What are the unique challenges for HVAC in schools?

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Smart Schools Symposium

Mark Modera, WCEC-UC Davis
“MISSION: Partner with stakeholders to identify technologies, conduct research and demonstrations, disseminate information, and implement programs that reduce cooling-system electrical demand and energy consumption in the Western United States.”

MORE THAN JUST COOLING
11 Staff Engineers
1 Behavioral Scientist
2 Support Staff
6 Grad Students
Multiple Undergrad Students
Presentation

- Heating and Cooling
  - Energy Use and Equipment Types
  - Occupancy patterns and loads
- Ventilation
  - IAQ dominated by occupancy?
  - Particular sensitivity to IAQ
- Potential Energy Savings Technologies
  - Maintenance reduction and energy savings
  - Controls
  - RTU Efficiency Improvements - DOAS
Energy Use in U.S. Schools

Energy bill = 2-5% of operating cost

U.S. Average: 10 kWh/ft² and 0.5 therms/ft²
or $1.5/ft² and $0.5/ft² at $0.15/kWh and $1/therm
or $0.41 HVAC electric and $0.495 HVAC gas
## Equipment Distribution in K-12 Schools

<table>
<thead>
<tr>
<th>Equipment Type</th>
<th>Characteristic</th>
<th>Installed Base</th>
</tr>
</thead>
<tbody>
<tr>
<td>Packaged DX unit</td>
<td>Single zone</td>
<td>60 to 65%</td>
</tr>
<tr>
<td>Packaged DX unit</td>
<td>Multiple zone</td>
<td>5%</td>
</tr>
<tr>
<td>Split System</td>
<td>Single zone</td>
<td>10 to 15%</td>
</tr>
<tr>
<td>Bard</td>
<td>Single zone</td>
<td>10%</td>
</tr>
<tr>
<td>Unit Ventilator/fan–coil</td>
<td>Central plant</td>
<td>10%</td>
</tr>
<tr>
<td>Split System</td>
<td>Variable Ref Flow</td>
<td>~1%</td>
</tr>
</tbody>
</table>

Data courtesy of Resource Solutions Group and Trane
HVAC Equipment in CA K-12

- **Typical Sizing** *(Tim Sisson)*
  - 1 cfm/ft²  350 cfm/ton
  - 350 ft² per ton (similar to light commercial)

- **Prefer one 4-ton RTU per classroom** *(Tim Sisson)*
  - many small units
    - Again similar to light commercial
    - Simultaneous retrofit could prove economical
HVAC Equipment in CA K-12

- Heating considered less important than cooling?
  - US data suggests comparable costs for electricity and gas
  - Higher electricity energy versus gas energy cost
  - CA schools starting earlier in the year – 2\textsuperscript{nd} week of August
  - California should have less heating relative to US average

- Schools afraid of increased maintenance costs?
  - Recent state funding rules for maintenance
  - Makes water a tough sell in some instances
  - But schools do tend to have maintenance personnel
Ventilation in K-12

- High but variable occupancy
  - Large ventilation needs and loads
  - Good applications for demand controlled ventilation
    - Multi-purpose rooms, gyms, assembly areas
  - CO$_2$ a good surrogate for IAQ?

- Large internal gains – sensible and latent
  - Larger cooling needs than you would think based upon seasonality

- Natural Ventilation
  - Apparently only used on Peninsula and North Coast
  - Currently being eliminated in San Diego
Ventilation in K-12

- Higher Ventilation - IAQ vs. Energy
  - Recent LBNL study in 150 classrooms suggests 3.4% reduction in absences due to better ventilation
  - Analysis suggests increases in energy use more than compensated by reductions in absences (increased state funds) and reduced medical and missed-work costs
Potentially Relevant WCEC Research

• RTUs
  ◦ Multi-Tenant Light Commercial retrofit technologies
    ◦ Evaporative pre-coolers
    ◦ Fan power reduction
    ◦ Downsized compressors
RTU Retrofit Opportunities

1. Advanced Economizer Controls
2. Demand Control Ventilation
3. Downsizing Fan Motors
4. Variable Speed Drive and Controller for Evaporator Fan
5. Fault detection and diagnostics
6. Evaporative Pre–coolers
7. Variable Speed Drive and Controller for Compressor
8. Downsize Compressor
9. “Smart” web–connected Thermostat
Potentially Relevant WCEC Research

- **RTUs**
  - **Fault Detection and Diagnosis**
    - Reduce maintenance and increase efficiency
    - Economizers that work
  - **Cloud Based Control**
    - Reduce maintenance and increase efficiency
    - Not just HVAC
Potentially Relevant WCEC Research

• Ventilation and Envelopes
  ◦ Dedicated Outdoor Air Systems (DOAS)
  ◦ Indirect evaporative
  ◦ Envelope Leakage Reduction
Potentially Relevant WCEC Research

- **Thermal Storage**
  - Combined with Dewpoint fluid cooling?
  - More extensive retrofit

- **Split Systems**
  - Evaporative Condensers