Cooling Tower Water Management Best Practices

- Introductions
- Cooling tower water treatment overview
- Alternative water treatment field test results
  - Alternative chemical treatments
  - Water softeners
  - Advanced oxidation process
  - Electrolysis
- Discussion
HVAC Research Team Call

- September 6, 2018 1-2 ET
- Field Test Results of New HVAC Technologies
  - High performance circulator pumps
  - Air scrubber technology that removes CO₂ and VOCs
  - high-performance variable speed screw chillers
- Registration at
  [https://attendee.gotowebinar.com/register/775157188383295745](https://attendee.gotowebinar.com/register/775157188383295745)
Cooling Tower Basics

- Evaporation removes about 1,000 Btu/lb of water
- Evaporation rate ~ 1.8 gal/ton-hr (varies with conditions and load)
- Evaporation leads to concentration of minerals and chemicals
- Control scale, corrosion, and biological growth with water treatment (usually chemicals) and blowdown

Credit: Michael Deru, NREL
Balancing Cooling Tower Water Quality

**Scale**
**Bad:** Reduce heat transfer, plug orifices, sites for corrosion or bacteria growth
**Good:** Small amounts can reduce corrosion
**Control:** Scale inhibitors, remove minerals, balanced chemistry, blowdown

**Corrosion**
**Bad:** Corrosion, sites for biological growth
**Good:** None
**Control:** Corrosion inhibitors, balanced chemistry

**Biological Growth**
**Bad:** Potential health hazard, reduce heat transfer, plug orifices, biocorrosion, sites for corrosion or scale
**Good:** None
**Control:** Biocides, balanced chemistry, reduce light, blowdown

Challenging to maintain balanced water chemistry
Cooling Tower Cycles of Concentration

- Cycle of Concentration (CoC) – Ratio of concentration in dissolved solids blowdown vs makeup water
- Typical CoC – 2.5 to 7
- At a CoC of 3, around 33% of cooling tower water make up is wasted as blowdown

Realize lion's share of savings from CoC of 3 to CoC of 10, savings level off after CoC of 15
Corrosion vs. Scale

- Analyzed 2-15 years of data from 8 CTs
- Most CTs maintained in a moderate to high scale condition
- Ryznar and Langelier Saturation indices predict the balance between scale and corrosion potentials
Genetic Biological Sampling

- Tested 9 towers in Denver CO area
- Significant growth in 8 towers
- No negative health concerns
- No Legionella!
- Bio-corrosion bacteria in 7 towers

<table>
<thead>
<tr>
<th>Unique Bacteria Genus</th>
<th>Sites Containing Genus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acinetobacter</td>
<td>2</td>
</tr>
<tr>
<td>Aeromonas</td>
<td>4</td>
</tr>
<tr>
<td>Alishewanella</td>
<td>1</td>
</tr>
<tr>
<td>Arthrobacter</td>
<td>2</td>
</tr>
<tr>
<td><strong>Bacillus</strong></td>
<td><strong>4</strong></td>
</tr>
<tr>
<td>Chryseobacgerium</td>
<td>3</td>
</tr>
<tr>
<td>Delfia</td>
<td>1</td>
</tr>
<tr>
<td><strong>Flavobacterium</strong></td>
<td><strong>2</strong></td>
</tr>
<tr>
<td>Halomonas</td>
<td>1</td>
</tr>
<tr>
<td><strong>Pseudomonas</strong></td>
<td><strong>7</strong></td>
</tr>
<tr>
<td>Rheinheimera</td>
<td>3</td>
</tr>
<tr>
<td>Shewanella</td>
<td>3</td>
</tr>
<tr>
<td>Stenotrophomonas</td>
<td>2</td>
</tr>
</tbody>
</table>
Technology Testing Programs

- **Department of Energy**: [High Impact Technology (HIT) Catalyst](#)  
  - 14 technology tests available with several more coming

- **General Services Administration**: [GSA Proving Grounds (GPG)](#)  
  - 34 reports, 23 technologies, 14 technologies deployed

- **Department of Defense**: [Environmental Security Technology Certification Program (ESTCP)](#)  
  - Many technologies
Emerging Technology Framework

Leading by example
GPG accelerates market acceptance by assessing innovative building technologies in real world environments and deploying those that deliver

GSA Green Proving Ground Objectives

Identify promising technologies at the edge of commercialization

Pilot technology installations within GSA’s real estate portfolio

Partner with Department of Energy national laboratories to objectively evaluate real-world performance

Recommend technologies with broad deployment potential for GSA

Communicating M&V Outcomes from GSA Test Beds

Technical report

4-page Findings

Infographic

Webinar Series

# Technologies Tested by GPG with Published Results

## Building Envelope
- High-R Window Panel Retrofits
- Thermochromic & Electrochromic Windows
- Vacuum Insulated Panels for Roofing
- Solar Control Films
- Electrochromic (EC) Windows for LPOEs
- EC Windows with Dynamic Controls for General Office Space
- Low-e Window Films

## HVAC
- Condensing Boilers
- Variable Refrigerant Flow
- Variable-Speed Maglev Chiller
- Synchronous & Cogged Fan Belts
- Multi-staged Indirect Evaporative Cooler
- Variable-speed Direct-drive Screw Chiller

## Lighting
- Occupant Responsive Lighting
- Integrated Daylighting Systems
- Wireless Advanced Lighting Controls
- LED Fixtures with Integrated Controls
- LED Downlight Lamps for CFL Fixtures
- Linear LED Lighting Retrofits

## Energy Management
- Wireless Sensor Networks
- Advanced Power Strips
- Wireless Control Optimization System for Chiller Plants
- Socially Driven HVAC Optimization

## Water
- Weather Station for Irrigation Control
- Wireless Soil Moisture Sensors for Irrigation Control
- Non-Chemical Prevention of Hard Water Scale

## On-Site Renewables
- Photovoltaics
- PV Guidance
- Photovoltaic-Thermal System
- Wood-Pellet-Fired Biomass Boiler
- Honeycomb Solar Thermal Collector

## Building Envelope
- HVAC
- Lighting
- Energy Management
- Water
- On-Site Renewables

### Notes
- Broad Deployment Potential for GSA
General AWT M&V Framework

**Typical M&V Points**
- Condenser water supply and return temperatures (°F)
- Condenser water pump status (ON/OFF)
- Cooling tower fan status (ON/OFF)
- Chiller water supply and return temperatures (°F)
- Chiller status (ON/OFF)
- Outdoor air temperature (°F) and humidity (%)
- Cooling Tower Make Up Water meter (Gal)
- Blowdown Water Meter (Gal)
- Chiller Plant Electrical Meter (kWh)

**Primary Objective:** Measure cooling tower water savings measured in gal/ton-hr

Conceptual model of the AWTs (Credit: Joelynn Schroeder, NREL)
Water quality was tracked on a monthly basis to ensure compliance with GSA Acceptable Ranges.

Additional biological testing was conducted by NREL.

<table>
<thead>
<tr>
<th>Test</th>
<th>Acceptable Ranges</th>
</tr>
</thead>
<tbody>
<tr>
<td>T alkalinity (ppm)</td>
<td>100 - 1000</td>
</tr>
<tr>
<td>pH</td>
<td>7.3 – 9.0</td>
</tr>
<tr>
<td>Chloride (ppm)</td>
<td>10 - 500</td>
</tr>
<tr>
<td>Cycles</td>
<td>&gt;2</td>
</tr>
<tr>
<td>Total Hardness (ppm)</td>
<td>500 - 1500</td>
</tr>
<tr>
<td>Phosphate (ppm)</td>
<td>43327</td>
</tr>
<tr>
<td>Conductivity (mmHos)</td>
<td>&lt;2400</td>
</tr>
<tr>
<td>Bacteria Count (cfu)</td>
<td>&lt;80000</td>
</tr>
<tr>
<td>Water Appearance</td>
<td>Clear</td>
</tr>
<tr>
<td>Iron (ppm)</td>
<td>&lt;4</td>
</tr>
<tr>
<td>Calcium Hardness (ppm)</td>
<td>&lt;500</td>
</tr>
<tr>
<td>Magnesium Hardness (ppm)</td>
<td>&lt;100</td>
</tr>
<tr>
<td>Chlorides (ppm)</td>
<td>&lt;250</td>
</tr>
<tr>
<td>Salt (ppm)</td>
<td>&lt;410</td>
</tr>
<tr>
<td>Sulfates (ppm)</td>
<td>&lt;250</td>
</tr>
<tr>
<td>Silica (ppm)</td>
<td>&lt;150</td>
</tr>
<tr>
<td>ORP (mV)</td>
<td>&gt;300</td>
</tr>
<tr>
<td>90-day Copper Coupon (mpy)</td>
<td>&lt;0.2</td>
</tr>
<tr>
<td>90-day Mild Steel Coupon (mpy)</td>
<td>&lt;3</td>
</tr>
<tr>
<td>90-day Galvanized Steel (mpy)</td>
<td>&lt;4</td>
</tr>
<tr>
<td>90-day Stainless Steel (mpy)</td>
<td>&lt;0.1</td>
</tr>
</tbody>
</table>
Terlyn Water Treatment

• Uses a very strong scale inhibitor, new PLC controller, side stream crushed glass media filter
• Controller set 13-18 CoC’s based on TDS
• Filter is backwashed for 30 seconds once a day, using 300 gallons/day

Manufacturer Reference: http://www.terlyn.com
AWT #1 Facility Description

Building Location
• Denver Federal Center
• Building 67

Building Facts
• 342,722 ft² Office building
• 1,200 occupants

Cooling System
• (1) 900-ton chiller, (1) 450-ton chiller
• (2) 600-ton cooling towers
• (1) flat plat heat-exchanger
AWT #1 Water Savings and Water Quality

Water Savings
• Measured CoC ranged from 13-18
• Measured 94% reduction in blowdown

Water Quality
• Realized significant reduction in scaling,
  – Increased run time of tower free cooling, 6 °F reduction in set point
• Observational improvements in water quality
• Conductivity (microsiemens): Control Range <2,400; maintained = 2,540 - 7,000 (5% - 290% outside range)
AWT #1 Economics

- Installed costs higher than normal due to Fed Gov. added factors, and side stream filtration
- O&M costs increased due to increased scaling chemical costs and side stream filtration O&M
- Local rebates would have offset ~50% of installed cost if Fed Center was not on one master water meter

<table>
<thead>
<tr>
<th>Economic Parameter</th>
<th>Building 67 (AWT #2) at Local Water Rate $7.14/kGal</th>
<th>Building 67 (AWT #2) at GSA Avg Water Rate $16.76/kGal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial Cost ($)</td>
<td>$39,900</td>
<td>$39,900</td>
</tr>
<tr>
<td>Cooling Tower Size (tons)</td>
<td>1,200</td>
<td>1,200</td>
</tr>
<tr>
<td>Water Savings (Gal/yr.)</td>
<td>824,448</td>
<td>824,448</td>
</tr>
<tr>
<td>Water and Sewer Cost Savings ($/yr.)</td>
<td>$5,887</td>
<td>$13,818</td>
</tr>
<tr>
<td>Annual Increase in O&amp;M ($/yr.)</td>
<td>$3,300</td>
<td>$3,300</td>
</tr>
<tr>
<td>Simple Payback with O&amp;M (yrs.)</td>
<td>15.4</td>
<td>3.8</td>
</tr>
<tr>
<td>Savings to Investment Ratio</td>
<td>1.3</td>
<td>5.3</td>
</tr>
</tbody>
</table>
Water Conservation Technology International

- Salt based water softening system to remove hardness
  - Polyethylene regeneration tank and brine tank
- No need for corrosion or scale inhibitor, very little biocide
- Regeneration uses 70 gallons, 2-3 times/week in summer, 1 time/week spring / fall

Manufacturer Reference: https://www.water-cti.com/technology.html
AWT #2 Facility Description

Building Location
• Denver Federal Center
• Building 25

Building Facts
• 360,797 square feet ft², office / lab building
• 425 occupants

Cooling System
• (2) 500-ton chillers
• (3) 500-ton cooling towers
• (1) flat plate heat-exchange
AWT #2 Water Savings and Water Quality

Water Savings
• Measured CoC ranged from 12-80
• Measured 99% reduction in blowdown

Water Quality
• Realized significant reduction in O&M
• Increased run time of tower free cooling
• Observational improvements in water quality
• Conductivity (microsiemens): Control range <2,400; maintained = 8,700 - 20,000 (300% - 800% outside range)
• pH value: Control range = 7.3–9.0; maintained = 9.6–10.2 (up to 13% outside range)
• “M” Alkalinity (as CaCO₃): Control range = 100–1,000 ppm; maintained = 1,680 – 3,004 (68% - 300% outside range)

<table>
<thead>
<tr>
<th>Month</th>
<th>2012</th>
<th>2013</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan</td>
<td>5,497</td>
<td>8,830</td>
</tr>
<tr>
<td>Feb</td>
<td>13,421</td>
<td>6,491</td>
</tr>
<tr>
<td>Mar</td>
<td>3,830</td>
<td>7,836</td>
</tr>
<tr>
<td>Apr</td>
<td>21,667</td>
<td>18,275</td>
</tr>
<tr>
<td>May</td>
<td>25,117</td>
<td>26,930</td>
</tr>
<tr>
<td>Jun</td>
<td>50,585</td>
<td>40,409</td>
</tr>
<tr>
<td>Jul</td>
<td>73,187</td>
<td>76,667</td>
</tr>
<tr>
<td>Aug</td>
<td>62,193</td>
<td>82,485</td>
</tr>
<tr>
<td>Sep</td>
<td>48,304</td>
<td>73,088</td>
</tr>
<tr>
<td>Oct</td>
<td>35,643</td>
<td>59,251</td>
</tr>
<tr>
<td>Nov</td>
<td>15,175</td>
<td>26,608</td>
</tr>
<tr>
<td>Dec</td>
<td>12,018</td>
<td>8,830</td>
</tr>
<tr>
<td>Totals</td>
<td>366,637</td>
<td>435,702</td>
</tr>
</tbody>
</table>
AWT #2 Economics

- Installed costs higher than normal due to Fed Gov. added factors, and side stream filtration

- O&M costs decreased due to reduce chemical usage / staff time

- Local rebates would have offset ~50% of installed cost if Fed Center was not on one master water meter

<table>
<thead>
<tr>
<th>Economic Parameter</th>
<th>Building 25 (AWT #1) at Local Water Rate $7.14/kGal</th>
<th>Building 25 (AWT #1) at GSA Avg Water Rate $16.76/kGal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial Cost ($)</td>
<td>$29,600</td>
<td>$29,600</td>
</tr>
<tr>
<td>Cooling Tower Size (tons)</td>
<td>1,500</td>
<td>1,500</td>
</tr>
<tr>
<td>Water Savings (Gal/yr.)</td>
<td>401,170</td>
<td>401,170</td>
</tr>
<tr>
<td>Water and Sewer Cost Savings ($/yr.)</td>
<td>$2,864</td>
<td>$6,724</td>
</tr>
<tr>
<td>Annual Increase in O&amp;M ($/yr.)</td>
<td>($2,768)</td>
<td>($2,768)</td>
</tr>
<tr>
<td>Simple Payback with O&amp;M (yrs.)</td>
<td>5.3</td>
<td>3.1</td>
</tr>
<tr>
<td>Savings to Investment Ratio</td>
<td>3.8</td>
<td>6.5</td>
</tr>
</tbody>
</table>
# Additional AWT #1 and #2 Deployments

<table>
<thead>
<tr>
<th>Denver Federal Center Facility</th>
<th>AWT System</th>
<th>Date Installed</th>
<th>Cooling Tower Size (Tons)</th>
<th>Installed Cost ($)</th>
<th>Annual Water Savings (Gal/yr.)</th>
<th>Annual Water Savings ($)</th>
<th>Annual Increase in O&amp;M ($/yr.)</th>
<th>Total Annual Cost Savings ($/yr.)</th>
<th>Simple Payback (yrs.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bldg. 20</td>
<td>AWT Technology #1</td>
<td>Nov-16</td>
<td>600</td>
<td>$31,057</td>
<td>718,597</td>
<td>$5,131</td>
<td>($2,768)</td>
<td>$7,899</td>
<td>3.9</td>
</tr>
<tr>
<td>Bldg. 41</td>
<td>AWT Technology #1</td>
<td>Jan-17</td>
<td>1,000</td>
<td>$36,976</td>
<td>1,809,921</td>
<td>$12,923</td>
<td>($2,768)</td>
<td>$15,691</td>
<td>2.4</td>
</tr>
<tr>
<td>Bldg. 85</td>
<td>AWT Technology #2</td>
<td>Jan-14</td>
<td>500</td>
<td>$8,756</td>
<td>62,450</td>
<td>$446</td>
<td>$1,000</td>
<td>($554)</td>
<td>-15.8</td>
</tr>
<tr>
<td>Bldg. 56</td>
<td>AWT Technology #2</td>
<td>Jan-15</td>
<td>1,000</td>
<td>$28,557</td>
<td>661,160</td>
<td>$4,721</td>
<td>$2,200</td>
<td>$2,521</td>
<td>11.3</td>
</tr>
<tr>
<td>Bldg. 810</td>
<td>AWT Technology #2</td>
<td>Jun-14</td>
<td>2 x 500</td>
<td>$31,047</td>
<td>1,131,450</td>
<td>$8,079</td>
<td>$3,300</td>
<td>$4,779</td>
<td>6.5</td>
</tr>
<tr>
<td>Bldg. 810 USDA</td>
<td>AWT Technology #2</td>
<td>Mar-16</td>
<td>3 x 500</td>
<td>$31,047</td>
<td>1,048,000</td>
<td>$7,483</td>
<td>$3,300</td>
<td>$4,183</td>
<td>7.4</td>
</tr>
</tbody>
</table>
Silverbullet

- Uses a combination of ozone (O$_3$), hydrogen peroxide (H$_2$O$_2$), and/or UV lights to generate highly reactive hydroxyl (OH•) and oxygen free radicals
- Air tube is ran into cooling tower basin and pumps AOP treated air into cooling tower basin
- Elimination of scale inhibitor, corrosion inhibitor, potential elimination of biocide

AWT #3 Facility Description

Building Location
• Denver Federal Center
• Building 95

Building Facts
• 163,206 ft², two-story
• Office / laboratory building

Cooling System
• (2) 250-ton water-cooled centrifugal chillers
• (2) induced draft cooling tower
# AWT #3 Performance Objectives

<table>
<thead>
<tr>
<th>Quantitative Objectives</th>
<th>Success Criteria</th>
<th>Metrics &amp; Data</th>
<th>M&amp;V Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water Savings</td>
<td>&gt;10% reduction in cooling tower water makeup (gal/ton-hr)</td>
<td>- Cooling tower makeup water</td>
<td>Met: Annual water savings 22.7% to 29.7%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Chiller plant energy usage</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Outside air conditions</td>
<td></td>
</tr>
<tr>
<td>Reduction in Chemical Costs</td>
<td>&gt;90% reduction in annual chemical costs</td>
<td>- Pre- and post- annual chemical costs</td>
<td>Met: Elimination of all chemicals other than biocides.</td>
</tr>
<tr>
<td>Water Chemistry</td>
<td>Meets or exceeds GSA cooling tower water chemistry requirements</td>
<td>- Pre- and post- water chemistry reports</td>
<td>Met: GSA water chemistry requirements</td>
</tr>
<tr>
<td>Cost Effectiveness</td>
<td>Simple payback; Savings to Investment ratio (SIR)</td>
<td>- Payback &lt; 10 years; SIR &gt; 1.</td>
<td>Met: SPP of 3.4 yrs.; SIR of 6</td>
</tr>
<tr>
<td>Qualitative Objectives</td>
<td>Success Criteria</td>
<td>Metrics &amp; Data</td>
<td>M&amp;V Results</td>
</tr>
<tr>
<td>Ease of Installation</td>
<td>Less than 2-day installation time</td>
<td>Labor hours to install technology</td>
<td>Met: Less than 1 day to install</td>
</tr>
</tbody>
</table>
Baseline Daily Cooling Tower Makeup Water Regression

Cooling Tower Makeup Water
\[ = c_0 + (c_1 \cdot WKD\_WKND) + (c_2 \cdot C\text{Energy}) + (c_3 \cdot CD\text{ewpoint}) + (c_4 \cdot C\text{Energy}^2) + (c_5 \cdot C\text{Energy} \cdot CD\text{ewpoint}) \]
AWT #3 Water Savings and Water Quality

Water Savings
• Measured CoC ranged from 5.1-14.4
• Measured 26.3% reduction in makeup water (blowdown not measured)

Water Quality
• Realized reduction in chiller condenser tube fouling
• Elimination of scaling / corrosion inhibitor, uses small amount of biocide
• ORP of 194, GSA range > 300

<table>
<thead>
<tr>
<th>Month</th>
<th>2017 Cooling Tower Makeup (Gal/Mon)</th>
<th>2014 Weather Normalized Baseline Water (Gal/Mon.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-Jan</td>
<td>928</td>
<td>0</td>
</tr>
<tr>
<td>1-Feb</td>
<td>15,042</td>
<td>18,301</td>
</tr>
<tr>
<td>1-Mar</td>
<td>46,706</td>
<td>54,556</td>
</tr>
<tr>
<td>1-Apr</td>
<td>52,254</td>
<td>66,350</td>
</tr>
<tr>
<td>1-May</td>
<td>54,904</td>
<td>107,543</td>
</tr>
<tr>
<td>1-Jun</td>
<td>282,322</td>
<td>375,419</td>
</tr>
<tr>
<td>1-Jul</td>
<td>398,206</td>
<td>506,684</td>
</tr>
<tr>
<td>1-Aug</td>
<td>298,039</td>
<td>445,116</td>
</tr>
<tr>
<td>1-Sep</td>
<td>190,375</td>
<td>275,749</td>
</tr>
<tr>
<td>1-Oct</td>
<td>61,146</td>
<td>108,623</td>
</tr>
<tr>
<td>1-Nov</td>
<td>35,554</td>
<td>44,930</td>
</tr>
<tr>
<td>1-Dec</td>
<td>40,005</td>
<td>0</td>
</tr>
<tr>
<td>Totals</td>
<td>1,475,482</td>
<td>2,003,273</td>
</tr>
</tbody>
</table>
AWT #3 Economics

- Installed costs higher than normal due to Fed Gov. added factors, and side stream filtration
- O&M costs decreased due to reduce chemical usage / staff time
- Local rebates would have offset ~50% of installed cost if Fed Center was not on one master water meter

<table>
<thead>
<tr>
<th></th>
<th>Baseline</th>
<th>Tested Technology (After)</th>
<th>Difference w/ Local Sewer+Water Rate ($7.14/kGal)</th>
<th>Difference w/ GSA Avg Water Rate ($16.76/kGal)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Installation</td>
<td>N/A</td>
<td>$21,125</td>
<td>$21,125</td>
<td>$21,125</td>
</tr>
<tr>
<td>Annual Water Consumption</td>
<td>2,003,273</td>
<td>1,475,482</td>
<td>527,791</td>
<td>527,791</td>
</tr>
<tr>
<td>Annual Water Costs</td>
<td>$14,303</td>
<td>$10,535</td>
<td>$3,768</td>
<td>$8,846</td>
</tr>
<tr>
<td>Simple Payback</td>
<td>yrs</td>
<td>3.4</td>
<td>1.9</td>
<td></td>
</tr>
<tr>
<td>Savings-to-Investment Ratio</td>
<td>Integer value between 0 and 100</td>
<td>6.0</td>
<td>10.8</td>
<td></td>
</tr>
</tbody>
</table>

1 Difference w/ Local Sewer+Water Rate: $7.14/kgal
2 Difference w/ GSA Avg Water Rate: $16.76/kgal
3 Installation cost: $21,125
AWT #3 Energy Modeling

- Energy Plus Commercial Building Reference Model
- Post 1980 construction, Large office building, 498,588 ft²
- Modeled 3 CoC baseline, 10 CoC, 15 CoC
AWT #3 Energy Modeling

- Modeled water rates for each city
- Water rates vary significantly by city, cities with highest rates had highest savings
AWT #3 Energy Modeling

• Calculated SIR per location as a function of water rate (SIR>1)
• Used for high cost case of $25,000
• Does not include O&M cost savings
AWT#4 Technology Description

Dynamic Water Technologies & Universal Environmental Technologies

• Chemical free electrolysis

Scale control
Electro-catalytic process accelerates scale formation in the reactors
Scale is easily removed from reactors

Corrosion control
Maintains balanced pH and mineral content to minimize corrosion

Biological Growth control
Forms HOCl and Cl₂ from the chlorides in the water for biocides

Expected Performance
• Blowdown water (and sewer) savings of 25-95% (CoC 30 or more)
• Elimination of chemicals
• Energy savings – depending on the amount of scale in the baseline case
Test site #1
- 240,000 ft² federal office building, Savannah GA
- 2 250-ton chillers and 2 cooling towers
- 1 UET reactor skid
- Test period: June – October 2017

Test site #2
- 530,000 ft² office building, Los Angeles, CA
- 2 800-ton and 2-500 ton chillers and 4 cooling towers
- 2 UET reactor skids
- Test period: June – October 2018 (ongoing)
AWT #4 Water Savings and Water Quality

**Water Savings**
- Measured CoC > 30
- Measured 98% reduction in blowdown
- > 1 million gal saved annually

**Water Quality**
- No measured reduction in scaling
- Noticeable reduction in biological growth and cleaning requirements
- Observational improvements in water quality
- DWT maintains a high conductivity setting (6,000)

Scale removal from reactor cores
### AWT #4 Test Site #1 Results

- Installed costs higher than normal due to tech demo costs and Fed Gov. added factors
- Revised cost used in analysis
- O&M costs increased slightly with annual service contract

<table>
<thead>
<tr>
<th>Economic Parameter</th>
<th>Local Water Rate $6.64/kGal</th>
<th>GSA Avg Water Rate $16.76/kGal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial Cost ($)</td>
<td>$59,369</td>
<td>$59,369</td>
</tr>
<tr>
<td>Cooling Tower Size (tons)</td>
<td>500</td>
<td>500</td>
</tr>
<tr>
<td>Water Savings (Gal/yr.)</td>
<td>1,003,300</td>
<td>1,003,300</td>
</tr>
<tr>
<td>Water and Sewer Cost Savings ($/yr.)</td>
<td>$6,662</td>
<td>$16,816</td>
</tr>
<tr>
<td>Annual Increase in O&amp;M ($/yr.)</td>
<td>($720)</td>
<td>($720)</td>
</tr>
<tr>
<td>Simple Payback with O&amp;M (yrs.)</td>
<td>10</td>
<td>3.7</td>
</tr>
<tr>
<td>Savings to Investment Ratio</td>
<td>2.0</td>
<td>5.4</td>
</tr>
</tbody>
</table>

- Installed costs higher than normal due to tech demo costs and Fed Gov. added factors
- Revised cost used in analysis
- O&M costs increased slightly with annual service contract
AWT#4 Test Site #2 Results

• Baseline period complete
• DWT-UET system start up on 7/9/2018
• Expected testing through October 2018
Questions

michael.deru@nrel.gov

jesse.dean@nrel.gov
Thank You