Findings from a Indirect/Direct Evaporative Cooling (IDEC) RTU Field Test

Mark Lyles
Project Analyst

Dan Harris, PE
Senior Project Manager
RTUs in Commercial Buildings

Packaged air conditioners and heat pumps (RTUs) are used in approximately 46% of commercial buildings, serving about 60% of the commercial floor space. (EIA 2003)
CBSA Data: Building Average Cooling Tons per Pack HVAC Unit
(Systems <50 Tons Cooling per HVAC unit) n=1041
Overview of NBI’s Evaporative RTU Work

• 2007: Proof-of-concept, 5-ton Desert Aire Indirect/Dx hybrid, multiple sites NW/CA
• Commercialized as the Coolerado H80
• 2010: Speakman 5-ton Indirect Direct (IDEC)/Dx hybrid; 2 Idaho sites

• 2012: AirMax 5-ton IDEC add-on; 1 Idaho site

• 2013: Next generation unit testing
Background

• Supported by Northwest Energy Efficiency Alliance (NEEA)
• Partnered with the Integrated Design Lab at the University of Idaho, Boise
Equipment Overview

- AirMax Indirect/Direct evap RTU-Idaho
  - 3 gen unit (2\textsuperscript{nd} gen IDEC/Dx hybrid)
  - Add-on to existing 5 ton RTU

- IDEC/RTU interface fabricated in the field
Four modes of operation:
1. Economizer
2. Direct
3. IDEC
4. DX mode
RTU vs. RTU/IDEC

Second Two Weeks of August

First Two Weeks of August

RTU + IDEC cooling

RTU only cooling

= total max

= total power

new buildings institute
IDEC Cycles

- No compressor energy
- Dampers open
- Indirect/direct mode at 2 kW
- Drying mode at 1.5 kW
- Direct mode at 1.2 kW
Ideal Operation

- IDEC goes off
- RTU comes on at second stage
- Dampers go from open to closed
- SAT and RAT behave as expected
Performance

EER vs Temperature

- EER
- Outside Air Temperature, deg F
- Indirect/direct
- Direct
- Direct model
- Indirect/direct model
Savings Potential

Compressor/Evaporative Mode Comparison

- Aug 1-14 (Compressor Mode)
- Aug 15-30 (Evap. Mode)

Temperature, DegF vs. kWh/day
Summary

<table>
<thead>
<tr>
<th>Equipment</th>
<th>RTU</th>
<th>IDEC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electric Energy (kWh)</td>
<td>6,475</td>
<td>2,849</td>
</tr>
<tr>
<td>Electric Demand (kW)</td>
<td>5.5</td>
<td>2.2</td>
</tr>
</tbody>
</table>

- Savings projections: energy @ 56% (3,600 kWh/yr) – additional savings achievable with refinement of control settings
- Demand @ 65% (3.6 kW)
## Other Cities: IDEC Savings

<table>
<thead>
<tr>
<th>City Name</th>
<th>Energy Savings</th>
<th>Demand Savings</th>
<th>Evap Direct Cooling</th>
<th>Evap Indirect/Direct</th>
<th>Total Evap Cooling</th>
<th>Dx AC</th>
<th>Non-Economizer Cooling</th>
<th>Water Consumption</th>
<th>Avg Gal/Ton/Hr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phoenix, AZ</td>
<td>51%</td>
<td>59%</td>
<td>2905</td>
<td>1674</td>
<td>4579</td>
<td>1184</td>
<td>5763</td>
<td>1.18</td>
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<tr>
<td>Las Vegas, NV</td>
<td>62%</td>
<td>65%</td>
<td>3052</td>
<td>1276</td>
<td>4328</td>
<td>223</td>
<td>4551</td>
<td>1.33</td>
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<td>Fresno, CA</td>
<td>57%</td>
<td>53%</td>
<td>1970</td>
<td>1560</td>
<td>3530</td>
<td>347</td>
<td>3877</td>
<td>1.10</td>
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<td>Albuquerque, NM</td>
<td>67%</td>
<td>64%</td>
<td>2493</td>
<td>514</td>
<td>3007</td>
<td>13</td>
<td>3020</td>
<td>1.15</td>
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<td>Salt Lake City, UT</td>
<td>55%</td>
<td>48%</td>
<td>2119</td>
<td>378</td>
<td>2497</td>
<td>2</td>
<td>2499</td>
<td>0.60</td>
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<tr>
<td>Lubbock, TX</td>
<td>42%</td>
<td>52%</td>
<td>1499</td>
<td>972</td>
<td>2471</td>
<td>1295</td>
<td>3766</td>
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<tr>
<td>Denver, CO</td>
<td>68%</td>
<td>64%</td>
<td>2080</td>
<td>208</td>
<td>2288</td>
<td>18</td>
<td>2306</td>
<td>1.13</td>
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<tr>
<td>San Diego, CA (EL Toro Inland)</td>
<td>48%</td>
<td>49%</td>
<td>1393</td>
<td>661</td>
<td>2054</td>
<td>703</td>
<td>2757</td>
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<td>Boise, ID</td>
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<td>73%</td>
<td>1773</td>
<td>268</td>
<td>2041</td>
<td>1</td>
<td>2042</td>
<td>1.05</td>
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<td>Los Angeles, CA</td>
<td>47%</td>
<td>40%</td>
<td>1333</td>
<td>702</td>
<td>2035</td>
<td>727</td>
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<td>Oklahoma City, OK</td>
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<td>36%</td>
<td>783</td>
<td>500</td>
<td>1283</td>
<td>2397</td>
<td>3680</td>
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<tr>
<td>Atlanta, GA</td>
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<td>28%</td>
<td>807</td>
<td>467</td>
<td>1274</td>
<td>2793</td>
<td>4067</td>
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<td>New York City, NY</td>
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<td>26%</td>
<td>729</td>
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<td>1725</td>
<td>2871</td>
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<td>Chicago, IL</td>
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<td>33%</td>
<td>696</td>
<td>445</td>
<td>1141</td>
<td>1201</td>
<td>2342</td>
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<tr>
<td>Charlotte, NC</td>
<td>15%</td>
<td>23%</td>
<td>785</td>
<td>276</td>
<td>1061</td>
<td>2768</td>
<td>3829</td>
<td>0.23</td>
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<tr>
<td>Austin, TX</td>
<td>14%</td>
<td>20%</td>
<td>653</td>
<td>393</td>
<td>1046</td>
<td>4252</td>
<td>5298</td>
<td>0.23</td>
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<tr>
<td>Seattle, WA</td>
<td>63%</td>
<td>59%</td>
<td>824</td>
<td>205</td>
<td>1029</td>
<td>5</td>
<td>1034</td>
<td>0.68</td>
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<tr>
<td>Boston, MA</td>
<td>29%</td>
<td>31%</td>
<td>667</td>
<td>349</td>
<td>1016</td>
<td>1166</td>
<td>2182</td>
<td>0.39</td>
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<tr>
<td>Indianapolis, IN</td>
<td>18%</td>
<td>34%</td>
<td>692</td>
<td>303</td>
<td>995</td>
<td>1824</td>
<td>2819</td>
<td>0.27</td>
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<tr>
<td>Madison, WI</td>
<td>25%</td>
<td>30%</td>
<td>632</td>
<td>339</td>
<td>971</td>
<td>1005</td>
<td>1976</td>
<td>0.32</td>
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<tr>
<td>San Francisco, CA</td>
<td>66%</td>
<td>52%</td>
<td>858</td>
<td>111</td>
<td>969</td>
<td>16</td>
<td>985</td>
<td>0.58</td>
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<tr>
<td>San Antonio, TX</td>
<td>12%</td>
<td>23%</td>
<td>675</td>
<td>284</td>
<td>959</td>
<td>4621</td>
<td>5580</td>
<td>0.21</td>
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<tr>
<td>Washington, DC</td>
<td>19%</td>
<td>33%</td>
<td>601</td>
<td>326</td>
<td>927</td>
<td>2099</td>
<td>3026</td>
<td>0.29</td>
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</tr>
<tr>
<td>Kansas City, KS</td>
<td>11%</td>
<td>28%</td>
<td>543</td>
<td>243</td>
<td>783</td>
<td>2514</td>
<td>3297</td>
<td>0.17</td>
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<tr>
<td>Omaha, NE</td>
<td>12%</td>
<td>31%</td>
<td>456</td>
<td>252</td>
<td>708</td>
<td>2216</td>
<td>2924</td>
<td>0.20</td>
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</tbody>
</table>
What About Water Use?

Idaho Power
Water Usage

- Direct mode water-use efficiency = 95%
- IDEC mode water – use efficiency = 30%
Water Usage

- Estimated Water Use for Cooling Season (May – October): 7,400 gallons
Water Usage

Table 2. Total Consumptive Use of Water for U.S. Power Plants

<table>
<thead>
<tr>
<th>Power Provider</th>
<th>Gallons Evaporated per kWh at Thermoelectric Plants</th>
<th>Gallons Evaporated per kWh at Hydroelectric Plants</th>
<th>Weighted Gallons Evaporated per kWh of Site Energy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Western Interconnect</td>
<td>0.38 (1.4 L)</td>
<td>12.4 (47.0 L)</td>
<td>4.42 (16.7 L)</td>
</tr>
<tr>
<td>Eastern Interconnect</td>
<td>0.49 (1.9 L)</td>
<td>55.1 (208.5 L)</td>
<td>2.33 (8.8 L)</td>
</tr>
<tr>
<td>Texas Interconnect</td>
<td>0.44 (1.7 L)</td>
<td>0.0 (0.0 L)</td>
<td>0.43 (1.6 L)</td>
</tr>
<tr>
<td>U.S. Aggregate</td>
<td>0.47 (1.8 L)</td>
<td>18.0 (68.0 L)</td>
<td>2.00 (7.6 L)</td>
</tr>
</tbody>
</table>

Source: Consumptive Water Use for US Power Production (NREL 2003)

- Water use associated with RTU only energy use = 28,600 gallons
- Water use associated with RTU/IDEC energy use PLUS direct water use by IDEC = 20,000 gallons
Recommendations

• Next generation IDEC needs to better consider the physical interface with the RTU
• Reduce use of IDEC mode when temps below 90 degF
• Reduce fan use during unoccupied times
• Incorporate water-use signature into RTF protocol
Next Generation IDEC Unit Features

- Water pump downsized 580w ↓ 380w
- Single speed motor to 3-speed
- Blower wheel depth change/w backward curve
- All LCD control board
- True 3-stage: economizer, direct, IDEC
- Improved purge control
- Redesign for 100% coil/pump drain down
- Control board fully integrated
Two evaporative units installed at the NBI Laboratory and Boise, ID:

- Next-gen AIR$\textsubscript{2}$O
- Coolerado M50
Two different approaches

HOW DOES IT WORK?

1. FRESH AIR: Outside air is drawn into the air conditioner by a fan.
2. FILTERED: The air is then cleaned by an array of air filters.
3. HEAT AND MASS EXCHANGE: The air enters an array of HMXs that use a new patented technology.
4. WORKING AIR AND WATER: About half of the air that enters the HMX is saturated with water and returns to the atmosphere, carrying heat energy removed from the conditioned air.
5. CONDITIONED AIR: The other half of the air that enters the HMX is cooled without adding humidity.

1. Centrifugal Fan
2. Control Box
3. Indirect Heat Exchanger
4. Top Cover
5. Direct Media
6. Indirect Media
7. Axial Fan (single Fan only for CRS2500, CRS500)
8. Water Sump
9. Indirect Water Pump
2013 Cooling Season Field Testing

Research Goals:

• Compare and analyze units in expanded climates
  – Eastern WA/OR
  – Western WA/OR

• Answer physical integration and controls questions from 2012

• Develop water usage model
Thanks!

Questions?

markl@newbuildings.org
www.newbuildings.org