Estimating Freshwater Needs to Meet Future Thermoelectric Generation Requirements in Western United States

Thomas J. Feeley, III
National Energy Technology Laboratory

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Outline

• Background on issue
• Thermoelectric withdrawal and consumption projections
• NETL’s R&D program
• Estimated benefits of R&D
• Summary
The Issues: Competing Water Uses

U.S. Freshwater Withdrawal (2000)

- Thermoelectric, 39%
- Public Supply, 13%
- Domestic, 1%
- Irrigation, 40%
- Livestock, 1%
- Aquaculture, 1%
- Industrial, 5%
- Mining, 1%

U.S. Freshwater Consumption (1995)

- Thermoelectric, 3%
- Mining, 1%
- Industrial, 3%
- Livestock, 3%
- Domestic, 6%
- Irrigation, 81%

- 2000 thermoelectric water requirements:
  - Withdrawal: ~ 136 BGD
  - Consumption: ~ 3 BGD

- Thermoelectric competes with other users, including in-stream use.
- Which is more important: drinking and personal use, growing food, or energy production?

Sources: USGS, Estimated Use of Water in the United States in 2000, USGS Circular 1268, March 2004

Recent Articles on Water-Related Impacts on Power Plant Siting and Operation

- Idaho May Adopt Moratorium on Coal Power Due to Water Issues
  - Reuters, March 2006

- California’s Efforts to End Use of Sea Water to Cool Plants Could Jeopardize 24 GW
  - POWERnews, October 2006

- Energy Project Could Threaten Water Supply in Salina, Kansas
  - McClatchy-Tribune Business News, November 2006

- Desert Rock Water Agreement Passes Navajo National Committee
  - The Daily Times, February 2006

- Southern Drought Leads to Shutdown of Hydro, Forcing Utilities to Buy from Market
  - POWERnews, October 2006
### Summary of Generation Capacity Impacted by Water-Related Issues

<table>
<thead>
<tr>
<th>Plant Generation Type</th>
<th>Generation Affected by Availability Issues (MW)</th>
<th>Generation Affected by Environmental Issues (MW)</th>
<th>Total Affected Generation (MW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pulverized Coal</td>
<td>17151</td>
<td>1200</td>
<td>18351</td>
</tr>
<tr>
<td>Hydro</td>
<td>8040</td>
<td>0</td>
<td>8040</td>
</tr>
<tr>
<td>Nuclear</td>
<td>4113</td>
<td>985</td>
<td>5098</td>
</tr>
<tr>
<td>Natural Gas/NGCC</td>
<td>1225</td>
<td>2887</td>
<td>4112</td>
</tr>
<tr>
<td>Total</td>
<td>30529</td>
<td>5072</td>
<td>35601</td>
</tr>
</tbody>
</table>

- New plants face difficulties in obtaining water withdrawal permits
- Existing plants face reduced generation
Projected Thermoelectric Capacity & Population Increases from 2005 to 2030

Regional Population and Thermoelectric Capacity Projected to Rise Significantly in the Future

Demands on our Limited Water Resources Expected to Constrain Regional Development

Sustainable Energy-Water Resource Strategies are Needed!


Water Use Projection Cases

- **Case 1 (Status Quo)** – Additions and retirements are proportional to current water source and type of cooling.

- **Case 2 (Regulatory Driven)** – All additions use freshwater and wet recirculating cooling (WRC), while retirements are proportional to current water source and type of cooling.

- **Case 3 (Regulatory Light)** – 90% of additions use freshwater and WRC, and 10% of additions use saline water and once-through cooling, while retirements are proportional to current water source and type of cooling.

- **Case 4 (Dry Cooling)** – 25% of additions use dry cooling and 75% of additions use freshwater and WRC, while retirements are proportional to current water source and type of cooling.

- **Case 5 (Conversion)** – Additions use freshwater and WRC, while retirements are proportional to current water source and type of cooling. 5% of existing freshwater once-through cooling capacity is retrofitted with WRC every five years starting in 2010.
Projected Changes in U.S. Thermoelectric Sector Freshwater Withdrawal and Consumption

Projected Changes in U.S. Thermoelectric Sector Freshwater Withdrawal and Consumption


Regional Thermoelectric Withdrawal Results (Case 2)


Regional Thermoelectric Consumption Results (Case 2)

- California: 352% ↑
- Northwest Power Pool: 66% ↑
- Rocky Mountain: 74% ↑

Western Electricity Coordinating Council (WECC) Regions


Overview of Regional Results: Case 2 (2005 – 2030)

by Western Electricity Coordinating Council (WECC)

- EIA thermoelectric capacity projections:
  - 47% increase in California
  - 50% increase in Northwest Power Pool
  - 48% increase in Rocky Mountains

- Case 2 withdrawal projections:
  - 3% decrease in California
  - 32% increase in Northwest Power Pool
  - 38% decrease in Rocky Mountains

- Case 2 consumption projections:
  - 352% increase in California
  - 66% increase in Northwest Power Pool
  - 74% increase in Rocky Mountains

FE/NETL IEP Water Technology Categories

**Category A**
Offset freshwater use with non-traditional water sources

**Category B**
Scaling control

**Category C**
Water recovery

**Category D**
Water recovery

**Category E**
Coal drying

Air Pollution Control Devices
- SCR
- Air Heater
- ESP or FF
- Wet FGD

Evaporation & Drift
Make-Up Water
Blowdown Water
Make-up Water

Moist stack gas

Warm Water
Cool Water
Steam Condenser

Turbine
Generator
Coal
Condensate
Steam
## IEP Energy-Water Technology Categories & Current Projects

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
</tr>
</thead>
</table>
| **A**    | **Provide Alternate Source of Cooling Water Make-up**  
  - Use of Produced Water in Recirculated Cooling Systems at Power Generation Facilities & Development of an Impaired Water Cooling System  
  - Reuse of Treated Internal or External Wastewaters in the Cooling Systems of Coal-Based Thermoelectric Power Plants |
| **B**    | **Increase Cycles of Concentration for Wet Recirculating Systems, thereby Decreasing Wet Cooling Tower Blowdown Requirements**  
  - A Synergistic Combination of Advanced Separation and Chemical Scale Inhibitor Technologies for Efficient Use of Impaired Water as Cooling Water in Coal-Based Power Plants  
  - Application of Pulsed Electrical Fields for Advanced Cooling in Coal-Fired Power Plants |
| **C**    | **Advanced Cooling Technology**  
  - Use of Air2Air™ Technology to Recover Fresh-Water from the Normal Evaporative Cooling Loss at Coal-Based Thermoelectric Power Plants |
| **D**    | **Reclaim Water from Combustion Flue Gas for Use as Cooling Water Make-up**  
  - Water Extraction from Coal-Fired Power Plant Flue Gas  
  - Recovery of Water from Boiler Flue Gas  
  - Reduction of Water Use in Wet FGD System |
| **E**    | **Reduce Cooling Tower Evaporative Losses via Coal Drying**  
  - Use of Coal Drying to Reduce Water Consumed in Pulverized Coal Power Plants |
Technical & Cost Goals

- **Short Term** – Have technologies ready for commercial demonstration by 2015 that, when used alone or in combination, can reduce freshwater withdrawal and consumption by 50% or greater for thermoelectric power plants equipped with wet recirculating cooling technology at levelized cost of less than $2.40 per 1000 gallons freshwater conserved.

- **Long Term** – Have technologies ready for commercial demonstration by 2020 that when used in combination can reduce freshwater withdrawal and consumption by 70% or greater at levelized cost of less than $1.60 per 1000 gallons freshwater conserved.
WECC Region (U.S.) Water Withdrawal with IEP Program Technologies

WECC Regional Results:

NETL, IEP Technology Scenario - WECC Region (U.S.), Case 2, Year 2030

WECC/California Water Withdrawal with IEP Program Technologies

WECC Regional Results:

NETL, IEP Technology Scenario - WECC/CA, Case 2, Year 2030

WECC/Northwest Power Pool Water Withdrawal with IEP Program Technologies

WECC Regional Results:

WECC/Rocky Mountain Water Withdrawal with IEP Program Technologies

NETL, IEP Technology Scenario - WECC/RM, Case 2, Year 2030

WECC Regional Results:

- **WECC Total**
- **CA**
- **NWPP**
- **RM**

Base Case (No IEP Technologies)

50% Market Penetration

Percent Reduction in Freshwater Withdrawal
WECC Region (U.S.) Water Consumption with IEP Program Technologies

NETL, IEP Technology Scenario - WECC Region (U.S.), Case 2, Year 2030

WECC Regional Results:

WECC
Total
CA
NWPP
RM

WECC/California Water Consumption with IEP Program Technologies

NETL, IEP Technology Scenario - WECC/CA, Case 2, Year 2030

WECC Regional Results:

WECC Total

CA

NWPP

RM

WECC/Northwest Power Pool Water Consumption with IEP Program Technologies

WECC Regional Results:

WECC/Rocky Mountain Water Consumption with IEP Program Technologies

NETL, IEP Technology Scenario - WECC/RM, Case 2, Year 2030

WECC Regional Results: WECC Total, CA, NWPP, RM
### Summary of Potential IEP Energy-Water Technology Benefits to WECC Region

<table>
<thead>
<tr>
<th>Region</th>
<th>Withdrawal Change</th>
<th>Consumption Change</th>
<th>Benefit (a-f/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>WECC Region</strong></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Withdrawal: 28.5% decrease</td>
<td></td>
<td></td>
<td>0.42 million</td>
</tr>
<tr>
<td>Consumption: 15.7% decrease</td>
<td></td>
<td></td>
<td>0.37 million</td>
</tr>
<tr>
<td><strong>WECC/California</strong></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Withdrawal: 9.4% decrease</td>
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<td></td>
<td>0.13 million</td>
</tr>
<tr>
<td>Consumption: 32.1% decrease</td>
<td></td>
<td></td>
<td>0.11 million</td>
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<tr>
<td><strong>WECC/Northwest Power Pool</strong></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Withdrawal: 18.8% decrease</td>
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<td></td>
<td>0.11 million</td>
</tr>
<tr>
<td>Consumption: 28.3% decrease</td>
<td></td>
<td></td>
<td>0.10 million</td>
</tr>
<tr>
<td><strong>WECC/Rocky Mountain</strong></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Withdrawal: 26.6% decrease</td>
<td></td>
<td></td>
<td>0.17 million</td>
</tr>
<tr>
<td>Consumption: 26.7% decrease</td>
<td></td>
<td></td>
<td>0.16 million</td>
</tr>
</tbody>
</table>

Projected benefits for Case 2, Year 2030, with a 50% Market Penetration. Values represent the maximum potential from the array of technology scenarios. [a-f/yr = acre-feet per year]
Summary

- Water-related issues will continue to challenge siting of new and/or operation of existing thermoelectric power plants.

- These issues may become more critical in future due to competing demands, population growth, and increased energy demands.

- In response, NETL will:
  - Update our analyses of water needs related to thermoelectric generation and coal, oil and natural gas production.
  - Continue research and development of advanced water management technologies and concepts.
  - Continue to work with/support Energy-Water Nexus team.
To Find Out More About NETL’s Energy-Water R&D

Questions?