

A photograph of three large, concrete cooling towers of a nuclear power plant. The towers are arranged in a row, with the largest one on the right. They are emitting thick plumes of white steam that rise into a clear blue sky with some light clouds. The foreground shows a body of water reflecting the towers and sky, with some greenery and a small building visible at the base of the towers.

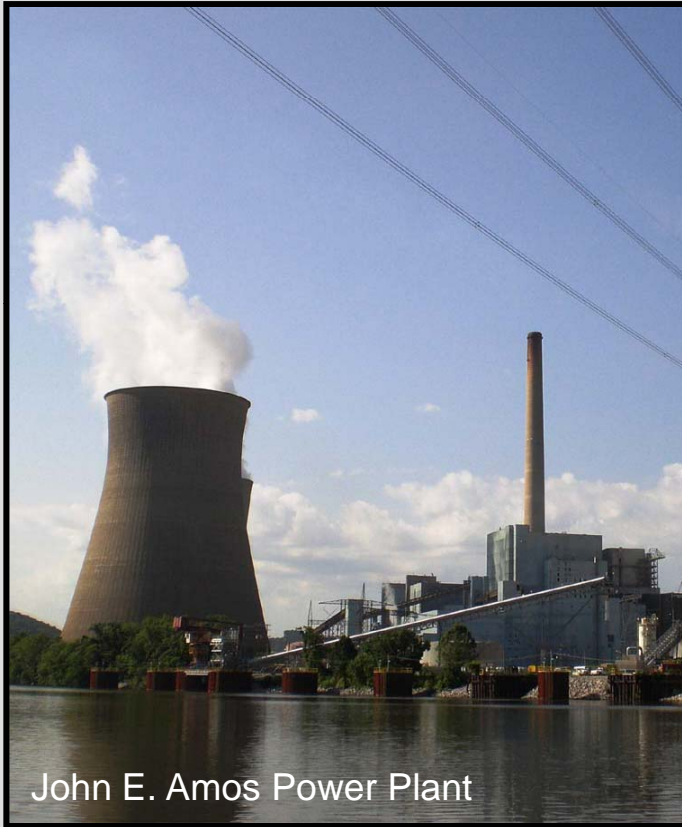
Water, Energy, and Drought

Water Use for Energy Production
in the United States

November 18, 2008

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Outline



John E. Amos Power Plant

Putnam County, West Virginia

- Introduction and Methods
- Cooling Types
- Supply Curve Analysis
- Fuel Sources
- Cooling Type vs. Fuel Source
- Drought
- Conclusions and Opportunities

Introduction

- Thermoelectric power plants - **39 percent** of the total fresh water withdrawn in the U.S.
- Water is used for **cooling** and emissions **scrubbing**.
- The purpose of this presentation is to further illustrate how water withdrawal and consumption rates relate to thermoelectric energy production in the United States.

Methods

- Based upon **two surveys** from the Energy Information Agency (**EIA**)
- 2001-2005/6
- **Power** survey – 5,051 facilities, comprehensive
- **Water** survey – 745 non-nuclear, thermoelectric facilities, greater than **100** megawatts
- Compiled, analyzed and geocoded

Cooling Types

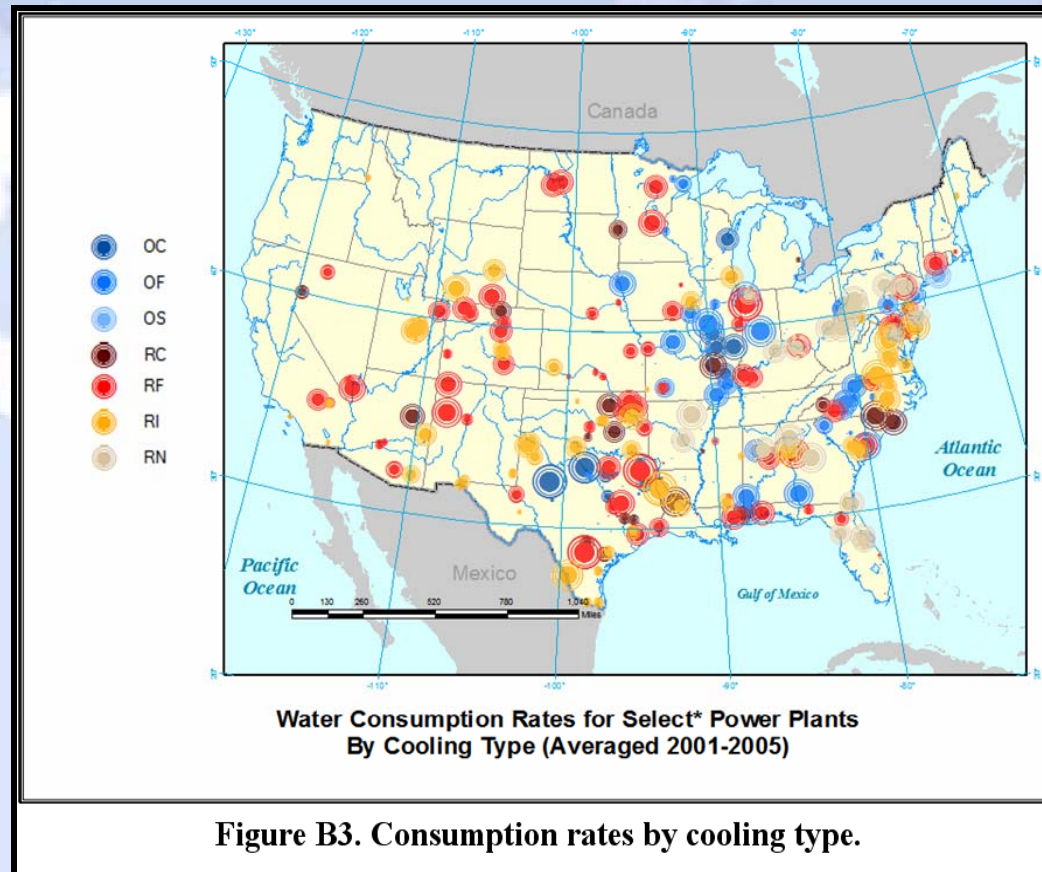
- **Open loop** and **Closed loop**
- Further divided into 7 categories

Table B1. Cooling types listed.

Code	Cooling System Description
OC	Once through with cooling pond(s) or canal(s)
OF	Once through, fresh water
OS	Once through, saline water
RC	Recirculating with cooling pond(s) or canal(s)
RF	Recirculating with forced draft cooling tower(s)
RI	Recirculating with induced draft cooling tower(s)
RN	Recirculating with natural draft cooling tower(s)

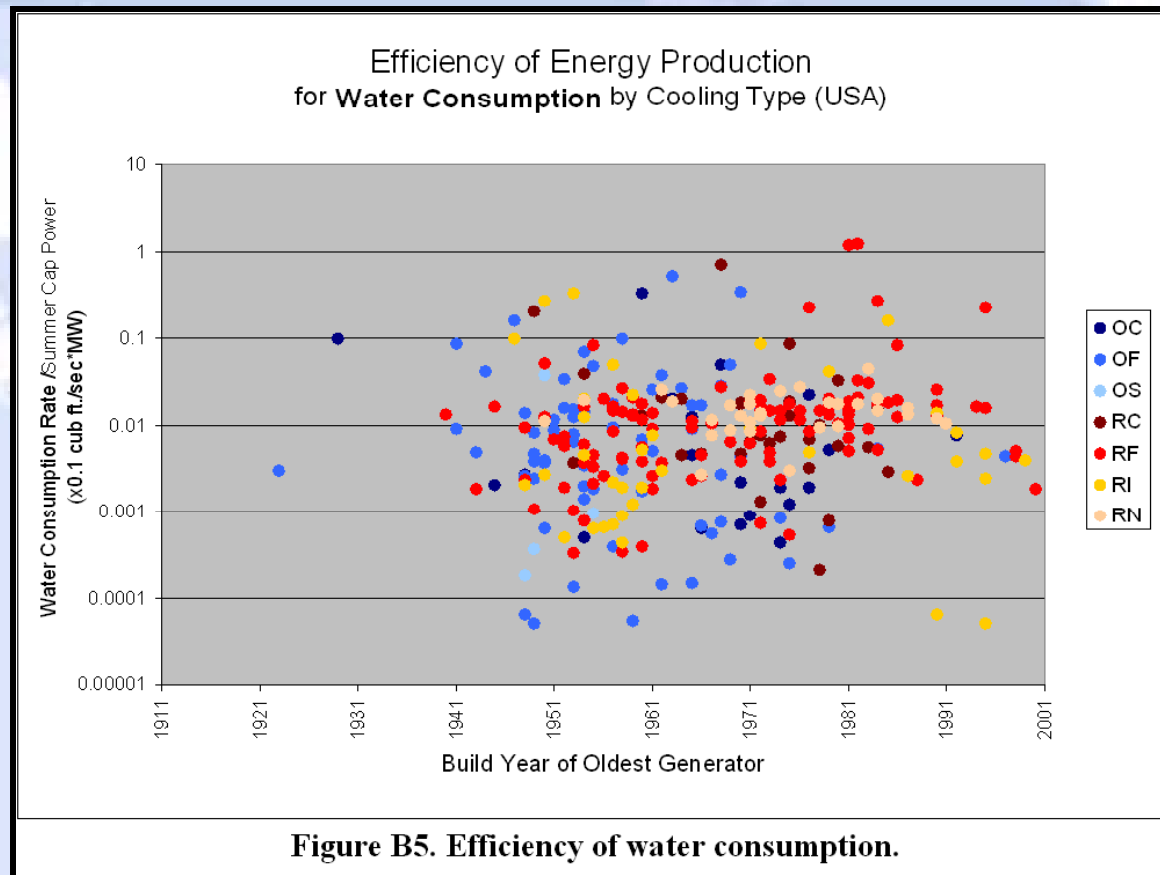
Cooling Types

- Open loop freshwater – **highest** withdrawal
- Eastern U.S. – **highest** withdrawal
- Symbol **size change**



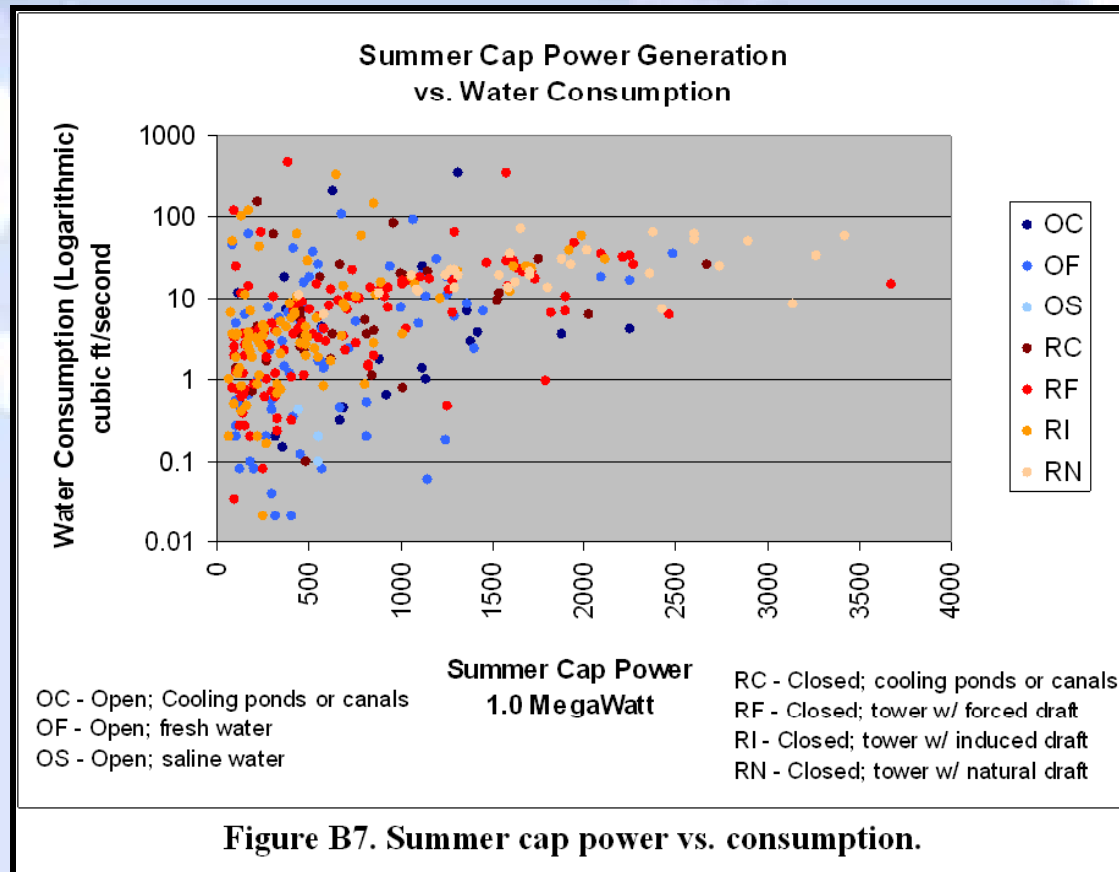
Cooling Types

- Logarithmic scale
- Through **time**
- Withdrawal – distinct **grouping**



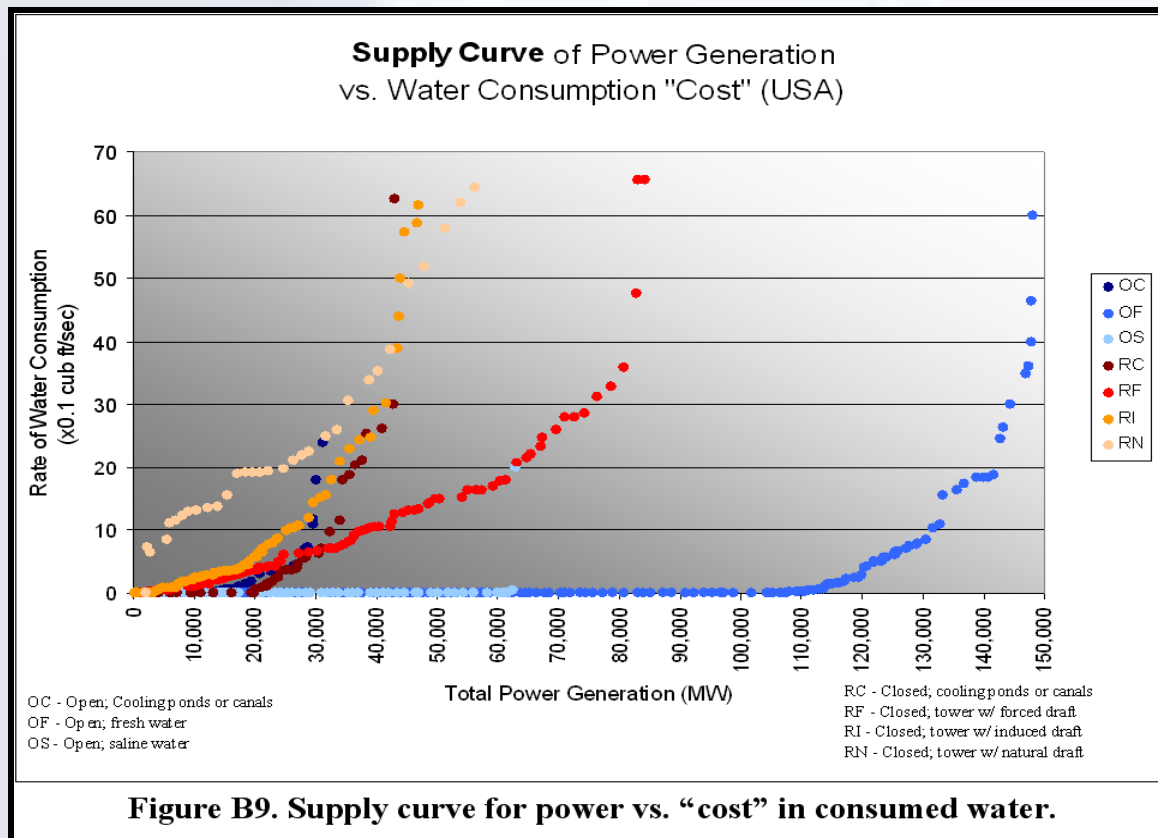
Cooling Types

- No temporal component
- Withdrawal – distinct grouping
- High variability at low production capacities



Supply Curve Analysis

- **Non-cumulative** rates of water use (y-axis)
- **Cumulative** increases in power generation (x-axis)
- Visible “**steps**”
- Area where **large increase** in water use corresponds to a **small increase** in power



Supply Curve Analysis

- Both Cumulative
- Totals for water use rates vs. power production for the U.S.
- “Points of departure”

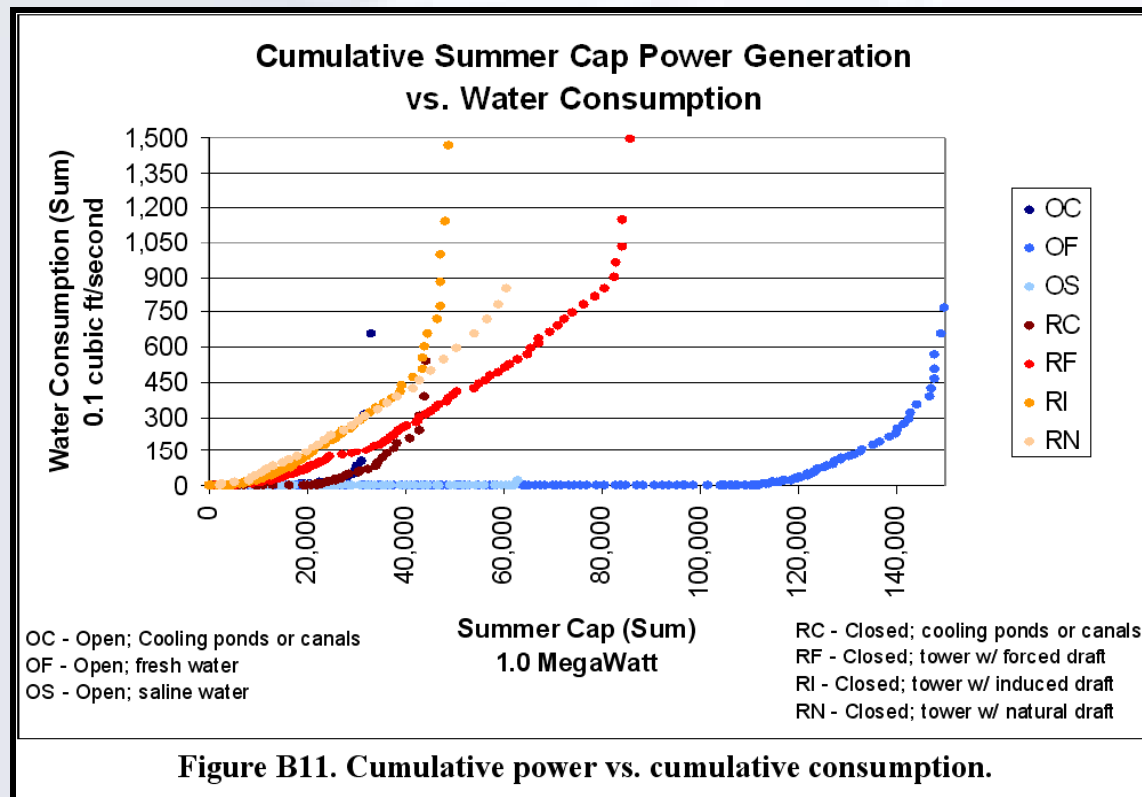


Table C1. Fuel source categories and subcategories.

BIT	(Anthracite Coal, Bituminous Coal)
LIG	Lignite Coal
SUB	Subbituminous Coal

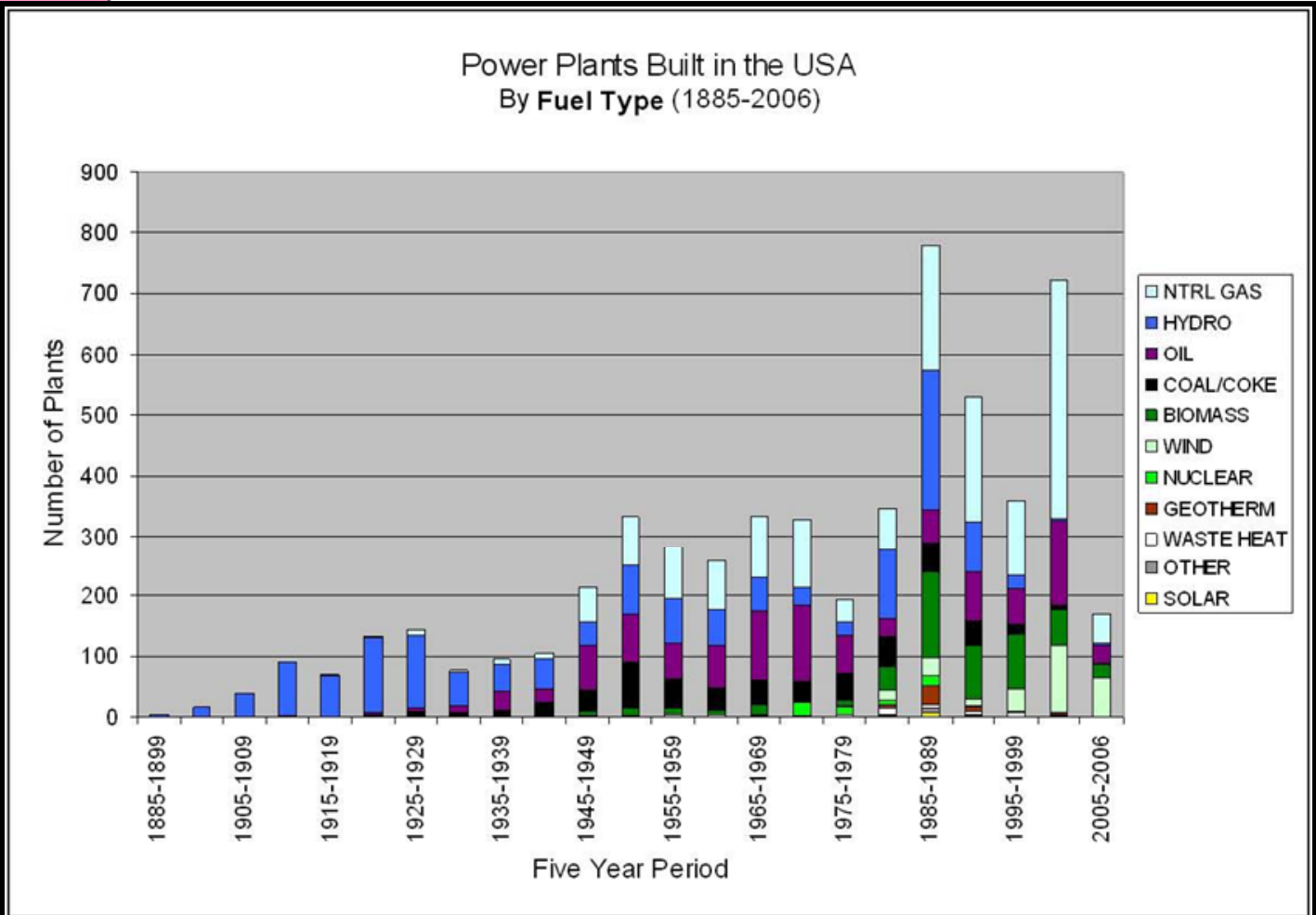


Figure C2. Power plants built through time.

Other (Batteries, Chromates, Cold Dross, Hydrogen, Iron, Lead, Tar, Coal, and Miscellaneous Technologies)

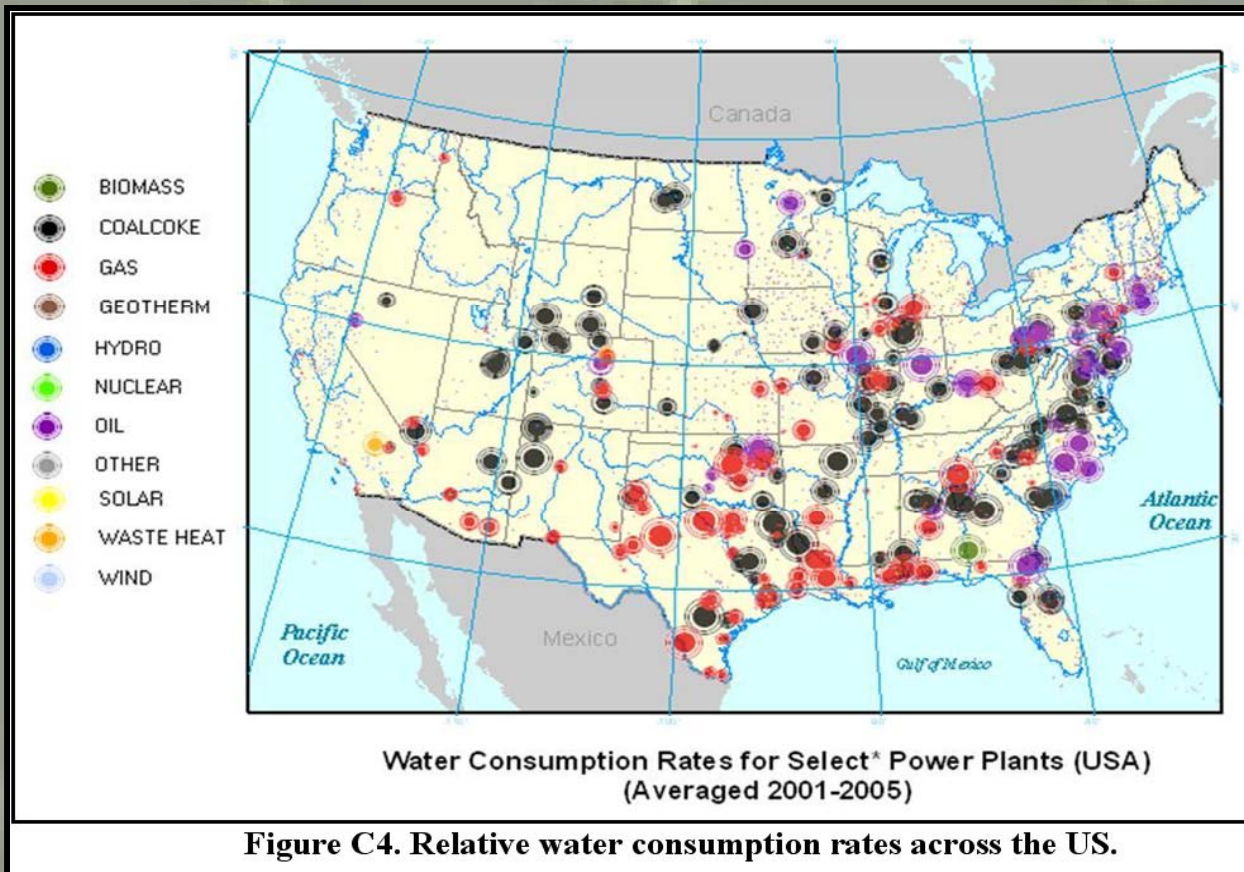
PUR Purchased Steam

TDF Tires

NA Not Available

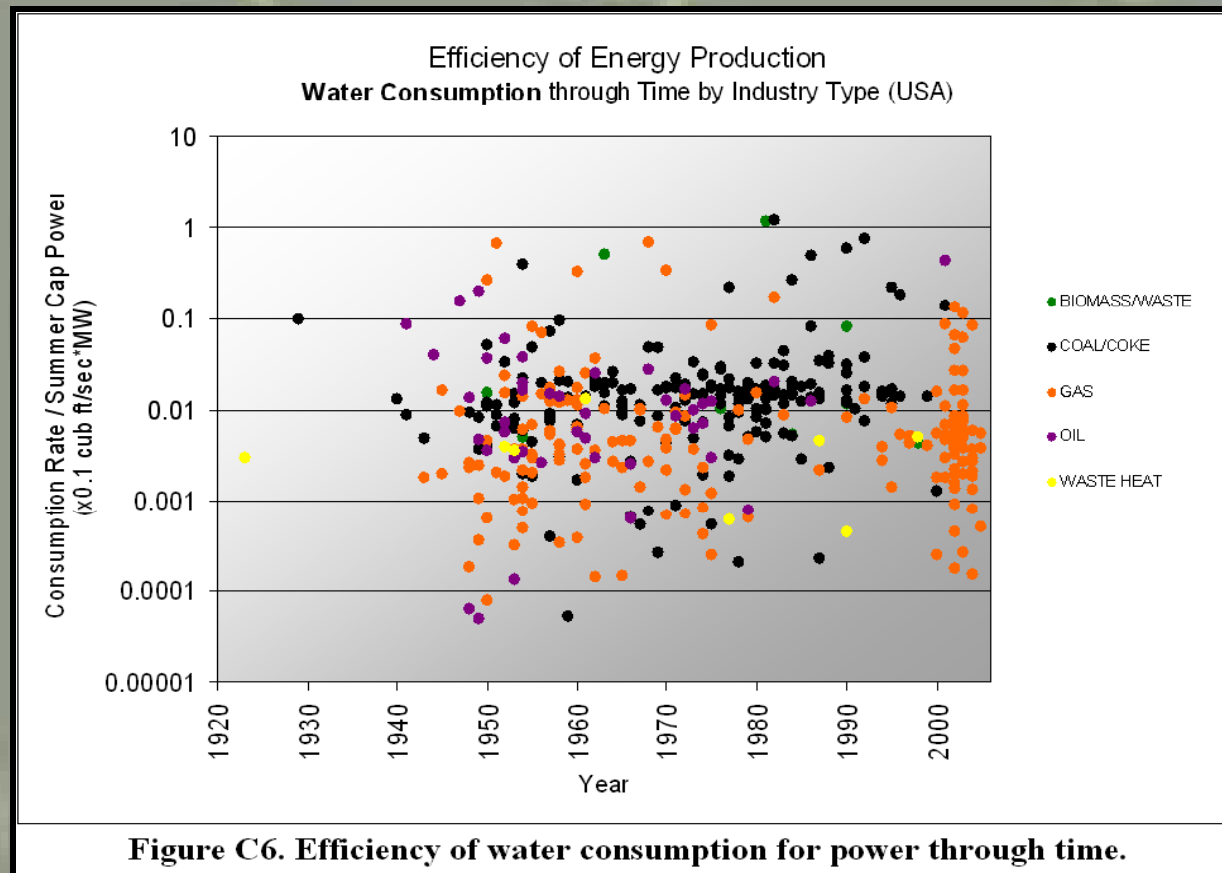
Fuel Sources

- Rates by fuel type
- The **big three** – Oil, Natural Gas, Coal
- **Similar** to Cooling Type maps



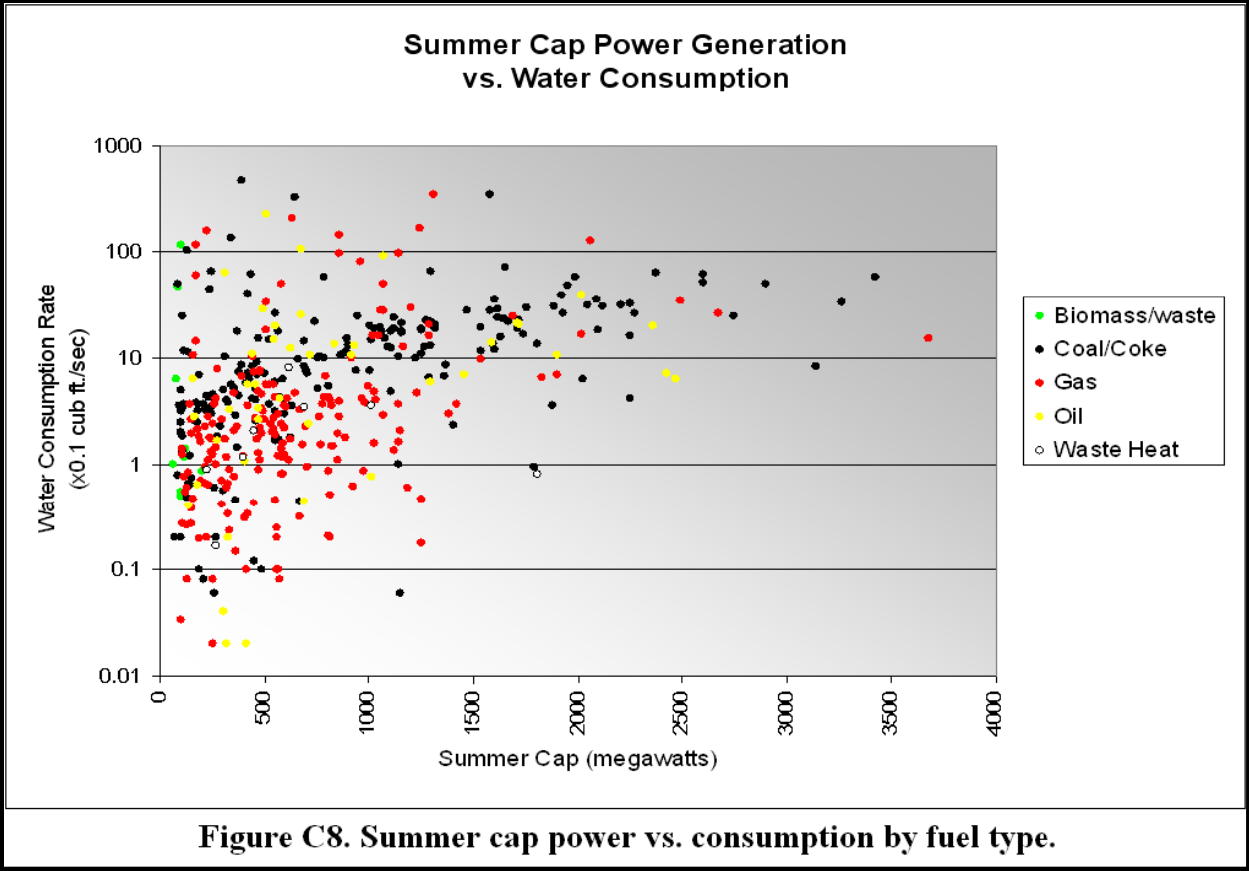
Fuel Sources

- Temporal component
- Two groups still visible, **not** associated with color
- Natural gas (orange)



Fuel Sources

- Non-temporal
- Coal in both groups
- High variability still visible



Drought

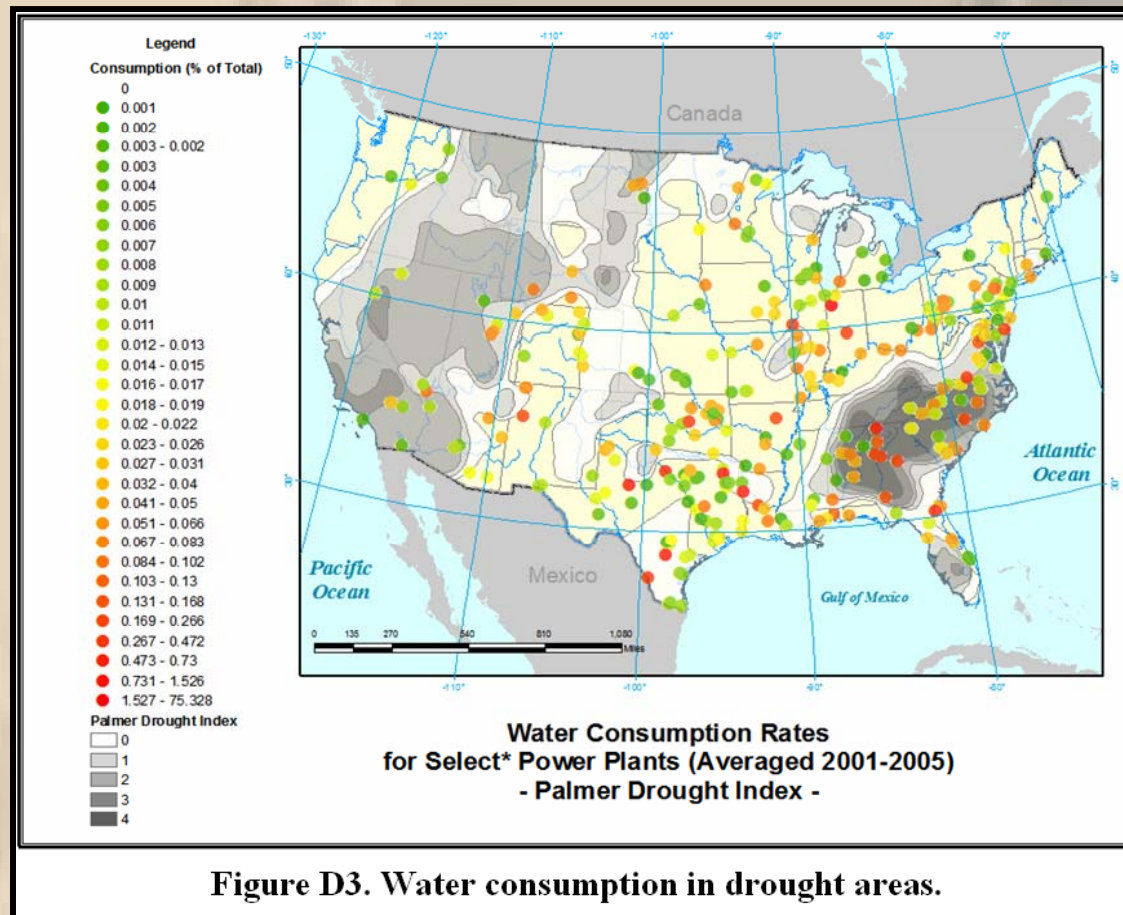
- **Increased** severity in some areas as time goes on
- **Palmer Drought Index (PDI)**
- **Drought vs. Low Precipitation**

Table D1. PDI rating system.

PDI score	Condition
4.00 or more	Extremely wet
3.00 to 3.99	Very wet
2.00 to 2.99	Moderately wet
1.00 to 1.99	Slightly wet
0.50 to 0.99	Incipient wet spell
0.49 to -0.49	Near normal
-0.50 to -0.99	Incipient dry spell
-1.00 to -1.99	Mild drought
-2.00 to -2.99	Moderate drought
-3.00 to -3.99	Severe drought
-4.00 or less	Extreme drought

Drought

- Areas of high withdrawal are most vulnerable
- Southeast
- More complete analysis is required



Conclusions

- **Water use efficiency** depends primarily upon **cooling type**
- Majority of open loop, freshwater facilities are **older** and **coal-fired**
- Open loop, freshwater plants **withdraw the most water** and may be the **most vulnerable** to prolonged drought

Opportunities

- Improving data set
- Analyses for individual states
- “Steps” in supply curves show potential areas of targeted improvement
- Proactively address energy security threats and water scarcity with existing technology
- Endless research potential

Acknowledgments

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