Energy - Water - Cooling Nexus
An Examination of Opportunity
• Agenda

Cooling in a changing environment

Water reclamation alternatives

Energy-Water Nexus for District Cooling

Opportunities and challenges in reclaimed water for campus cooling towers
The colors on the map show temperature changes over the past 22 years (1991-2012) compared to the 1901-1960 average for the contiguous U.S., and to the 1951-1980 average for Alaska and Hawaii. The bars on the graph show the average temperature changes for the U.S. by decade for 1901-2012 (relative to the 1901-1960 average). The far right bar (2000s decade) includes 2011 and 2012. The period from 2001 to 2012 was warmer than any previous decade in every region. (Figure source: NOAA NCDC / CICS-NC).
Cooling Degree Days

[Map of the United States showing cooling degree days with color codes]

STATES
13 MEAN TOTAL CDD (CDD)
- ANNUAL -
A < 101
B 101 - 400
C 401 - 700
D 701 - 1000
E 1001 - 1500
F 1501 - 2000
G 2001 - 2500
H 2501 - 3500
I > 3500

TITLE
Cooling Degree Day Projection

Figure 4.3. These maps show projected average changes in cooling degree days for two future time periods: 2021-2050 and 2070-2099 (as compared to the period 1971-2000). The top panel assumes climate change associated with continued increases in emissions of heat-trapping gases (A2), while the bottom panel assumes significant reductions (B1). The projections show significant regional variations, with the greatest increases in the southern United States by the end of this century under the higher emissions scenario. Furthermore, population projections suggest continued shifts toward areas that require air conditioning in the summer, thereby increasing the impact of temperature changes on increased energy demand. (Figure source: NOAA NCDC / CICS-NC).
Figure 8.1. Climate change is projected to reduce the ability of ecosystems to supply water in some parts of the country. This is true in areas where precipitation is projected to decline, and even in some areas where precipitation is expected to increase. Compared to 10% of counties today, by 2050, 32% of counties will be at high or extreme risk of water shortages. Projections assume continued increases in greenhouse gas emissions through 2050 and a slow decline thereafter (A1B scenario). Numbers in parentheses indicate number of counties in each category. (Reprinted with permission from Roy et al., 2012. Copyright 2012 American Chemical Society).
Global Water Supplies

Lake Mead, July 2015
Observations from the Middle East

- Urban Density
- Desalination
- District Cooling
- Treated Sewage Effluent
Desalination in US
Treated Sewage Effluent in US

Water Reclamation Facility Flow Path

- 1,800 GPM Avg Flowrate
- 56,000 GPM Summer flow rate
- Sulfuric acid (reduce pH) and chlorine (control biological growth)

85-acre Reservoir

56,000 GPM

Gravity Filters
Suspended solids captured

Clarifiers
Phosphates, Magnesium, Silica and Calcium removed

Trickling Filters
Reduce ammonia and alkalinity

45-acre Reservoir

Underground Pipeline
Delivers effluent to Palo Verde

Source: Google Earth
Treated effluent in US cooling towers
District Cooling Energy and Water
Water in Energy

Simple Cycle

Rankine Cycle

Combined Cycle
Water in Cooling

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
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<tbody>
<tr>
<td>thermal extracted</td>
<td>10,000 Ton</td>
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<td></td>
<td>120 MMBTU/hr</td>
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<td></td>
<td>thermal energy in</td>
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<td>chiller efficiency</td>
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<td></td>
<td>7.0 COP</td>
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<td>heat rejected</td>
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<td>latent energy</td>
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<tr>
<td></td>
<td>1000 BTU/lb</td>
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<tr>
<td>Evaporation</td>
<td>16,434 gal/hr</td>
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<td></td>
<td>1.64 gal/tonhr</td>
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<tr>
<td>Blowdown Cycles</td>
<td>3.5</td>
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<td>0.66 gal/Tonhr</td>
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<tr>
<td>Make Up Water</td>
<td>2.30 gal/Tonhr</td>
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</tbody>
</table>

Evaporation: 16,434 gal/hr

Blowdown Cycles: 3.5

Make Up Water: 2.30 gal/Tonhr
Water in Cooling

Sensible heat transfer

Q total heat transfer

h_A

h_B

A

B

E

D

W_A

W_B

W_D

GLHN Architects & Engineers, Inc.

Tucson AZ - Binned Hourly Weather Data (June 1997-2006)

7123 Data Points

Note: All data points as reported by NOAA for Tucson International Airport
Energy – Water - District Cooling
Reclaimed Water in District Cooling

- **Treatment Approaches**
  - Blowdown and chemical control
  - Mechanical methods
  - Decentralized and biological treatment
Summary

• History and success in power plants –
• Specific Issues are geographic
  – Water to Energy Cost Ratio
  – Water constituent quality
• Decentralized and Public Utility Alternatives
• Best and Highest Use

• Recycled water - an opportunity for district cooling at university campus scale