Consumptive water-use estimates for thermoelectric power plants in the Apalachicola-Chattahoochee-Flint basin

Jenny Murphy and Tim Diehl, USGS Tennessee Water Science Center, Nashville
Thermoelectric water use

Withdrawal vs. Consumption (Evaporation)

Once-through cooling

Cooling Towers

Three Mile Island Nuclear Plant

Thermal plume

Brunner Island Coal Plant
Consumption Coefficients

Once-through cooling at coal plants

Literature References
See last slide for citation
Basis of model

**Heat-budget model**
Thermodynamics of evaporation
(Diehl, poster: Abstract 6e)

**Synthesized published methods:**
- Leung and Moore 1970
- Ward 1980
- Harbeck 1964

Once-through cooling
Basis of model

Heat-budget model
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(Diehl, poster: Abstract 6e)

Synthesized published methods:
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• Ward 1980
• Harbeck 1964
Structure of model

- Cooling Tower model
- Once-Through cooling model

Consumption model: amount of evaporation

Percent evaporation

OR

(Diehl, poster: Abstract 6b)
Structure of model: input data

Environmental variables
Monthly average
1) Dry bulb temperature
2) Wet bulb temperature
3) Wind speed
4) Water temperature
Structure of model: input data

Environmental variables

Power plant variables & characteristics
1) Cooling system type
2) Boiler efficiency
3) Monthly net generation
4) Monthly fuel heat
Consumption Coefficients, revisited

Once-through cooling at coal plants

Gallons per kWh

Literature References
See last slide for citation

Once-through cooling at coal plants

3.1

Literature References

See last slide for citation
Consumption Coefficients, revisited

Once-through cooling at coal plants

Literature References

See last slide for citation

Gallons per kWh

Unrealistic

Realistic

Unrealistic
Consumption Coefficients, revisited

Once-through cooling at coal plants

Gallons per kWh

0.5

1

3.1

Literature References

See last slide for citation

Unrealistic

Realistic for individual plants

Unrealistic

1 2 3 4 5 6 7 8 9
Case Study: ACF

Plants ranked by size

1) Wansley
2) Joseph M Farley
3) Yates
4) Jack McDonough
5) Wansley Unit 9
6) Wansley Combined Cycle
7) Chattahoochee Energy Facility
8) Mitchell
9) Scholz
10) Crisp Plant
## Consumption Scenarios

### Environmental conditions

<table>
<thead>
<tr>
<th>Generation</th>
<th>Average (20-30yr avg)</th>
<th>2007 (Drought)</th>
</tr>
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<td>Average (2003-2009)</td>
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Maximum monthly consumption in cfs
## Consumption Scenarios

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Maximum monthly consumption in cfs

**2007 August streamflow in ACF = 6,209 cfs**
## Consumption Scenarios

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<th>2007+2°C</th>
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Maximum monthly consumption in cfs

**2007 August streamflow in ACF = 6,209 cfs**
Sensitivity analysis: Once-through cooling

High sensitivity
- Wind speed
- Water temperature

Low sensitivity
- Dry bulb temperature
- Wet bulb temperature

Example: Mitchell power plant
Flint River, Georgia
(Harbeck 1964)
Sensitivity analysis: Cooling Tower

2°C increase over 2007 temperatures

**High sensitivity**
- Wet bulb temperature
- Dry bulb temperature

**Insensitive**
- Water temperature

Percent change in evaporative cooling

Percent evaporative cooling in 2007
Tower versus Once-Through: Seasonal

Jack McDonough

Consumption in cfs

Month

Cooling Towers

Once-through cooling
Conclusions

- Published estimates of water consumption vary widely and most fall outside range of plausible thermodynamic limits
Conclusions

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• Thermoelectric water consumption in ACF was 2% of 2007 August streamflow
Conclusions

• Published estimates of water consumption vary widely and most fall outside range of plausible thermodynamic limits
• Thermoelectric water consumption in ACF was 2% of 2007 August streamflow
• Cooling towers consume more water but reduce thermal load on the stream
Questions?

Acknowledgments
Melissa Harris, Susan Hutson, Kim Shaffer, David Stannard
Citations


Once-through consumption coefficient references: