

The Energy Water Nexus: Financial and Environmental Modeling Tools for Alternative Cooling Technologies



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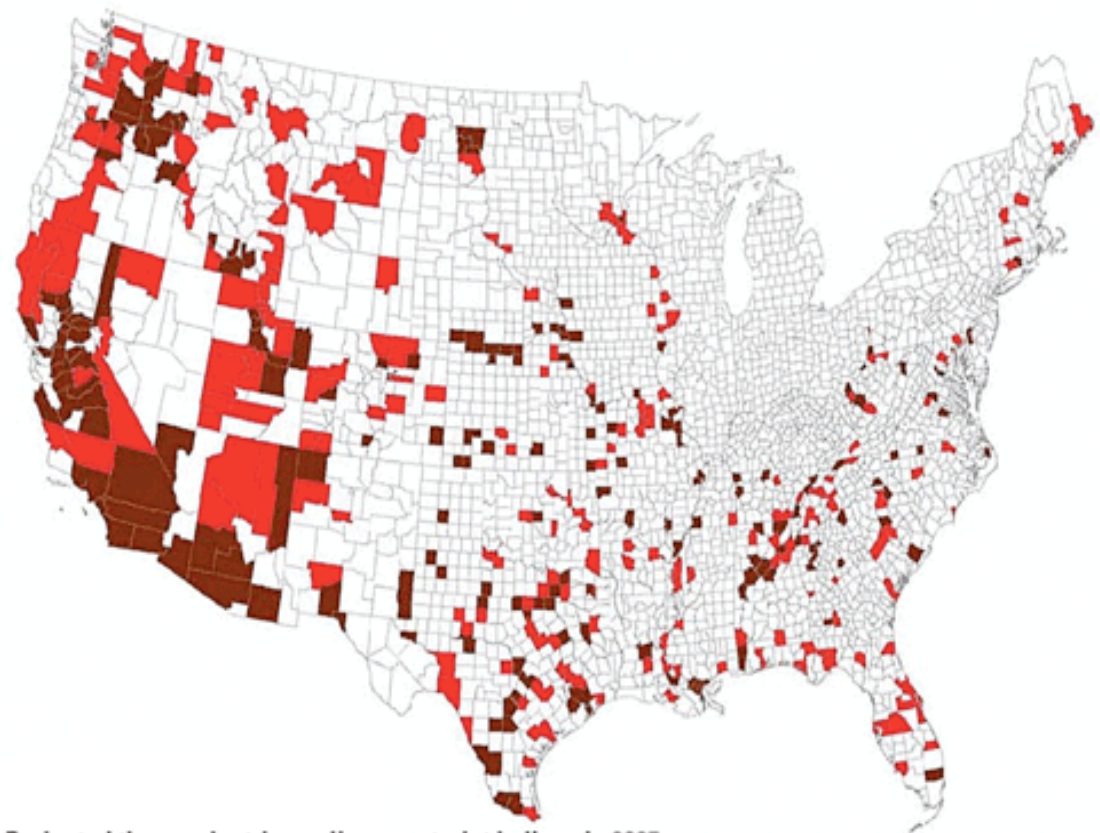
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The Challenge

Uncertainties in:

- water availability
- water quality and
- electricity pricing

challenge energy utilities to make investment decisions in water conservation and alternative cooling technologies.



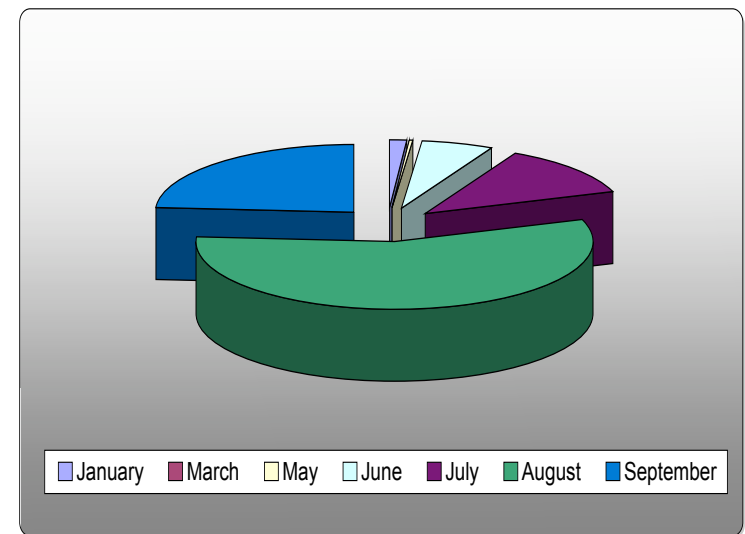
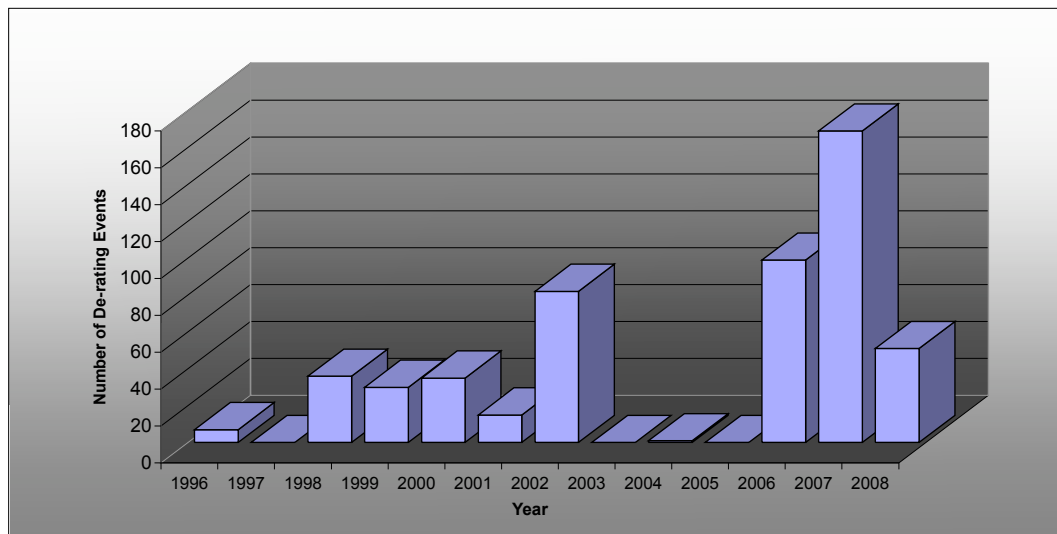
Projected thermoelectric cooling constraint indices in 2025

- Highly constrained
- Moderately constrained
- No existing generation, or constraints unlikely

The Financial Driver:

Cost of Derating Events vs. Technology Investment

- Cost of de-rating events at 5 unit coal fired power plant (SE):
2007: \$8 - \$32 per MWh; 2008: \$18 - \$36 per MWh
- Replacement Cost (cost of shifting production to other plants, \$/kwh) + Market Cost (loss of revenue from selling excess capacity on the market) = **Implied Value of Water**





Technology Options

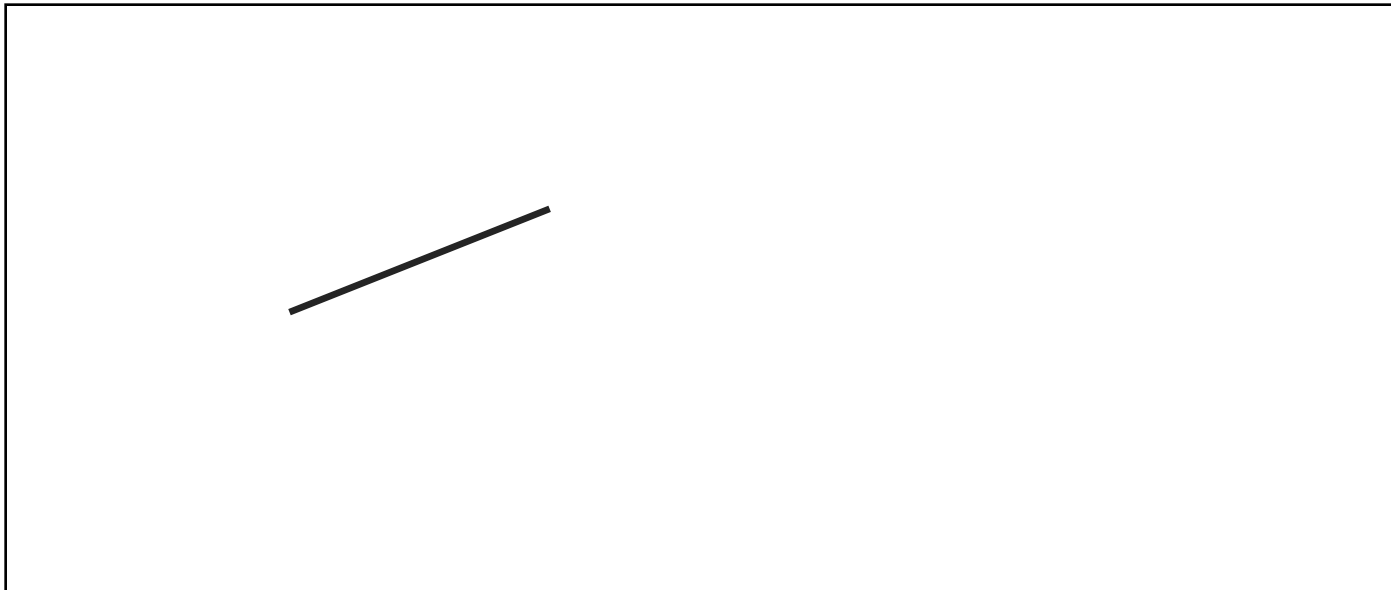
| Technology | Water Savings | Effect on Heat Rate | Research Stage, Issues | Capital Cost* |
|--|-------------------------------------|---------------------|--|---------------|
| Coal Drying w/ Waste Heat and Flue Gas | 10% | -3% | Bench Pilot, technical effectiveness | 0.5x |
| Evaporation Capture from Cooling Towers | 20% | Depends | Utility Pilot, size and cost | 3x |
| Wet Surface Air Condenser for Aux Towers | Make-up water and blowdown disposal | minimal | Cost, changing condenser, pilot underway | 1.5x |
| Heller Hybrid | 80-90% | +1.5% | Cost reduction, minimize parasitic load | 4x |

***Capital & Installed Cost: closed-loop cooling tower retrofit cost, ~\$40m**



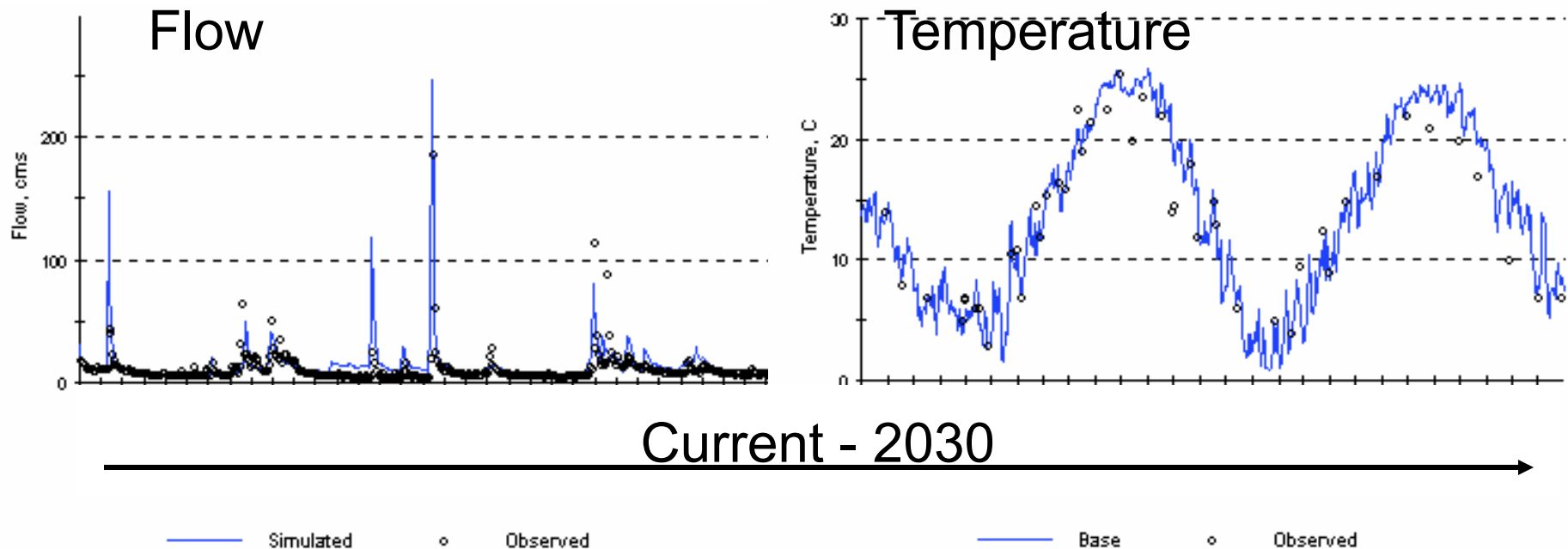
Financial Modeling: Real Options Framework

- ROA) offers a nuanced approach to strategic investment that quantitatively takes into account investment risks and the value of the open options for budget decision-makers.
- Define and price the volatility of the options
- BAU (business as usual): replacement and market costs



Environmental Modeling: Quantify Water-Based Derating Events

- WARMF (Water Quality Risk Management Framework):
Water quality (incl. temp) and quantity modeling
- Inform frequency/cost of derating events





Conclusions

- Value of water to impact production capacity is significant even if cost is not
- Real options framework capitalizes on volatility to inform investment decisions
- Flexible technology (e.g. hybrid cooling) is similar to call option, dependent on water penalty
- Challenge is to define alternate options and volatility spread
- Need to include R&D to test full scale technology integration