Exploring Energy-Water Issues in the United States

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Crosscutting Research and Rare Earth Elements Review
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Challenge

Thermoelectric energy production withdraws more water in the U.S. than any other use sector.

Energy-Water Nexus Issues are playing out all across the U.S.

Source: DOE 2013

Source: USGS 2014
Objectives

- Extend capabilities of the Integrated Environmental Control Model (IECM) to assess alternative options for designing and managing power plant water systems at the unit level.
- Develop a National Water Atlas, estimating water availability, cost and projected future demand at the watershed level (8-digit HUC, or roughly 2250 watersheds).
Power Plant Lifecycle Water Use
Configure a Plant with Wet or Dry or Hybrid Cooling to Assess Plant-Level and Life Cycle Water Use
Hybrid Cooling System
### Life Cycle Water Use

![Image of data interface](image)

#### GET RESULTS: Water Life Cycle Assessment: Water Withdrawals

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Process/Chemical</td>
<td>Water Withdrawal (gal/MWh)</td>
</tr>
<tr>
<td>1 Fuel Extraction</td>
<td>2.170</td>
</tr>
<tr>
<td>2 Fuel Supply</td>
<td>15.00</td>
</tr>
<tr>
<td>3 Fuel Processing</td>
<td>13.01</td>
</tr>
<tr>
<td>4 Fuel Transport</td>
<td>0.7234</td>
</tr>
<tr>
<td>5 Total Fuel Supply</td>
<td>15.00</td>
</tr>
<tr>
<td>6 Plant Infrastructure</td>
<td>15.30</td>
</tr>
<tr>
<td>7 Ammonia (90-95% MEA)</td>
<td>0.0</td>
</tr>
<tr>
<td>8 Limestone</td>
<td>2.479</td>
</tr>
<tr>
<td>9 Total Chemical Production</td>
<td>3.509</td>
</tr>
<tr>
<td>10 Plant Operation</td>
<td>657.5</td>
</tr>
</tbody>
</table>

**Total Life Cycle**

693.2 gal/MWh
Water for Thermoelectric Development
Integrated Transmission Planning

- Interconnections are conducting long-range transmission planning (20 yrs.)
  - Siting of new power plants
  - New transmission capacity
- Address water issues:
  - Reduce impact of development on water resources,
  - Reduce vulnerability of system to “water interruptions”
Methods: Collected Data from States

**Water Supply**
- Mean Gauged Streamflow

**Water Demand**
- Municipal Demand
- Irrigation Demand

**Water Institutions**
- Groundwater Depletion
- Unappropriated Water
- Administrative Control Areas
Methods: Metric Development

- Data on “available water” are rare
- As such, metrics were estimated from available information
- Assisted by volunteer team from WSWC
  - Bret Bruce (USGS)
  - Dan Hardin (TX)
  - Sara Larsen (WSWC)
  - Dave Mitamura (TX)
  - Andy Moore (CO)
  - Ken Stahr (OR)
  - Todd Stonely (UT)
  - Steve Wolff (WY)
  - Dwane Young (WSWC)
Methods: Water Sources

- **Potable Water**
  - Unappropriated surface water
  - Unappropriated groundwater
  - Appropriated water (rights transfers)

- **Non-Potable Water**
  - Municipal/Industrial wastewater
  - Shallow brackish water
Water Availability: Fresh Surface Water

- Surface water beyond current use that is available for new development.
- Based on environmental constraint:
  \[ Q_{sw}^j = 0.5 \times (Q_p^j + C^j) - C^j \]
- Areas of Concern (basins outlined in red) designated regions requiring additional permitting.
Water Availability: Fresh Groundwater

- Groundwater beyond current use that is available for new development.
- Difference between sustainable recharge and pumping while considering:
  - Areas of overdraft, and
  - Principle aquifers.
- Areas of Concern (basins outlined in blue) designated regions requiring additional permitting.
Water Availability: Wastewater

- Projected future wastewater (2030) available for re-use.
- Reflects wastewater currently being reused.
Water Availability: Brackish Groundwater

- Brackish water defined by salinities between 1,000 and 10,000 ppm TDS no deeper than 2500 ft.
- Estimates are data limited based on:
  - Current brackish water use, and
  - USGS well logs that indicated brackish water availability.
Projected Future Use 2010-2030

- Water needed for development after 2010.
- Based on estimates directly from states.
- Does not include thermoelectric water demand.
Water Supply Availability

Fresh Surface Water

Fresh Groundwater

Municipal Wastewater

Brackish Groundwater

Consumptive Demand 2010-2030
Water Cost

- Goal is to establish a consistent and comparable measure of cost to deliver water of potable quality to the point of use.

- Basic costs considered:
  - Capital costs:
    - Purchase water,
    - Wells,
    - Conveyance, and
    - Treatment.
  - Operation and Maintenance:
    - Electricity,
    - Labor,
    - Consumables, and
    - Disposal.
Water Supply Availability: West

Unappropriated Surface Water

Unappropriated Groundwater

Municipal Wastewater

Brackish Groundwater

Appropriated Water

Consumptive Demand 2010-2030
Relative Cost of Water: West

Unappropriated Groundwater

Appropriated Water

Municipal Wastewater

Brackish Groundwater
Integrated Energy-Water Planning
Effects of Alternative Water Sources as Makeup Water for Cooling System on Annual Levelized Water Use Cost and Total Variable O&M Cost for Units under the Rate-based Emission Standard outlined by Clean Power Plan*

*In the base case, the water price for fresh water already in use is assumed to be $0/kgal.
Methods: Scenario Development

- **Reference Case**: adopted trajectory of recent WECC planning information.
- **Scenario One**: favored continued trends in growing use of natural gas and renewables.
- **Scenario Two**: distinct shift toward renewables, energy efficiency and significant carbon tax.
- **Scenario Three**: reliance on traditional technologies while simply meeting current state renewable portfolio standards.
- **Scenario Four**: similar technology development and policies as in scenario two except limited by sluggish economic growth.

Source: WECC 2013
Data Utilization: Transmission Expansion Planning
Data Utilization: Integration in Regional Energy Deployment System model (ReEDS)

Effect of Water Constraint on Future Thermoelectric Water Consumption

NREL 2015
Data Utilization: EISPC EZ Mapping Tool

The EISPC Energy Zones Mapping Tool is a free online mapping tool to identify potential clean energy resources in the Eastern Interconnection. This website provides information about the study, background on the energy resources, and details on the data layers used in the tool. There are also links to policies and regulations, printable maps, documents, and related links.

Features:
- Nine energy resources: Biomass, Clean Coal, Geothermal, Nuclear, Solar, Wind, and Hydro
- Flexible analysis of siting factors such as slope and land protections
- Analysis of potential collection of energy technologies
- Informal analysis to reduce new transmission construction

Getting Started:
Click the Launch Tool button above to start the tool, or view an introductory video, or use the help menu at the top of the page for more detailed directions.

Partners and Sponsors:
The study is led by the Eastern Interconnection States Planning Council (EISPC). The research support and technical assistance to EISPC is provided by Argonne National Laboratory, National Renewable Energy Laboratory, and Oak Ridge National Laboratory. Funding is provided by the U.S. Department of Energy.
Summary

- Seeing clear impacts today from the climate-energy-water nexus.
- Need data and tools to integrated water into energy planning.
- The Integrated Environmental Control Model (IECM) has been extended to aid in designing and managing power plant water systems at the unit level.
- Water Atlas is being developed to map water availability, cost and future use at the 8-digit HUC level for different sources of water.