Energy & Water Nexus: Availability & Impacts

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• **Water-Energy Link**

**Water for Electricity Production**
(Thermoelectric -- cooling) / Hydro / Mining)

Energy

**Energy for Water & WW**
(Pumping / Extraction / Transfer, W&WW Treatment, Distribution, Disposal)

Water

Reliability & Sustainability of Both Entities Linked with Each Other Strongly
• Typical Urban Water Cycle

Source Water
Ground / Surface

Extraction / Transfers
Pumping

Distribution
Pumping

Raw Water
Treatment

End Users

Pumping to WWT Plant

WWT / Water Recycling Plant

Disposal
Energy & the Water Sector

Worldwide Water Pumping
~ 7% of World’s Total Energy Use
→ ~ Energy Use in Japan & Taiwan Combined

U.S.* 3% of Total Electricity Use for Pumping
+1% for Treatment of W&WW

Water Facilities 161,000 (Public & Private)
~ 60,000 POWT Systems, Serves 92% of Population

WW Facilities 16,225 (~ All Publicly Owned)

For U.S. Water Cycle**: 521 x 10^6 MWhr
13% of All Electricity Produced in the U.S.
→ 290 M Metric Tons CO2e GHG Emissions

* EPRI, 2002
** River Network, 2009
• Energy Input in Typical Water Cycle

Energy Intensity:
2,000 – 20,000 kWh/MG

Source

Collection, Extraction & Conveyance

22.5%

Water Treatment

Water Distribution

End-use

Commercial 12.6%
Industrial 17.3%
Residential 28.3%
Agricultural 15.2%

Nat. Gas Use:
Ag., W & WWT 1.8%
Residential 48.4%
Commercial 5.6%
Industrial 44.2%

Resource Water Collection

Resource Water Treatment

Recycled Water Collection

Recycled Water Distribution

Recycled Water Treatment

Discharge

Energy Input

Source
• Major Energy User in the Water Systems

Electric Pump/Motors –

Single Largest Category Electric End-Use, Consumes 23% of all Electricity Sold in the U.S., & Generally Most Inefficient (Survey Finds Eff. Range 5 – 80%)

Water Treatment

WW Treatment

<table>
<thead>
<tr>
<th>Process</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aeration</td>
<td>55%</td>
</tr>
<tr>
<td>Pumping</td>
<td>14%</td>
</tr>
<tr>
<td>Solids Handling</td>
<td>14%</td>
</tr>
<tr>
<td>Others</td>
<td>90%</td>
</tr>
</tbody>
</table>

Others (lighting, belt press, clarifiers, return sludge handling etc)

Life Cycle Cost of Pump

• **Electricity Use @ W&WWTP Level**

Energy Costs:
Could be as High As 80% of Plant’s Energy Costs,
40 – 55% of W&WW Utilities’ Operating Budget,
2nd after Staffing, &
One of Five Top Rated Concerns.
• **Reducing Energy Use @ W&WW Facilities**

Water Conservation & Water Use Efficiency,  
Repairing / Replacing Leaking & Damaged Pipes & Equipment,  
Energy Efficient Buildings, Lighting, & HVAC Systems,  
Reducing Process Energy Usage,  
Replacing / Retrofitting Aging Equipment with More Efficient Technologies  
(VFDs, More Efficient Pumps & Motor Systems, etc.)  
Improving Electrical Load Management through Scheduling or Control modifications, &  
Adding System Flexibility with Storage.
• Emerging Challenges in W-E Nexus

Increasing Population

→ More Water & Energy Needs

Traditional Water Sources →
Dwindling Supplies + Deteriorating Quality + New Contaminants + Environmental & Regulatory Constraints (i.e. Stringent Regulations)

→ Energy Intensive Technologies
(UF, MF, UV, Ozone, MBRs, Desalination)

Water Related Energy Demand is Increasing @ Much Faster Rate – May be 50% More by 2030

New Kids on the Block

GHG Emissions / Climate Change Impacts, → Carbon Neutrality; & Sustainability Considerations
• **Measures Needed - Water Side**

**Short-Term Actions**

- Aggressively Increasing Water Conservation, Water Use Efficiency, & Water Leak Detections;
- Expanding Water Storage & Improved Coordination between Stored and Other Water Supplies;
- Developing Conjunctive Use Management Plans;
- Water Efficiency in Ag. Sector by Applying All Feasible Efficient Water Management Practices;
- Increasing Use of Recycled Water
- Developing Other Local Resources - Desalination

**Long Term Strategies include**

- R&D and Monitoring & Evaluation Activities

  Evaluating Long Terms Impacts of CC on Future Water Supply through Expanded Monitoring and Atmospheric Observations,

  Identifying Research Needs to Help Reducing Vulnerability to Climate Change, etc.
• Future Water & WW Treatment Systems

**Sustainability** through **Holistic** Water-Energy Management Approach,

**Incorporate** **Broader Vision** & **Flexible Engineering Design** Over the System’s Life Span in Terms of:

- Treatment Capacity
- Capital Investment & Operating Costs
- Source Water Quality
- Effluent Standards, &
- Biosolids Management

**Wastewater Treatment Systems will Serve as Resource Centers to Recover & Reuse:**

- Water, Energy, Nutrients, & Heavy Metals
Emerging Considerations in Sustainable Water Systems

- Water Transfers vs. Developing Local Water Sources, Demand & Constraint Based Advanced Transport & Treatment Management Systems,
- Innovative & EE Treatment Processes & Technologies, Advanced Sensors and Real Time Monitoring of Raw Water Quality for Instantaneous Treatment Process Control & O&M Optimization;
- New Design, Management, & Operational Philosophies (e.g. Decentralized Treatment Systems);

Better Coordination
Among Resource Management Agencies to Identify and Address Energy Implications of Water Policy Decisions.

Learn from Others
Oil Industry - Avoid Racing to the Pump
Explore Alternatives
• Future Water Resources Development
  – On Case by Case Basis

(Singapore NEWater)
900 – 1,150 kWh / AF
• Renewable Energy Helps Saving Water

(gal / kWh)

Wind  0.001
PV Solar  0.030
Oil  0.43
Coal  0.49
Nuclear  0.62
Hydro  18.27

Avg. Water Use / Loss:

Hydro vs. Thermal:
18.27 vs. 0.47 (Gal/kWh)
California Energy Commission

• Government can Help Accelerating the Water-Energy Systems’ Sustainability by Supporting:
  
  RD&D Programs
  Technology Transfer Activities, and
  Education, Information Dissemination & 
  Out Reaching