Regional Analysis of Dry Cooling Retrofits Using IECM

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Disclaimer and Acknowledgments

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Motivation

• Thermoelectric power plants are a major source of freshwater withdrawals and consumption in the U.S.

• Increasing water stress in arid regions or during dry seasons has driven some states to restrict freshwater use by power plants.

• Future capacity expansion in these regions can be constrained by water availability (and exacerbated by climate change).

• Evaporative emissions from wet cooling towers are typically the largest source of water consumption at electric power plants.
Project Objectives

- Estimate the potential savings in water consumption that would result from retrofitting dry cooling systems at existing coal-fired power plants with wet cooling systems in a specified region.
- Estimate the associated costs of these retrofits.
- Identify the potential for a shortfall in net generating capacity due to the increased energy requirements of dry cooling.

All impacts to be evaluated at each electrical generating unit (EGU) on a monthly and annual average basis, with results aggregated to the regional level.
• The study region includes two states: Arizona and New Mexico. Existing coal-fired units with wet cooling tower systems are:

• Plants in Arizona:
  - Cholla (2 units)
  - Apache Station (1 unit)
  - Coronado (2 units)
  - Springerville (4 units)

• Plants in New Mexico:
  - Escalante (1 unit)
  - San Juan (2 units)

Total = 6 locations and 12 units analyzed
## Existing Coal-Fired EGUs with Wet Towers in Arizona and New Mexico*

<table>
<thead>
<tr>
<th>State</th>
<th>New Mexico</th>
<th></th>
<th>Arizona</th>
<th></th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Escalante</td>
<td>San Juan</td>
<td>Cholla</td>
<td>Apache</td>
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<tr>
<td></td>
<td>Escalante</td>
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<td>Cholla</td>
<td>Apache</td>
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<tr>
<td>Nameplate capacity (MW)</td>
<td>257</td>
<td>369.0</td>
<td>555.0</td>
<td>312.3</td>
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<td></td>
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<td>414.0</td>
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<td>Annual net heat rate (Btu/kWh)</td>
<td>10,740</td>
<td>11,232</td>
<td>11,649</td>
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<td>Parasitic load (% of MWg)</td>
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### Air Pollution Controls

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<th>NOx (in-furnace)</th>
<th>NOx (post-combustion)</th>
<th>Mercury</th>
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<td>Wet FGD</td>
</tr>
<tr>
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<td>√</td>
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<td>√</td>
<td>Wet FGD</td>
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<td>Dry FGD</td>
</tr>
</tbody>
</table>

*As of 2017
Monthly Net Heat Rate of Existing Coal-Fired Units with Wet Towers
Monthly Temperature Trend at Climate Monitoring Stations Nearest Each Plant

Air Dry-Bulb Temperature (°F)

Month of 2017

Springerville /Coronado
Apache Station
Cholla
San Juan
Escalante
Research Approach

• Use the IECM to model each unit with a wet cooling system; estimate its current monthly and annual water consumption, and the levelized cost of electricity generation over its remaining life

• Repeat the unit-level analysis assuming retrofit of a new dry cooling system (air cooled condensers, ACC)
  • Update the IECM thermodynamic and cost models for ACC based on a recent NETL study of dry cooling system performance, capital cost, and operating & maintenance costs

• Use these results to calculate the dry cooling system water savings, cost per gallon of water saved, and net MW capacity reduction at each plant; aggregate these results to regional totals and averages
Modeling Coal-Fired Units in IECM

Free IECM download at: www.iecm-online.com
Key Assumptions for Unit-Level Analysis

- Dry cooling system size is based on annual average ambient conditions
- Monthly plant heat rate and parasitic load with dry cooling are adjusted based on monthly average dry bulb air temperature
- Dry cooling capital cost is amortized over 30 years or remaining EGU life (based on a 50 year life)
- Base case assumes IECM water price and no capital cost premium for retrofits
- Monthly fuel use and operating hours are same for pre- and post-retrofit cases

See two NETL reports for details of all modeling assumptions

Plant-Level Parametric Cooling Technology Models

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Haozhi Zhai, Edward S. Rubin
June 2014

April 3, 2020
Key Results for Existing Coal-Fired EGUs with Wet and Dry Cooling Systems

Water Consumption Intensity

Levelized Cost of Electricity

Regional average water consumption falls by 92.5%

Regional average cost of electricity increases by 12.4%
Cost per Gallon of Water Saved

Cost of Reduced Water Consumption vs. Annual Water Savings

Regional average cost = $9.6/kgal saved

100% = 14.5 billion gal/yr

Cumulative Annual Water Consumption Saved (% of current regional total)

Regional Cost Sensitivity to Water Price and Retrofit Factor

Base Case

Cost of Water Consumption Saved ($/kgal)

Cost of Water Consumption Saved ($/kgal)

Water Price ($/kgal)
Changes in Net Regional Capacity after Dry Cooling Retrofits

• On an annual basis, the estimated reduction in net regional capacity is 32 MW, or 0.8% of total net capacity.

• On a monthly basis the change in net regional capacity varies from:
  • +8 MW to -79 MW, or
  • +0.2% to -2.0% of net capacity
  • The largest decreases in capacity (and water consumption) occur in the month of July.

These decreases in net regional capacity can be offset by increases in unit-level capacity factors.
Conclusions

- Replacing wet cooling tower systems with dry cooling systems can substantially reduce power plant water consumption in dry, arid regions.
- There are tradeoffs in terms of increased cost and reductions in net generating capacity, especially during summer months.
- This study estimated the magnitude of these water reduction benefits and associated costs for coal-fired power plants in a two-state region of the western U.S.
- Additional plant-level data and analysis are needed to refine the estimates presented here, or to extend them to shorter time periods.
Thank you

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