Up On the Roof

Recent advances in rooftop unit controls

Jay Stein
Executive Vice President, E Source

Cooling Efficiency Workshop
What’s So Special About This RTU?

Source: Trane
Single-Zone Constant Volume (CV)

- One zone
- Fixed fan speed
- Fan either on or off
Multizone Variable Air Volume (VAV)

- Multiple zones
- Variable fan speed
- Fan speed based on duct pressure
Combine the Two …
Single-Zone Variable Air Volume (SZVAV)

- One zone
- Variable fan speed
- Fan speed based on $\Delta T$ between setting and actual room temperature
- Low speed when neither heating nor cooling is called for
Advantages of SZVAV

Reduces energy consumption
  - SEER boost 2.5 points
  - At least 20% energy savings

Helps compensate for oversizing

Improves dehumidification

Reduces fan noise

Reduces complexity

Courtesy: Clker.com
Additional Features

- Integrated economizer
- Demand-controlled ventilation
- Variable-speed compressor

Courtesy: Clker.com
Where Can You Get a SZVAV?

Aaon
Carrier
  ▪ Centurion
Daikin/McQuay
  ▪ Rebel
Lennox
  ▪ MSAV
Trane
  ▪ Precedent Plus
York

Courtesy: Daikin/McQuay
Source: Lennox
Size Matters

Where to use SZVAV:
Single zone units
7.5 tons or larger
  - Occasionally cost-effective as low as 5 tons
Long run hours
  - 24/7 the best
  - Office hours (M-F, 9-5) are on the bubble
Oversized
  - The more excess capacity, the greater the savings
Coming Soon to a Building Code Near You

Effective dates for SZVAV required by California Title 24 for DX cooling equipment

Cooling Capacity (Btu/hr) vs. Year

- 2011 to 2017
- 0 to 120,000 Btu/hr
What About All Those Existing Units?
RTU Variable-Frequency Drive Retrofit Devices

- Catalyst
  - Transformative Wave Technologies

- Enerfit
  - Enerfit LLC

- Digi-RTU Optimizer
  - Bes-Tech (DTL Controls)
## Different Strokes for Different Folks

<table>
<thead>
<tr>
<th>Product</th>
<th>VFD evaporator fan</th>
<th>VFD compressor</th>
<th>VFD type</th>
<th>Damper for coil 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Catalyst</td>
<td>✓</td>
<td></td>
<td>Indexed</td>
<td></td>
</tr>
<tr>
<td>Enerfit</td>
<td>✓</td>
<td></td>
<td>Continuous</td>
<td>✓</td>
</tr>
<tr>
<td>Digi-RTU</td>
<td>✓</td>
<td>✓</td>
<td>Continuous</td>
<td></td>
</tr>
</tbody>
</table>

Note: VFD = variable-frequency drive.
All Provide Additional Features

- Demand-controlled ventilation
- Integrated economizer control
- Web control and monitoring
- Fault detection and diagnostics
They’re Not Modest

<table>
<thead>
<tr>
<th>Product</th>
<th>Annual HVAC energy savings</th>
<th>Simple payback period</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Catalyst</td>
<td>25–40%</td>
<td>2 years</td>
<td>$4,000 (15-ton)</td>
</tr>
<tr>
<td>Enerfit</td>
<td>50–70%</td>
<td>1–3 years</td>
<td>$4,700 (20-ton)</td>
</tr>
<tr>
<td>Digi-RTU</td>
<td>50%</td>
<td>1–4 years</td>
<td>$600 per ton</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>$12,000 (20-ton)</td>
</tr>
</tbody>
</table>
Finally, from PNNL, a Definitive Study

- Number of rooftop units tested: 66
- Building types: mercantile, office, food sales, healthcare
- Savings varied widely: 22% to 90%
- Average savings: 55%
- Average simple payback period: 3 years

Source: Pacific Northwest National Laboratory
In Addition to Energy Efficiency

Courtesy: Transformative Wave Technologies
Fault Detection and Diagnostics

Unit03
Health Status

- Drive Communication
- Drive Fault
- Fan Run
- Fan Belt
- Heating Fail
- Cooling Fail
- Damper Fail
- Space Sensor
- Supply Sensor
- Return Sensor
- OSA Sensor
- CO2 Sensor
- Service Off

Courtesy: Transformative Wave Technologies
# System Monitoring

**Scottsdale**  
7111 E. Mayo Blvd.

<table>
<thead>
<tr>
<th>Unit Name</th>
<th>Serves</th>
<th>Comm Mode</th>
<th>Health Occ</th>
<th>Fan Call</th>
<th>Comfort Status</th>
<th>Space Temp</th>
<th>Actual Heat S/P</th>
<th>Actual Cool S/P</th>
<th>Fan Status</th>
<th>Fan Speed</th>
<th>Fan Power</th>
<th>Cooling 1</th>
<th>Cooling 2</th>
<th>Heating 1</th>
<th>Heating 2</th>
<th>Supply</th>
<th>Return</th>
<th>OSA</th>
<th>CO2</th>
<th>OSA Volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit01 Sales Seafood</td>
<td>Food Prep</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>71.6 °F</td>
<td>70 °F</td>
<td>73 °F</td>
<td>40 %</td>
<td>0.34 kW</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>80.3 °F</td>
<td>77.5 °F</td>
<td>87.9 °F</td>
</tr>
<tr>
<td>Unit02 Main Sales Ctr</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>72.3 °F</td>
<td>70 °F</td>
<td>73 °F</td>
<td>40 %</td>
<td>0.33 kW</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>80.7 °F</td>
<td>77.8 °F</td>
<td>88.7 °F</td>
</tr>
<tr>
<td>Unit03 Sales Tapes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>72.8 °F</td>
<td>70 °F</td>
<td>73 °F</td>
<td>40 %</td>
<td>0.36 kW</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>79.7 °F</td>
<td>76.7 °F</td>
<td>88.0 °F</td>
</tr>
<tr>
<td>Unit04 Loading Dock</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>70.3 °F</td>
<td>68 °F</td>
<td>71 °F</td>
<td>90 %</td>
<td>1.80 kW</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>53.0 °F</td>
<td>72.1 °F</td>
<td>84.2 °F</td>
</tr>
<tr>
<td>Unit05 Food Prep</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>71.0 °F</td>
<td>68 °F</td>
<td>71 °F</td>
<td>40 %</td>
<td>0.13 kW</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>82.7 °F</td>
<td>77.8 °F</td>
<td>82.7 °F</td>
</tr>
<tr>
<td>Unit06 Checkstands</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>70.6 °F</td>
<td>68 °F</td>
<td>73 °F</td>
<td>40 %</td>
<td>0.14 kW</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>82.8 °F</td>
<td>78.1 °F</td>
<td>80.3 °F</td>
</tr>
<tr>
<td>Unit07 Bakery</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>71.5 °F</td>
<td>68 °F</td>
<td>71 °F</td>
<td>40 %</td>
<td>0.14 kW</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>81.4 °F</td>
<td>77.6 °F</td>
<td>80.6 °F</td>
</tr>
<tr>
<td>Unit08 Vestibule</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>74.0 °F</td>
<td>68 °F</td>
<td>71 °F</td>
<td>90 %</td>
<td>0.84 kW</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>45.2 °F</td>
<td>74.0 °F</td>
<td>82.4 °F</td>
</tr>
<tr>
<td>Unit09 Produce</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>72.3 °F</td>
<td>68 °F</td>
<td>71 °F</td>
<td>90 %</td>
<td>0.46 kW</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>46.3 °F</td>
<td>76.8 °F</td>
<td>47.6 °F</td>
</tr>
</tbody>
</table>

**Site Data**

- **OSA Humidity**: 20.5 %RH  
- **OSA Dewpoint**: 39.4 °F  
- **Space Static**: 0.02 in/wc

<table>
<thead>
<tr>
<th></th>
<th>Space Humidity Setpoint</th>
<th>Dehumidification Cool</th>
<th>Dehumidification Reheat</th>
<th>Dehumidification Supply</th>
<th>Dehumidification Fan Speed</th>
<th>Space Dewpoint</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit01</td>
<td>31.3 %RH</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>39.7 °F</td>
</tr>
<tr>
<td>Unit02</td>
<td>28.8 %RH</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>38.1 °F</td>
</tr>
<tr>
<td>Unit03</td>
<td>35.7 %RH</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>44.7 °F</td>
</tr>
<tr>
<td>Unit04</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unit05</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unit06</td>
<td>34.4 %RH</td>
<td></td>
<td></td>
<td></td>
<td>55.0 °F</td>
<td>41.3 °F</td>
</tr>
<tr>
<td>Unit07</td>
<td>34.9 %RH</td>
<td></td>
<td></td>
<td></td>
<td>55.0 °F</td>
<td>42.5 °F</td>
</tr>
<tr>
<td>Unit08</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unit09</td>
<td>32.7 %RH</td>
<td></td>
<td></td>
<td></td>
<td>55.0 °F</td>
<td>41.4 °F</td>
</tr>
</tbody>
</table>

Courtesy: Transformative Wave Technologies
For More Information

Jay Stein
Executive Vice President, E Source
303-345-9131
jay_stein@esource.com

Have a question? Ask our experts: www.esource.com/question