WATER-ENERGY NEXUS

HOLISTIC SOLUTIONS FOR CLIMATE CHANGE AND RESILIENCY

PG&E Energy Center
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Lyle Keck, PE, LEED AP BD+C
Building Performance Consultant
Agenda

• Drivers for Rapid Water and Sewer Cost Increase
• Understanding the Energy:Water Nexus
• Wholistic Accounting of Energy and Water
• Water Modeling - Challenges & Opportunities
Drivers for Rapid Water & Sewer Cost Increase
Rising Cost of Water & Sewer

Trends in Consumer Prices (CPI) for Utilities with forecasts

Drivers for Rapid Cost Increase

- Climate Change
- US growth patterns
- Diminishing availability
- Declining quality
- Full cost accounting
- Infrastructure profile
Local Understanding: Results May Vary

2019 Water and Sewer Rates, U.S. Cities

- Seattle, WA: $29.89
- Portland, OR: $20.39
- San Francisco, CA: $21.75
- Berkeley, CA: $17.39
- Palo Alto, CA: $20.35
- Phoenix, AZ: $8.79
- San Diego, CA: $12.85
- El Paso, TX: $12.90
- Dallas, TX: $10.26
- Austin, TX: $14.81
- Houston, TX: $10.68
- Minneapolis, MN: $11.50
- Chicago, IL: $39.14
- Colorado Springs, CO: $11.50
- Ann Arbor, MI: $12.56
- Cambridge, MA: $24.41
- Boston, MA: $21.01
- New York, NY: $13.50
- Pittsburgh, PA: $29.95
- Baltimore, MD: $13.43
- Washington, DC: $15.79
- Bethesda, MD: $20.23
- Charlottesville, VA: $21.34
- Atlanta, GA: $29.22

Rates are calculated per 1,000 gallons and are effective as of 1/1/2019. Water charges are for potable water. Misc. special charges included, as applicable. Where rates vary by user size and type, calculations have been made for hospitals over 200,000 sf. Purple outline indicates location in state that allows for water reuse. Blue and grey indicate proportion of combined rate for water (blue) and sewer (gray).
Local Understanding: Results May Vary
Energy: Water Nexus
WATER for ENERGY

U.S. power plants use three times as much fresh water daily – **143** billion gallons – as is used for public water supplies.

*Sandia National Laboratories*
WATER for ENERGY

35 gal/kWh\(^1\)  |  44 gal/kWh\(^1\)
---|---
Natural Gas | Nuclear

36 gal/kWh\(^1\)  |  65 gal/kWh\(^2\)
---|---
Coal | Hydroelectric

\(^1\) Macknick et al. 2011
\(^2\) UNESCO-IHE 2011
ENERGY for WATER

Rapidly Rising

Due to:
- Population growth
- Failing infrastructure
- More distant, lower quality sources
- Regulatory change
- True cost accounting

\[ \approx 80\% \text{ of the cost is related to energy} \]

* Sandia National Laboratories
Wholistic Accounting
Energy + Water
Wholistic Accounting - Site vs. Source

- Water-cooled chiller VS. evaporative cooling
- Consider both site and source consumption
Wholistic Accounting - Site vs. Source

Building Cooling Demand

<table>
<thead>
<tr>
<th></th>
<th>Total Cooling Load (MBtu)</th>
<th>Total Load on Cooling Coil</th>
<th>Cooling Coil Reduction from Evaporative Cooling</th>
</tr>
</thead>
<tbody>
<tr>
<td>Title 24 Baseline</td>
<td>2100</td>
<td>2000</td>
<td>10% Reduction</td>
</tr>
<tr>
<td>Optimized Building</td>
<td>1700</td>
<td>1600</td>
<td>10% Reduction</td>
</tr>
<tr>
<td>Indirect Direct Evaporative Cooling</td>
<td>700</td>
<td>600</td>
<td>41% Reduction</td>
</tr>
</tbody>
</table>

10% Reduction
41% Reduction
Wholistic Accounting - Site vs. Source

Indirect/direct evaporative cooling saves 38,500 kWh/year

**SITE**

- 218,000 gal Site Water Increase (evap.)
- 129,500 gal Site Water Decrease (cooling tower)
  - 88,500 gallons
  - Total Site Water Increase (+)

**SOURCE**

- 178,500 gallons
  - Source Water Reduction (-)

- Net electricity savings of 38,500 kWh/year (site)
- Net water savings of 90,000 gallons/year (site + source)
Water Modeling
Whole Building Water Modeling

• Benchmark and goal set
• Preliminary water budget, early water balance
• Refine calculations as information and models become available
• Work design alternatives into BOD and design documentation
• Final models and calculations to support compliance
Whole Building Water Modeling

Benchmark and goal set

End Uses of Water in Office Buildings

- Kitchen/Dishwashing: 13%
- Landscaping: 22%
- Cooling and Heating: 28%
- Domestic/Restroom: 37%

End Uses of Water in Hospitals

- Kitchen/Dishwashing: 35%
- Landscaping: 9%
- Cooling and Heating: 7%
- Domestic/Restroom: 7%
- Medical Equipment: 7%
- Medical Restroom: 20%
- Laundry: 9%
- Other: 15%

Created by analyzing data from: New Mexico Office of the State Engineer, American Water Works Association (AWWA), AWWA Research Foundation, and East Bay Municipal Utility District.
Whole Building Water Modeling

Benchmark and goal set (challenges)

<table>
<thead>
<tr>
<th>Data Source</th>
<th>Metric</th>
<th>End-Uses Included</th>
</tr>
</thead>
<tbody>
<tr>
<td>USEPA (14 building types)</td>
<td>Per sf Per customer Per bed Per employee</td>
<td>Varied by program</td>
</tr>
<tr>
<td>CBECS (large hospitals)</td>
<td>Per sf Per bed</td>
<td>Building, landscape, central plant</td>
</tr>
<tr>
<td>AWWA (11 building types)</td>
<td>Per person/customer</td>
<td>Building, landscape</td>
</tr>
<tr>
<td>Pacific Institute (numerous building types)</td>
<td>Per person/employee Per sf</td>
<td>Building, landscape</td>
</tr>
</tbody>
</table>
Whole Building Water Modeling

Preliminary water budget, early water balance

• Establish WUI baseline
• Identify water end-uses and develop preliminary water balance
• Consider water use by month, quality requirements, water reuse potential
• Demonstrate savings potential and identify strategies with high impact

Water Consumption by End-Use: Alternate Scenario

Potential Potable vs. Non-Potable Consumption: Alternate Scenario
Whole Building Water Modeling

Refine calculations as information and models become available

- Energy Modeling + Water Modeling (detailed hourly modeling)
Whole Building Water Modeling

Refine calculations as information and models become available

- Energy Modeling + Water Modeling (detailed hourly modeling)
- Hourly diversity schedules (challenge)

Ref: Madison, WI Water Utility screen shot
Whole Building Water Modeling

Refine calculations as information and models become available

- Energy Modeling + Water Modeling (detailed hourly modeling)
- Hourly diversity schedules (challenge)
- Precipitation data (challenge)
Whole Building Water Modeling

Final models and calculations to support compliance

LEED Pilot Credit Library

Pilot ACP: Whole Project Water Use Reduction

Applicable Rating Systems
This Alternative Compliance Path is available for pilot testing by the following LEED project types:

- LEED v4 BD+C
  - New Construction
  - Core and Shell
  - Schools
  - Retail
  - Healthcare
  - Data Centers
  - Hospitality
  - Warehouses and Distribution Centers

Intent
To reduce indoor and outdoor water consumption of the entire project.

Background
Depending on the building type and use, LEED may not currently address all the water use within the project boundary. This performance pathway for water conservation uses a whole project whole campus water budget approach. It allows projects to quantify water use with whole-building water balance modeling, similar to the compliance path for whole-building energy modeling. It also allows projects to include potentially significant water savings that previously went unrecognized, such as process water. This alternative compliance path (ACP) documents overall water consumption reduction and establishes point thresholds based on this performance metric.
QUESTIONS?

Lyle Keck, PE, LEED AP BD+C
Lkeck@aeieng.com

aeieng.com

AEI/Affiliated Engineers, Inc.

@AEITweets