

This presentation premiered at WaterSmart Innovations

watersmartinnovations.com



Accounting for the Water – Energy - Greenhouse Gas Relationship

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Table of Contents

- The Water-Energy Nexus
- Water Embedded in Energy
- Energy Embedded in Water
- What Can Water and Waste Water Agencies Do?

The Water-Energy Nexus

The Water-Energy Nexus

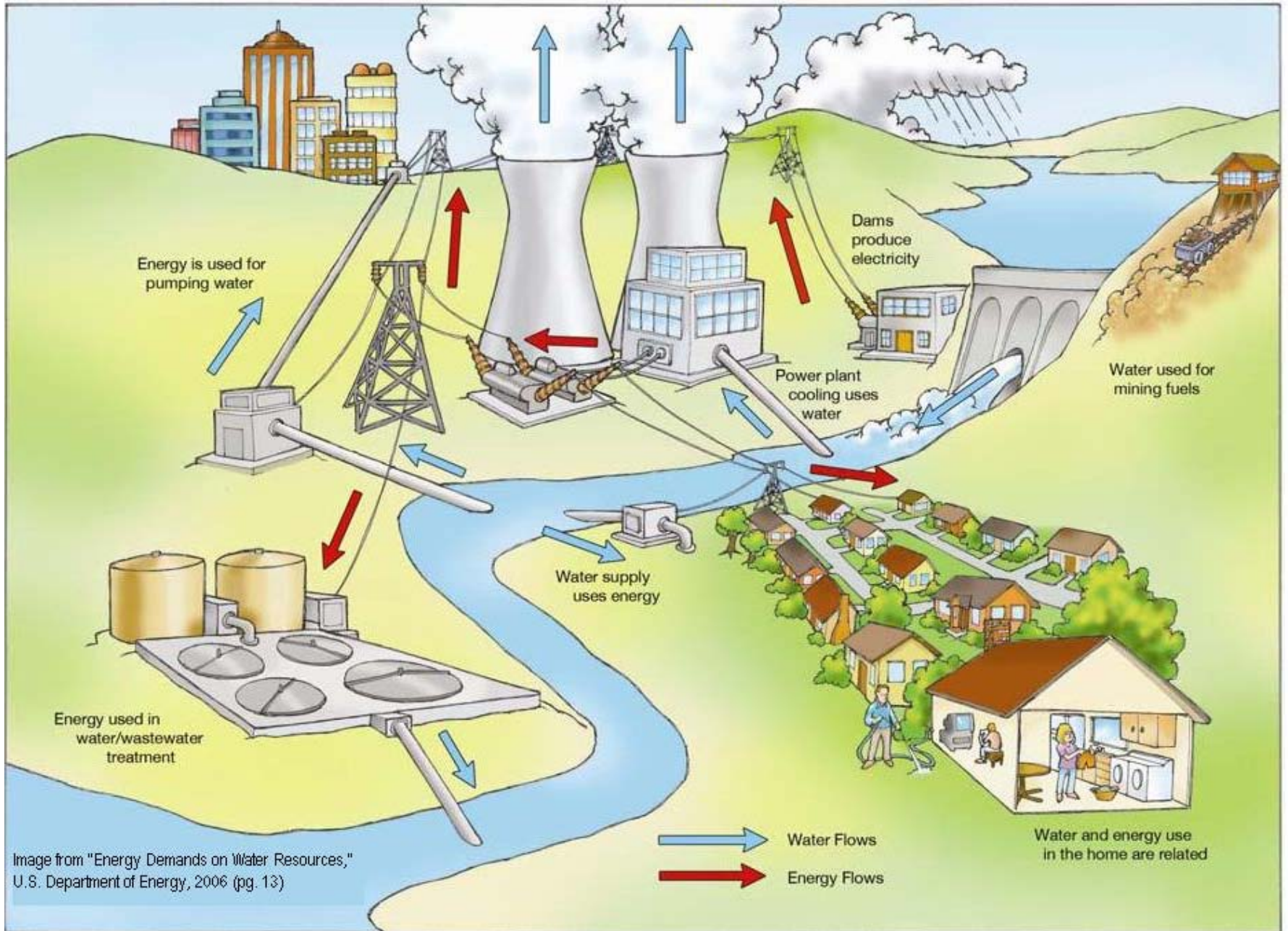


Image from "Energy Demands on Water Resources,"
U.S. Department of Energy, 2006 (pg. 13)

Drought in North Carolina

A Birdseye View...

December 13, 2007, 1 PM

Courtesy of:

- Lana Armstrong
- Waterfront Sportsman
- Dale Swiggett
- Bob Epting



Photographs by:

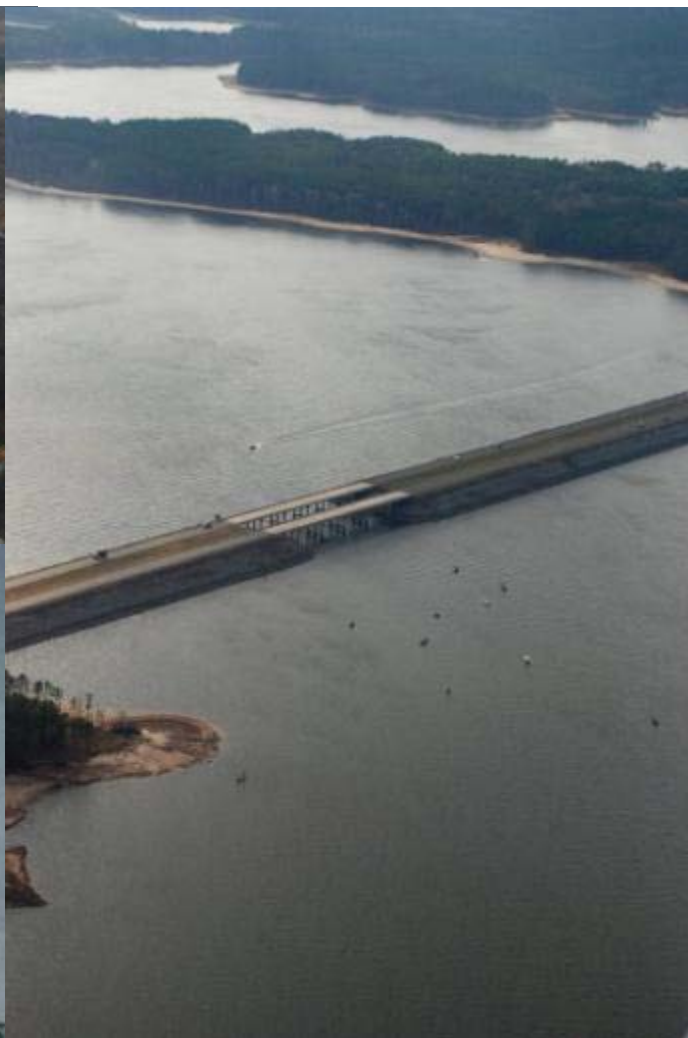
- Eric Schneider

Falls Lake, North Carolina



**Water level down
approximately 20 feet**

Jordan Lake, North Carolina



**Water level down
approximately 10 feet**

Wastewater Treatment



These are source of water running in the “rivers” shown entering Falls Lake and Jordan Lake

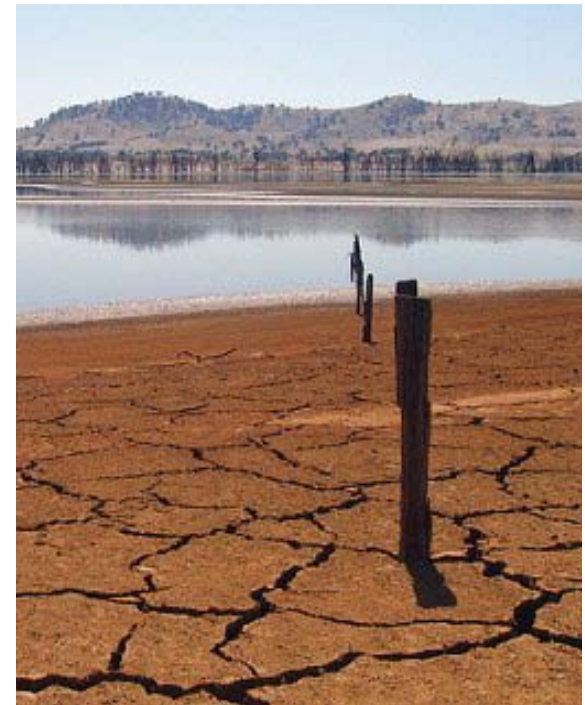


Sharon Harris Nuclear Power Plant



Evaporates approximately $\frac{1}{2}$ gallon of potentially potable water per kWh to produce electricity

Water Embedded in Energy



U.S. Sources of Electricity

- Thermoelectric power accounts 90% of all electricity
 - Coal (49%)
 - Natural Gas (20%)
 - Nuclear (19%)
 - Petroleum (2%)



Primary Effects of Once Through: Withdrawals

- Thermoelectric power generation accounts for approximately:
 - 136 billion gallons of water withdrawals per day
 - 39% of total freshwater withdrawals
 - 52 percent of fresh surface-water withdrawals.
- A 500 MW power plant uses over 12 million gallons of water per hour.
 - Equivalent to the volume of 436 Olympic sized swimming pools each day!

Primary Effects of Once Through: Rivers

- Cooling water intakes can endanger billions of fish, larvae and other aquatic organisms
- Low quality returning water:
 - Altered chemical composition
 - Higher temperature
 - Can affect fish, other aquatic organisms, animals and the local habitat



Primary Effects of Recirculating Wet: Consumption

- Approximately 25 percent of all non-agricultural fresh water consumption U.S. is used for thermoelectric power generation..



Water-Energy Nexus: A Necessary Synergy for the 21st Century National Conservation Training Center of the U.S. Fish and Wildlife Service November 17-19, 2008

PIER Project Summary, "Wet, Dry, Hybrid Wet/Dry and Alternative Cooling Technologies."

http://www.energy.ca.gov/research/environmental/project_fact_sheets/100-98-001-6.html

Consumption Trends: 2030

- Electricity demand increase of 50%
 - consumption of water for electrical energy production could more than double.
 - could equal the entire country's 1995 non-agricultural water consumption.

Hydroelectricity

- Accounts for an estimated 3.8 billion gallons of water loss per day



Water Consumption per kWh

| Power Provider | Gallons Evaporated per kWh at Thermoelectric Plants | Gallons Evaporated per kWh at Hydroelectric Plants | Weighted Gallons Evaporated per kWh of Site Energy |
|-----------------------|--|---|---|
| Western Interconnect | 0.38 (1.4 L) | 12.4 (47.0 L) | 4.42 (16.7 L) |
| Eastern Interconnect | 0.49 (1.9 L) | 55.1 (208.5 L) | 2.33 (8.8 L) |
| Texas Interconnect | 0.44 (1.7 L) | 0.0 (0 L) | 0.43 (1.6 L) |
| U.S. Aggregate | 0.47 (1.8 L) | 18.0 (68 L) | 2.00 (7.6 L) |

“Consumptive Water Use for U.S. Power Production.” National Renewable Energy Laboratory, 2003 <http://www.nrel.gov/docs/fy04osti/33905.pdf>

Water: Yet Another Reason to Push for Wind and Solar

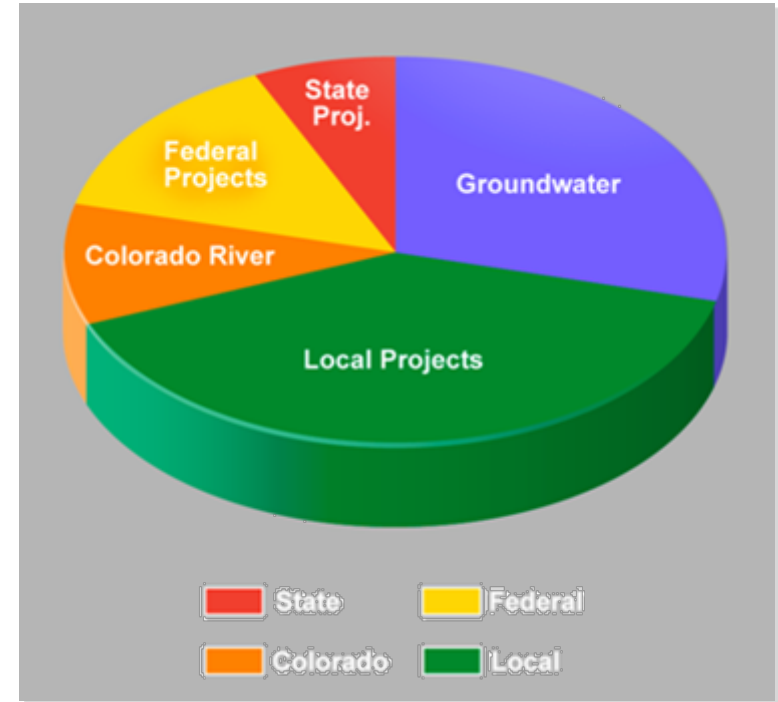


| Source | Gallons Per kWh |
|-----------------|-----------------|
| Wind | 0.001 |
| PV Solar | 0.030 |
| Nuclear | 0.62 |
| Coal | 0.49 |
| Oil | 0.43 |
| Hydro | 18.27 |



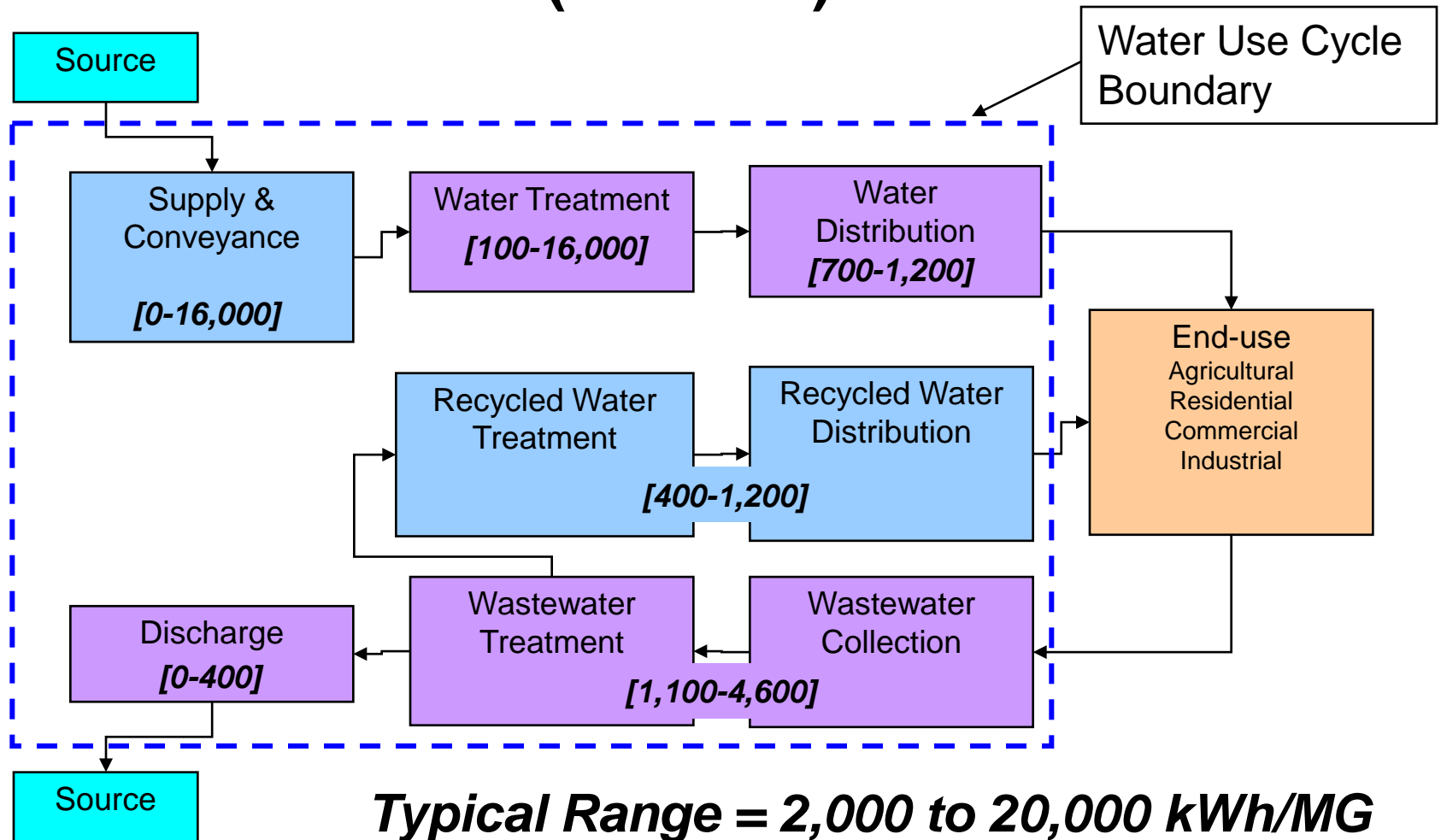
Energy Embedded in Water

California's Water Supply Systems



Lester Snow, California
Department of Water
Resources

Water Use Cycle Energy Intensities (kWh/MG)



Water-Related Energy Use-CA 2001

| | Electricity (GWh) | Natural Gas (Million Therms) | Diesel (Million Gallons) |
|---|----------------------|------------------------------------|--------------------------------|
| Water Supply and Treatment | | | |
| Urban | 7,554 | 19 | ? |
| Agricultural | 3,188 | | |
| End Uses | | | |
| Agricultural | 7,372 | 18 | 88 |
| Residential | 27,887 | 4,220 | ? |
| Commercial | | | |
| Industrial | | | |
| Wastewater Treatment | 2,012 | 27 | ? |
| Totals | 48,012 | 4,284 | 88 |
| 2001 Consumption | | | |
| | 250,494 | 13,571 | ? |
| Percent of Energy Use | | | |
| | 19% | 32% | ? |
| CO₂ e (Million Metric Tons) | | | |
| | 56 | 50 | |

Approximately 20-25 % of the nation's stationary energy use goes to water in some form.

Source: California Energy Commission, 2005 Integrated Energy Policy Report

Regional Differences

| Northern California | Southern California |
|---------------------|---------------------|
| kWh/MG | kWh/MG |

| | | |
|----------------------|--------------|--------------|
| Supply & Conveyance | 150 | 8,900 |
| Water Treatment | 100 | 100 |
| Distribution | 1,200 | 1,200 |
| Wastewater Treatment | <u>2,500</u> | <u>2,500</u> |
| Regional Total | 3,950 | 12,700 |

Source: California Energy Commission, 2005 Integrated Energy Policy Report

**What is the Water-Energy Relationship
where you live or work?**

Water & Wastewater System Energy Use

- U.S. annual total = 75 billion kilowatt hours per year
- 3-4% of total U.S. consumption of electricity
- Equal to entire residential electricity demand of California
- More than entire energy-intensive pulp/paper and petroleum sectors *combined*



Sources: Pacific Institute & NRDC

What Can Water and Waste Water Agencies Do?

Estimating Energy Intensity

- Call your water/wastewater utility and ask some questions
 - Water Utility
 - What was your energy bill?
 - How much water did you treat and deliver to customers?
 - Waste Water Utility
 - What was your energy bill?
 - How much waste water did you collect and treat?
 - To better understand the opportunities:
 - Do you have water/energy use data categorized by month?
 - Do you have historical data?
 - What types of water sources supply the system?
 - » Is the data separated by water source or facility?
 - » Which is the primary source?
 - » What time of the year are these sources used?

The following slides are provided courtesy of:

Bevan Griffiths-Sattenspiel

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Portland, Oregon

- Two Sources of Drinking Water
 - Gravity fed used most of the year
 - Groundwater pumped in the summer months when gravity cannot meet peak demands
- Two water treatment facilities
 - A large 73 MGD facility
 - A small 7.1 MGD facility
 - Unable to get disaggregated data
 - Numbers seem fairly typical

Portland, Oregon

2 Water Sources:

–Gravity

- 570 kWh per million gallons

–Groundwater

- 3710 kWh per million gallons

**Groundwater pumping consumes
6.5 times more energy per unit of water**

The following slides are
provided courtesy of:

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Alliance for Water Efficiency

www.aw4e.org

Comparative Energy Usage

Supply source: Lake Water

Pumping to Treatment Plant 636 kWh/AF (1,953 kWh/MG)

Treatment 395 kWh/AF (1,213 kWh/MG)

Wastewater Collection 596 kWh/AF (1,830 kWh/MG)

Wastewater Treatment 1,299 kWh/AF (3,988 kWh/MG)

Total: 2,926 kWh/AF (8,984 kWh/MG)

Comparative Energy Usage

Supply source: Ground Water

Pumping to Treatment Plant 600 kWh/AF (1,842 kWh/MG)

Treatment 395 kWh/AF (1,213 kWh/MG)

Wastewater Collection 596 kWh/AF (1,830 kWh/MG)

Wastewater Treatment 1,299 kWh/AF (3,988 kWh/MG)

Total: 2,890 kWh/AF (8,873 kWh/MG)

Comparative Energy Usage

Supply source: State Water Project

Pumping through Central Valley to Lake Silverwood
3,300 kWh/AF (10,131 kWh/MG)

Pumping from Lake Silverwood to Lake Arrowhead
Treatment Plant 2,550 kWh/AF (7,829 kWh/MG)

Treatment 395 kWh/AF (1,213 kWh/MG)

Wastewater Collection 596 kWh/AF (1,830 kWh/MG)

Wastewater Treatment 1,299 kWh/AF (3,988 kWh/MG)

Total: 8,140 kWh/AF (24,991 kWh/MG)

Water-Energy Relationship: Synergies

✓ End-User Water and Energy Conservation

- ✓ Saving water can save energy
- ✓ Saving energy can save water

✓ Water and Wastewater Utility Operational Efficiency

- ✓ Increasing water and wastewater system efficiency reduces energy in the water use cycle

✓ Water Storage

- ✓ Increased water storage and more flexible water storage shifts peak energy requirements
- ✓ Pumped storage increases peak electric generation and improves electric system efficiency

✓ Improve Price Signals

- ✓ Time of use water rates and meters
- ✓ Time of use electric rates and meters

✓ Renewable Generation by Water and Wastewater Utilities

- ✓ Increase generation from in-conduit hydro and biogas. Add generation from solar and wind.
- ✓ Assist in meeting California's renewable generation goals

**If we did all this,
what would be the combined impact on GHG emissions?**



Resources

California Energy Commission

www.energy.ca.gov

2005 Integrated Energy Policy Report,
Chapter 8 Integrating Water and Energy Strategies

<http://www.energy.ca.gov/2005publications/CEC-100-2005-007/CEC-100-2005-007-CMF.PDF>

California's Water-Energy Relationship-Final Staff Report

<http://www.energy.ca.gov/2005publications/CEC-700-2005-011/CEC-700-2005-011-SF.PDF>

Refining Estimates of Water-Related Energy Use in
California

<http://www.energy.ca.gov/2006publications/CEC-500-2006-118/CEC-500-2006-118.PDF>

Resources

California Public Utilities Commission

www.cpuc.ca.gov

- Water Action Plan

http://www.cpuc.ca.gov/static/hottopics/3water/water_action_plan_final_12_27_05.pdf

- Joint Agency Symposium: “*The Regulatory Challenge Linking Water and Energy*” March 28, 2006. http://energy.ca.gov/process/water/2006-03-28_symposium/index.html

- Water-Energy Partnership

- CPUC Rulemaking 06-04-010 on Energy Efficiency –Proceedings

<http://www.cpuc.ca.gov/Published/proceedings/R0604010.htm>

Resources

- Climate Action Team and Initiatives
 - http://www.climatechange.ca.gov/climate_action_team/index.html
- State Water Resources Control Board (SWRCB) Calendar
 - http://www.swrcb.ca.gov/board_info/calendar/2008.html
- California Department of Water Resources (DWR) Water Plan
 - <http://www.waterplan.water.ca.gov/>