Climate Influences on Capacity Expansion Planning

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Water and Energy: What Connection Can We Draw?
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Energy-Water-Climate Issues
322 BGD Total Withdrawals
~7-8 BGD Total Consumption

Source: USGS 2018

Source: Tidwell et al. 2016
Current Impacts

Climate Extremes Impact Power Production

Water Scarcity Impacts Plant Siting

State denies permit to Burrillville power plant

Burrillville – In a gripping decision that followed several delays, the state Energy Facility Siting Board today denied an application to build an oil and gas-burning power plant in Burrillville.

The decision came after just a few hours of public debate: dozens of opponents of the state board expressed doubts about the state's energy produced by the plant, key argument made by representatives of the company.

The decision was a victory for environmentalists and local residents, some of whom have been fighting for years to prevent the plant from being built.

Company's bid to use groundwater for nuclear plant denied

PHEONIX (AP) – Arizona water regulators have rejected an application by an energy company to tap groundwater in the Phoenix area to cool its energy-producing plants in the area.

The water district, which service most of the city, said the application was not in the public interest.

The decision comes as the state faces growing concerns about drought and the need to conserve water resources.

The permit requires water use on other beneficial uses, state department officials said.
Cascading Impacts on Electric Power

- Change in precipitation
- Increased temperatures
- Increased evaporation
- Increased water demands challenge deliveries to thermoelectric plants
- Higher temperatures reduce transmission line capacity
- Increased temperatures reduce transformer and substation capacity
- Range/forest fires damage transmission infrastructure
- Higher temperatures reduce plant efficiency
- Lost reservoir operational flexibility threatens balancing of variable wind/solar generation
- Increased temperature leads to increased peak electricity demand
Reduced Water Use

Systems are Moving to Less Water Intensive Forms of Generation

Current generation relies on high-water use technology:
- Coal
- Gas-Steam
- Nuclear

New capacity favors low-water use technology:
- Natural gas combined cycle
- Wind
- Solar PV

Source: UCS 2011
Reduced Withdrawals

Systems are Moving to Less Water Intensive Forms of Cooling

High Water Withdrawal
Low Water Consumption

Low Water Withdrawal
High Water Consumption

Open-loop “once-through” cooling cycle

Closed-loop cooling cycle

Source: EPRI 2002
Alternative Water Source

Retrofit existing plants to eliminate freshwater use

- **Retrofit options:**
  - Dry cooling
  - Municipal waste water
  - Brackish groundwater

- **Costs:**
  - Capital
  - Operating and Maintenance
  - Capture
  - Treatment
  - Parasitic energy losses

1,178 Freshwater Using Thermoelectric Power Plants

Water Availability

- Municipal Wastewater
- Brackish Groundwater
Alternative Water Source

<table>
<thead>
<tr>
<th>Technology</th>
<th>Number of plants</th>
</tr>
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<tr>
<td>Waste water</td>
<td>823</td>
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<tr>
<td>Brackish water</td>
<td>109</td>
</tr>
<tr>
<td>Dry cooling</td>
<td>246</td>
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</tbody>
</table>

1,178 Freshwater
Using Thermoelectric Power Plants

Note: ΔLCOEs tend to be lower in the West, Texas Gulf Coast and south Florida, which are areas prone to drought stress.

Least cost alternative values mapped on watersheds vulnerable to drought (outlined in red).

With wholesale cost of electricity about $40/MWh*, many retrofits could be accomplished at levels that would add less than 10% to current power plant generation expenses.

*average 2012 wholesale cost over 3 US trading hub regions

Source: Tidwell et al. 2014
**Integrated Planning**

- Integrated climate into WECC’s capacity expansion planning exercise
- Explored how water extremes influence planning decisions

Analysis platform included:
- Hydrologic modeling,
- Capacity expansion modeling, and
- Production Cost Modeling
Limited Supply for Development

Fresh Surface Water
Fresh Groundwater
Appropriated Water

Wastewater
Brackish Water
Growth in Demand 2015-2035

Source: Tidwell et al. 2018
Limited Water for Hydropower

Relative trends in available hydropower

Moderate emissions pathway

Extreme emissions pathway
Climate Impacts on Capacity Expansion

Generation Expansion Profiles

Difference with and without Water Constraint

- Additional capacity needed to meet peak load.
- Hydropower production is key uncertainty.
- Considerable adaptive capacity available in the grid.

Implications for System Reliability and Cost

Source: Tidwell et al 2020
Heat-driven demand can increase costs, but increased hydropower can reduce costs.

Cumulative climate impacts on cost range from -17.7–17.6 billion $

Climate impacts on electricity prices are small compared to technology and electrification.
Climate Impacts on Environment

Implications for Future Water Use

Combined influence of climate and water availability influence siting decisions

Source: Tidwell et al 2020
Key Points

1. Energy-Water-Climate issues are affecting energy production today.

2. Without attention these issues will intensify.

3. Changes in the energy and water sectors are mitigating some climate vulnerabilities.

4. Options are available to adapt to a changing and uncertain future.
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