
- Heating and cooling delivery efficiency
Main loop suitable for:
10" Pipe (2000 gpm 800 tons)
12" pipe (3500 gpm 1450 tons)
Lake Land Loop Diagram
West Field Extension
Central Systems

■ Building central systems
  ■ Adaptable to “conventional systems”
    ■ Chilled Beams
    ■ Fan coils/ Unit Ventilators
    ■ VAV (Delivery efficiency is a concern here)
    ■ Single Zone
  ■ Centralized maintenance

■ Campus central systems
  ■ Campus wide diversity
  ■ Utility utilization
Central system issues

- System EER and COP
  - Affected by temperatures, system delivery efficiency and pumping
- Chilled water delivery
  - 40-45 F water (EER)
  - Additional heat transfer surface
- Hot water delivery
  - Remember the 2\textsuperscript{nd} law of thermodynamics (COP)
  - 120F water (refrigeration limitation)
  - Line loss significance
  - Cascade refrigeration (180F)
  - Additional heat transfer
- Pumping
  - Major component of system efficiency
Lake Land Community College System Diagram

Main loop suitable for:
10” Pipe (2000 gpm 800 tons)
12” pipe (3500 gpm 1450 tons)
Systems Supported at Lake Land

- Distributed heat pumps
- VAV with Terminal Reheat
- 4 Pipe fan coils
- Chilled Beam with dedicated outside air delivery
  - Outside air Delivered to space
  - Individual space heating and cooling
  - Humidity controlled by OA
## Electric Use in Buildings

<table>
<thead>
<tr>
<th>Buildings</th>
<th>Original W/ft(^2)</th>
<th>After Renovation W/ft(^2)</th>
<th>% Change</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Northwest</td>
<td>2.81</td>
<td>2.20</td>
<td>-21.7%</td>
<td>Added dental to building usage</td>
</tr>
<tr>
<td>Field House</td>
<td>2.91</td>
<td>2.25</td>
<td>-22.6%</td>
<td>Added 10,000 ft(^2)</td>
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<tr>
<td>V0-Tech</td>
<td>5.50 (est.)</td>
<td>5.06</td>
<td>-8%</td>
<td></td>
</tr>
<tr>
<td>West Building</td>
<td>4.80</td>
<td>2.80</td>
<td>-41.6%</td>
<td>Added 57,364 ft(^2)</td>
</tr>
</tbody>
</table>
Considerations

1. Heating is proportionally delivered from central plant
2. Cooling is proportionally delivered from the central plant
3. 2011 Energy usage is metered at the building
4. Central plant will come offline in 2013
System Funding

- **DCEO Energy Efficiency** funding for those in Com Ed or Ameren service areas

- **ICECF Funding** for
  - Innovative HVAC systems
  - 1/3 of Ground source differential cost (90K cap)

- **Third party financing**
  - Leasing of Ground Loops
    - Advanced depreciation
    - 10% tax credit
Questions