CPUC Embedded Energy in Water Studies

Study 1: “Statewide and Regional Water-Energy Relationship Study”

Study 2: “Water Agency and Function Component Study and Embedded Energy-Water Load Profiles”

March 20th, 2013
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In 2007, the CPUC opened a proceeding to consider if/how energy embedded in water should be recognized as an energy efficiency resource.

» Decision 12-07-050:
  - Authorized the California Investor Owned Utilities (IOUs) to conduct water-energy pilots
  - Directed that three studies be conducted:
    o Study 1 - Statewide and Regional Water Energy Relationship Study
    o Study 2 - Water Agency and Function Component Study and Embedded Energy-Water Load Profiles
    o Study 3 - End-Use Water Demand Profile Study

» The CPUC engaged the California Institute for Energy and Environment (CIEE) to manage the three studies. The team of GEI Consultants, Inc. and Navigant Consulting, Inc. (the Study Team) was engaged to conduct Study 1 and Study 2.

» Both studies collected and analyzed significant amounts of water and energy data:
  - 10 years worth of water and energy data for nine large wholesale suppliers
  - One year of detailed monthly/hourly data for 20+ retail water agencies throughout California
  - Secondary analysis of additional water supplies (groundwater, recycled water, desalination, local surface water)
The two studies looked at different parts of the water system.
Energy Intensity and Embedded Energy are two terms that are key to understanding the Water-Energy nexus

» Energy Intensity (EI)
  - The average amount of energy needed to transport or treat water or wastewater on a per unit basis (kilowatt hours per acre-foot of water [kWh/AF]).
  - The energy intensity is associated with a particular facility and is similar to a measure of efficiency.
  - The energy intensities of individual facilities within a water agency can be aggregated to represent the energy intensity of water supply.

» Energy Embedded in Water
  - The amount of energy that is used to collect, convey, treat, and distribute water to end users, and the amount of energy that is used to collect and transport wastewater for treatment prior to safe discharge of the effluent.
  - Captures the entire energy picture both upstream and downstream of an end user customer.
  - Embedded energy is not associated with a particular facility but with the water itself.
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Study 1 aimed to understand and quantify the primary predictors of energy consumption related to water supply systems

» The Study Team collected 10 years of water and energy data from 9 wholesale agencies to develop a predictive model of energy use.
  - Most of these large pumping plants are powered by non-IOU energy

» Energy for water supplies not provided by the 9 agencies were added (these supplies rely more on IOU energy for operations)
  - Groundwater
  - Local Surface Water
  - Recycled Water
  - Desalination (Brackish and Seawater)
The Study Team calculated the average energy intensity of each supply to each hydrologic region as a first step to calculating total energy use.

[Graph showing energy intensity (kWh/AF) for various hydrologic regions and supplies.]

Note: Several low intensity supplies excluded from graph for clarity: Local Surface Supply (10 kWh/AF), Los Angeles Aqueduct (0 kWh/AF)
Statewide groundwater pumping accounts for more electricity use during summer months than pumping for the state’s three largest water conveyance systems – SWP, CVP and CRA – combined.

Note: A total of 17 supplies are represented on this graph; 12 of them do not contribute significant energy use and are not labeled for clarity.
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Retail water agencies use energy in multiple end uses: groundwater pumping, treatment, distribution, wastewater treatment, and more.
For Study 2, the team developed and refined methodologies for calculating energy intensity and embedded energy.

<table>
<thead>
<tr>
<th>Identify Infrastructure</th>
<th>Collect Energy and Water Data</th>
<th>Interview System Operators</th>
<th>Develop Analysis Algorithms</th>
<th>Analyze Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>» Identify various sources of water for a given agency</td>
<td>» Collect water delivery data and pump energy use data.</td>
<td>» Understand operational strategy, identify marginal supply</td>
<td>» Develop methodology to calculate system wide energy intensity</td>
<td>» Implement methodology in a calculation tool to process data</td>
</tr>
<tr>
<td>» Understand the types of infrastructure (pumps, reservoirs, canals)</td>
<td>» Link water and energy data for each piece of infrastructure</td>
<td>» Address data inconsistencies</td>
<td>» Account for multiple supplies, sources, and delivery points.</td>
<td>» Examine trends and ranges of energy intensity</td>
</tr>
<tr>
<td>» Understand inter-connections</td>
<td></td>
<td></td>
<td></td>
<td>» Produce example energy load profiles</td>
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</tbody>
</table>
Varying levels of data are available for retail water utilities; lack of granularity does not prevent calculation of energy intensity.

» Energy data is often available for each facility within a water agency (sometime upwards of 100 facilities)
  – Hourly interval data – mostly for large facilities
  – Monthly energy bill data (sometimes time of use data is available)

» Water data is often only available at key points in the system (sometimes only 5-10 locations): effluent from treatment plants, production by groundwater wells
  – While water utilities may have SCADA to monitor flow rates and pressure live, though historic data is not always recorded
  – Monthly water production data is regularly recorded
  – Rarely are water flow data for individual distribution pumps available

» Study 2 saw many cases where detailed energy data was available, but water data was available only at a monthly level at a few key points

» However, this does not prevent calculation of EI…
Energy intensity of water supply is calculated aggregating energy and water data for each agency.

- Energy data may be available for each individual facility, water flow data may be available only for groups of faculties.
Aggregating energy and water data for groups of facilities allows calculation of Energy Intensity by supply type.

\[ EI = \frac{\text{Total Plant Energy Use}}{\text{Total Water Treated}} \]

\[ EI = \frac{\text{Total Booster Pump Energy Use}}{\text{Total Water Delivered}} \]

\[ EI = \frac{\text{Total Groundwater Pump Energy Use}}{\text{Total Groundwater Pumped}} \]

\[ EI = \frac{\text{Total Plant Energy Use}}{\text{Total Wastewater Treated}} \]
Aggregating energy and water data the entire agency allows calculation of average Energy Intensity of water delivered by agency.

\[ EI = \frac{\text{Total Energy Use}}{\text{Total Water Delivered}} \]
Study 2 summarized the Energy Intensity of facility types statewide.

- Groundwater energy intensity depends on depth to groundwater, which varied across all agencies studied.
- Distribution system energy intensity has a large range across the agencies studied. Service area size, topology and other characteristics contribute to the large range.
- Water and wastewater treatment plant configurations is customized for an agency’s resources, service area, and treatment requirements.
Study 2 also examined energy load profiles to understand time-of-use of energy in the water sector.

- Variability in data granularity across agencies and facilities makes this a more challenging effort, though results are still useful.
- Study 2 totaled and plotted actual energy use by each water agency by facility type (groundwater, distribution, treatment, etc.).
- Only when hourly data was available could time-of-use trends be observed.
- Study 2 did not attempt to estimate the load profile of facilities for which hourly energy use was not available.
  - Pumping load profile depends on water demand, system storage capacity, service territory topology, and operation strategy.
  - Monthly billed data was assumed to follow a flat load profile throughout the day.
- Study 2 developed the Water Energy Load Profiling Database to store all the data from the 20+ agencies in Study 2.
  - Access database available on the CPUC website*
  - Ability to look at any of the agencies for any day in 2008.
  - Detailed load profile data is available in the database.
  - Instructions on use are available in Study 2: Appendix C.

Wastewater treatment plants have a relatively consistent daily load profile: result of the consistent indoor water demand (and thus wastewater production) by customers.

Represents actual energy use by Orange County Sanitation District
Potable distribution systems can have a relatively constant daily profile of energy use in some cases.

Represents actual energy use by San Jose Water Company
Some potable water system operators can respond to price signals, adjust their operations and change their daily energy use profile.
Study 2 and its appendices contain other types of data (some summary, some detailed) that may be useful to future water-energy work.

### Summary EI for All Agencies Studied

<table>
<thead>
<tr>
<th>Agency</th>
<th>Segment</th>
<th>Summer Average (kWh/MG)</th>
<th>Winter Average (kWh/MG)</th>
<th>Summer Range (kWh/MG)</th>
<th>Winter Range (kWh/MG)</th>
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<tbody>
<tr>
<td>Cal-Amp Corporation</td>
<td>Groundwater</td>
<td>3,855</td>
<td>3,623</td>
<td>5,496 - 8,412</td>
<td>4,018 - 6,868</td>
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<td>Contra Costa Water District</td>
<td>Booster Pumps</td>
<td>1,116</td>
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<td>2,911 - 1,535</td>
<td>668 - 1,534</td>
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<td>Raw Water Pumps</td>
<td>1,304</td>
<td>1,212</td>
<td>2,144 - 1,614</td>
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<td>538</td>
<td>499 - 519</td>
<td>319 - 499</td>
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<td>District (Water)</td>
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<td>Marin Municipal Water</td>
<td>Raw Water Pumps</td>
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<td>District</td>
<td>Recycled Water Pumps</td>
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<td>Wastewater Treatment</td>
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<td>981 - 1,126</td>
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<td>Booster Pumps</td>
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<td>Monterey Regional Water</td>
<td>Wastewater Pumps</td>
<td>256</td>
<td>275</td>
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<td>241 - 330</td>
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<td>Pollution Control Agency</td>
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<td>1,622</td>
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<td>Nutramus Mutual Water</td>
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<td>Company</td>
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<td>San Jose Water Company</td>
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<td>Semipalmet Water Storage</td>
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<td>51.0 - 67.2</td>
<td>15.0 - 23.0</td>
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<td></td>
<td>Wastewater Treatment Plant</td>
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<td>11.9</td>
<td>39.7 - 41.5</td>
<td>37.8 - 43.3</td>
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<tr>
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<td>Treatment Plant</td>
<td>38.2</td>
<td>11.9</td>
<td>39.7 - 41.5</td>
<td>37.8 - 43.3</td>
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<td>Recycled Water Pumps</td>
<td>0.4</td>
<td>0.4</td>
<td>0.4</td>
<td>0.4</td>
</tr>
</tbody>
</table>

### Water Agency Profiles: EI and Load Profiles for each Agency Studied
Aggregating the data from Study 1 and Study 2 provides an updated view of the California Statewide Water-Energy Connection

- Water infrastructure in California consumes 7.7% of the state’s electricity use
- Similarly, nationwide the amount is estimated to be 4%

### California Statewide Electricity Use

- **Non-Water related uses** 80.9%
- **Water-Related Uses** ~19.1%
- **Customer End Uses** ~11.4%
  - **Water Infrastructure** 7.7%
  - **Water-Related Uses** 3.9%
  - **Non-Water Related Uses** 0.8%


Source: Study 1 and Study 2
Key Contacts

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