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Energy-Water Nexus in the U.S.

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Sandia National Laboratories
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U.S. DEPARTMENT OF ENERGY NNSA

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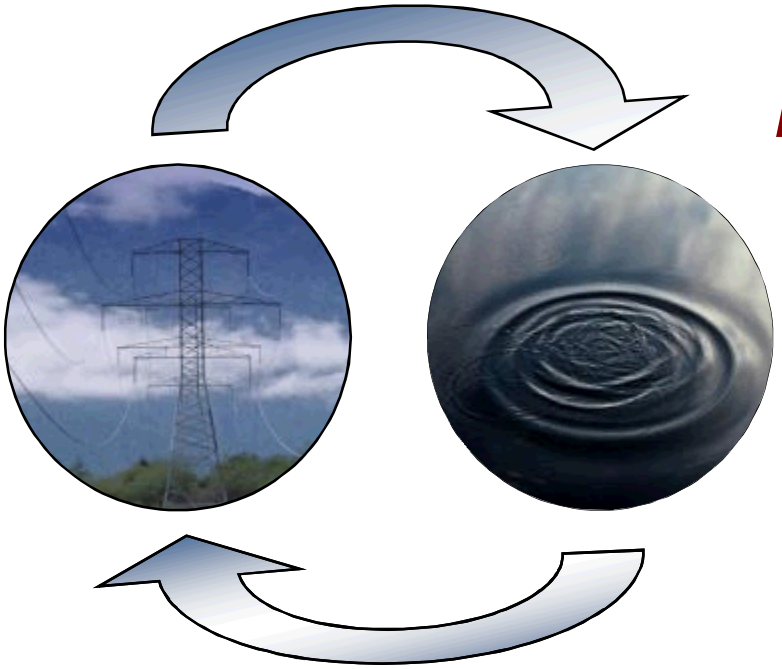
Energy-Water Nexus

Water for Energy:

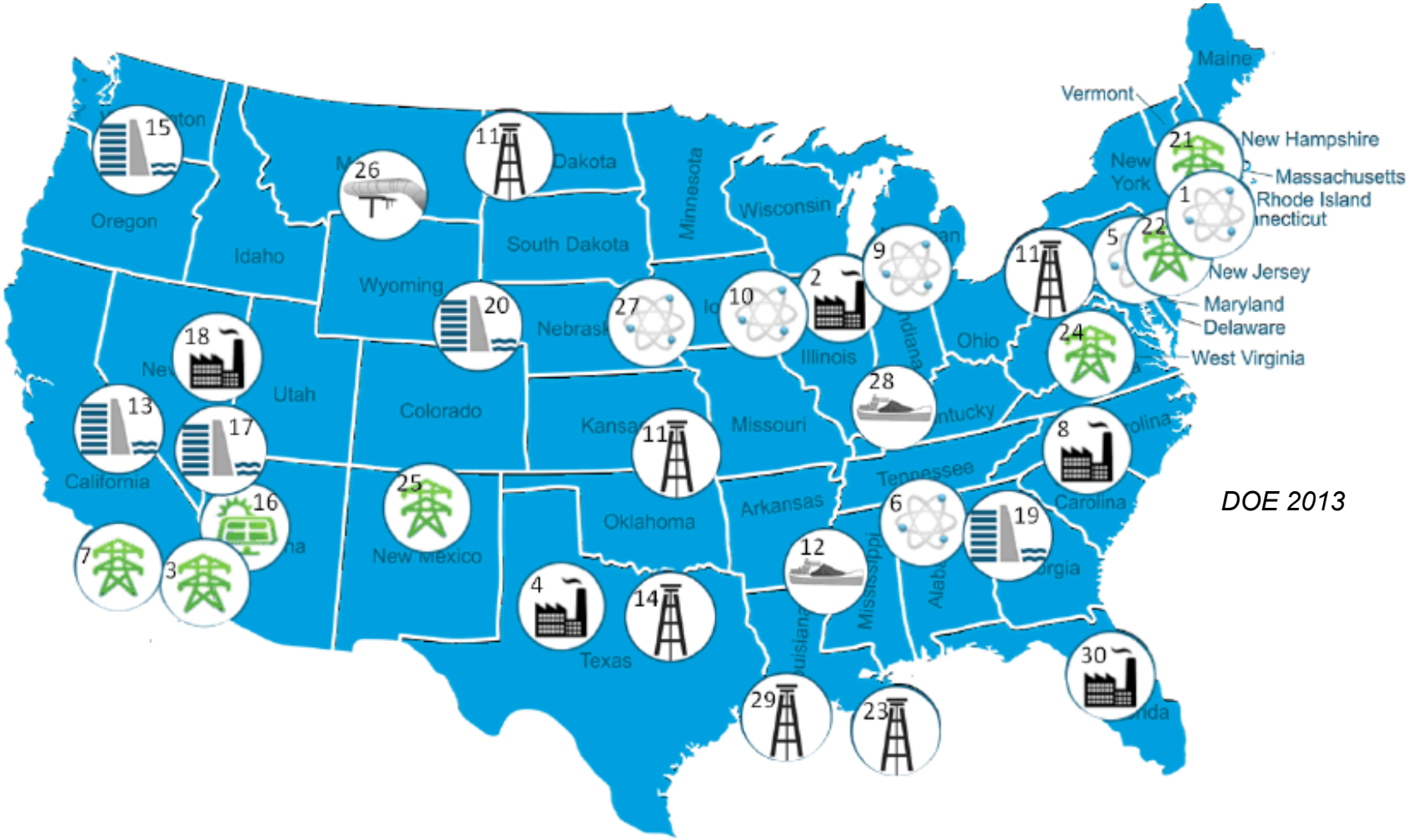
- ***Thermoelectric Cooling***
- ***Transportation fuels***
- ***Hydroelectricity***
- ***Fossil fuel extraction***
- ***Feedstock production & transport***
- ***Many more***



Energy for Water:

- ***Extraction***
- ***Transport***
- ***Treatment***
- ***Heating***

Energy-Water Nexus Events 2003-2013



DOE 2013

2007: Severe drought in the Southeast caused the Chattahoochee River, which supports more than 10,000 MW of power generation, to drop to one-fifth of its normal flow. Overall, hydroelectric power generation in the Southeast declined by 45% (Bigg 2007).

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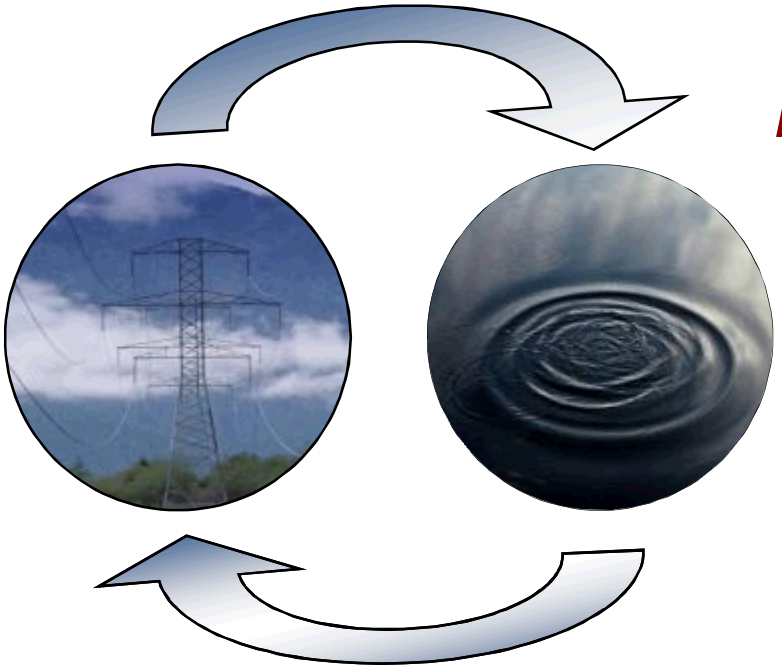

Energy for Water:

- *Extraction*
- *Transport*
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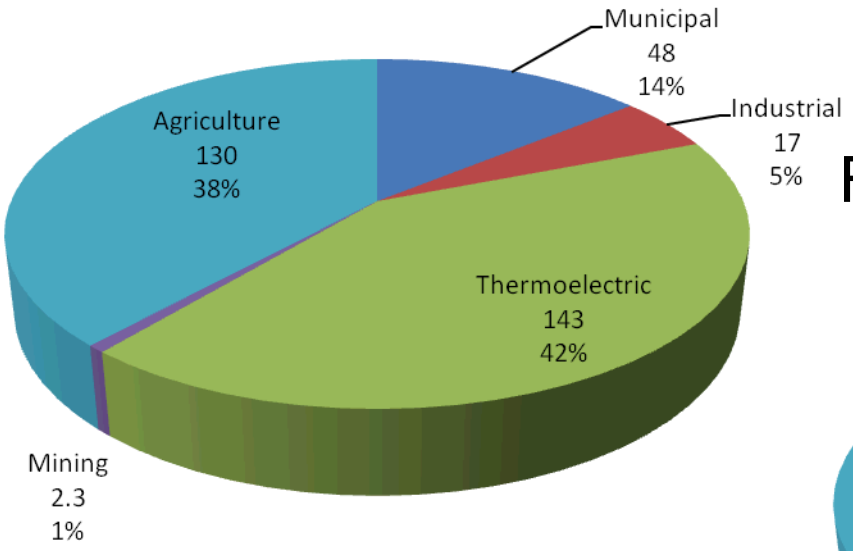
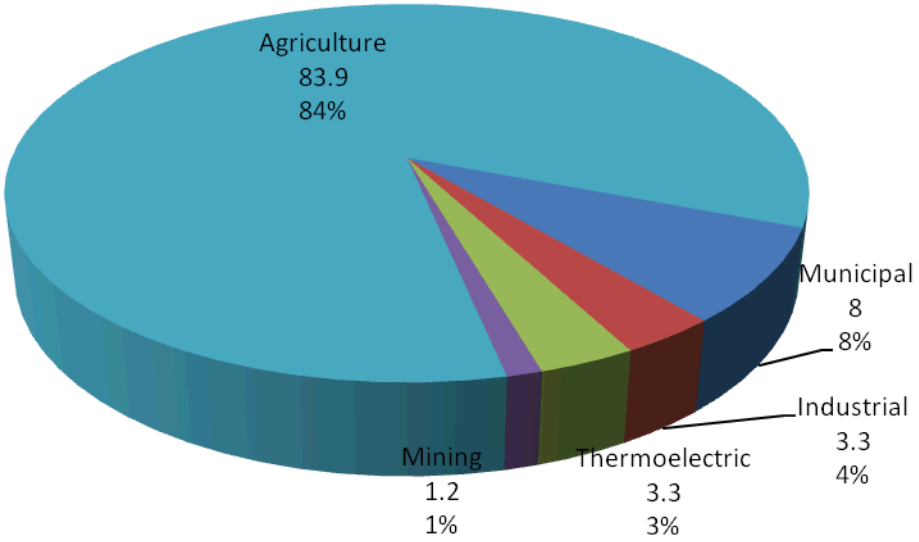
Water for Thermoelectric Cooling - National

Fresh Water Withdrawal (BGD) 2005



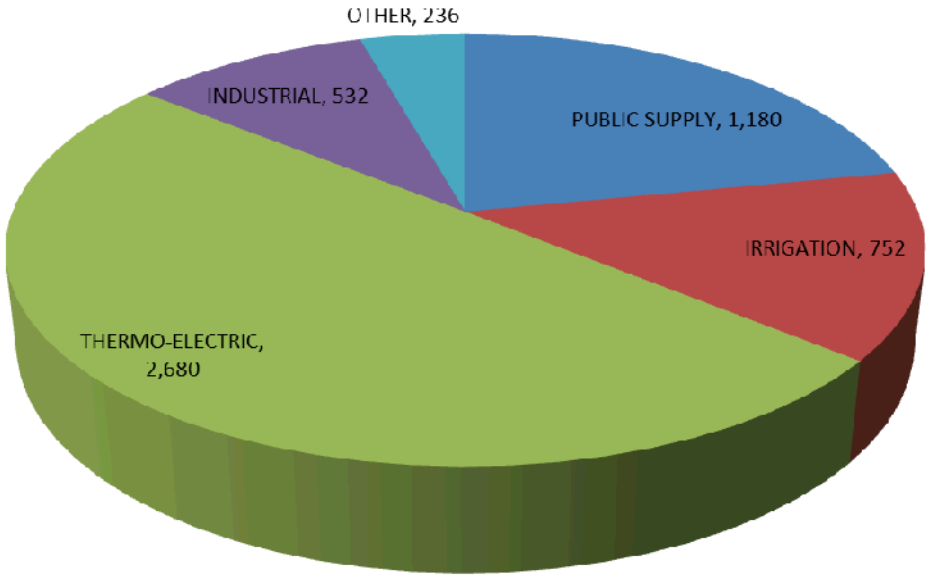
Fresh Water Consumption (BGD) 1995



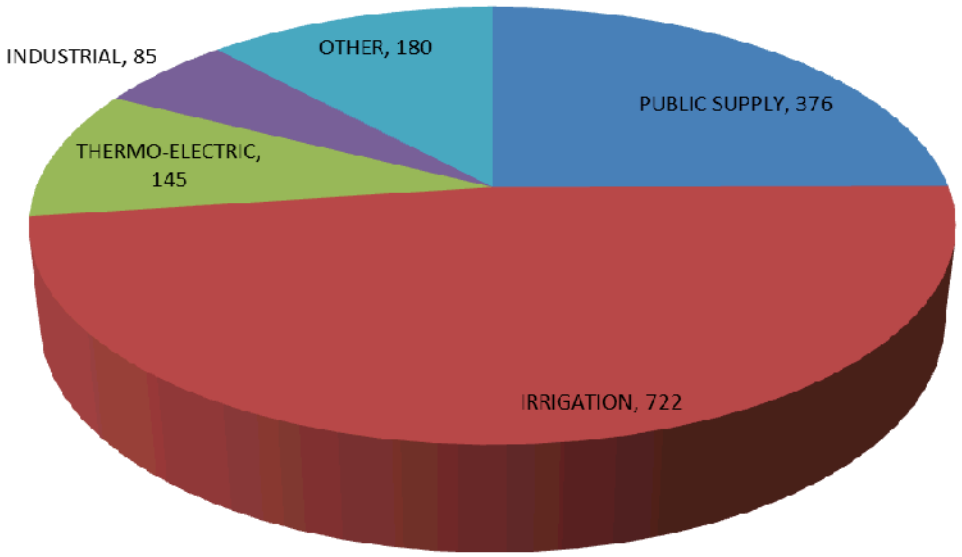
Source: USGS 1995 & 2005

Water for Thermoelectric Cooling - Georgia

Fresh Water Withdrawal (MGD) 2005

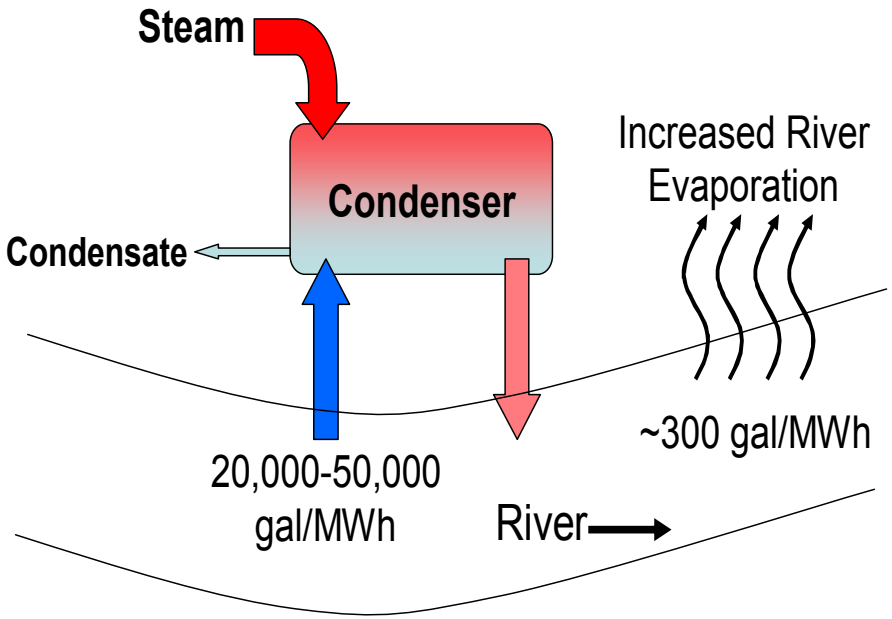


Fresh Water Consumption (BGD) 1995

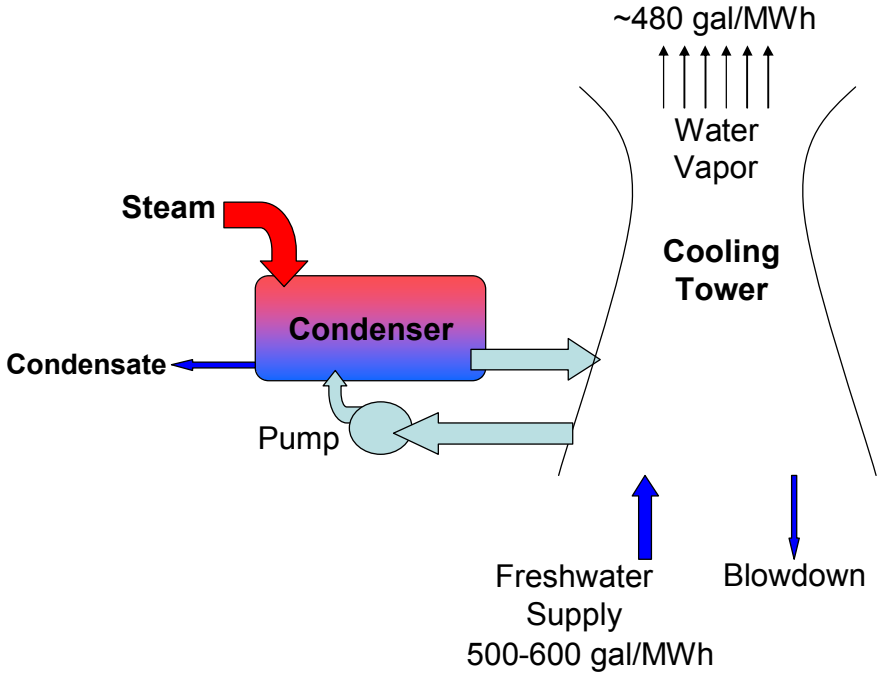


Source: USGS 1995 & 2005

Power Plant Cooling Options



Open-loop “once-through” cooling cycle

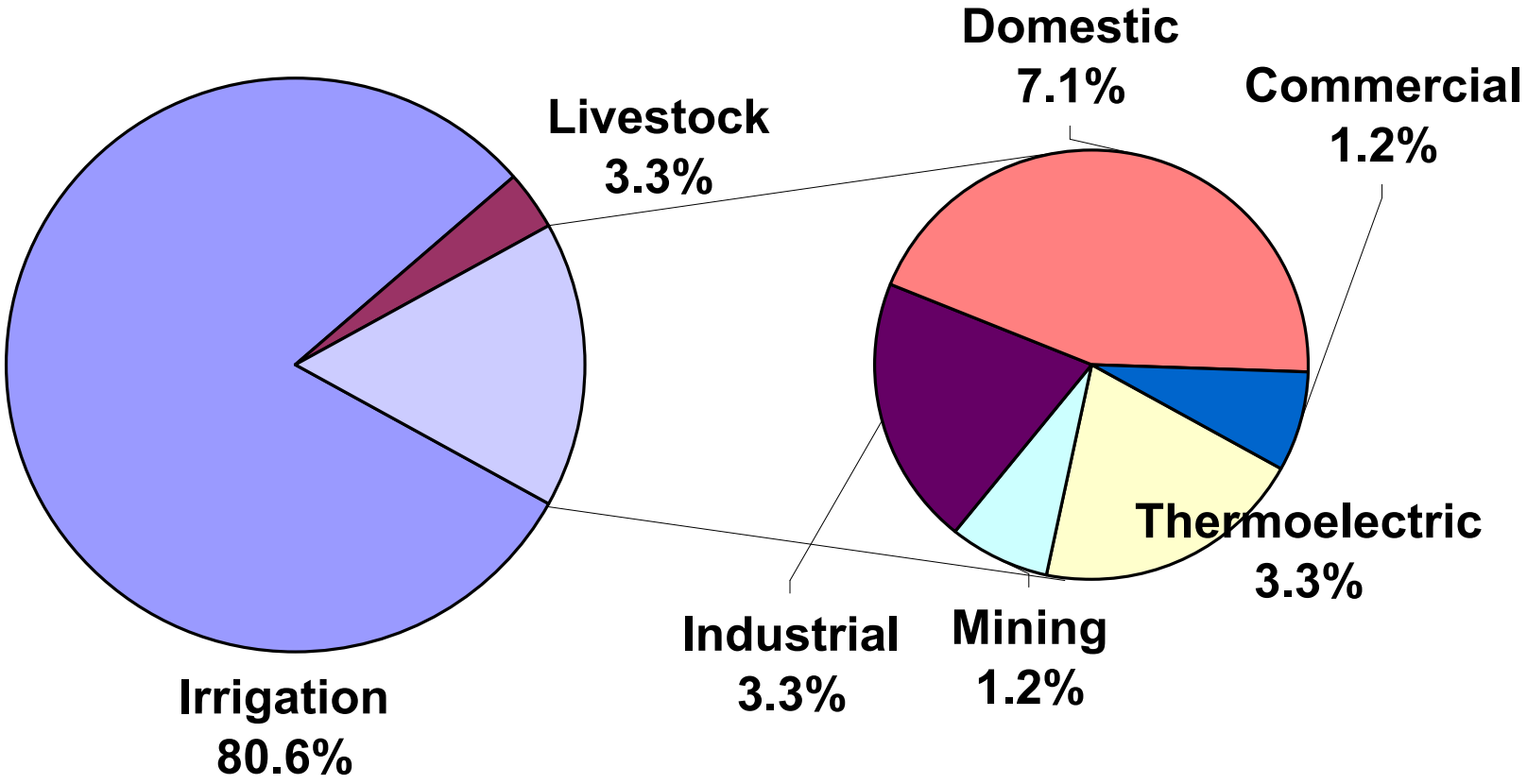


Closed-loop cooling cycle

Source: EPRI, 2002

Water Consumption by Sector

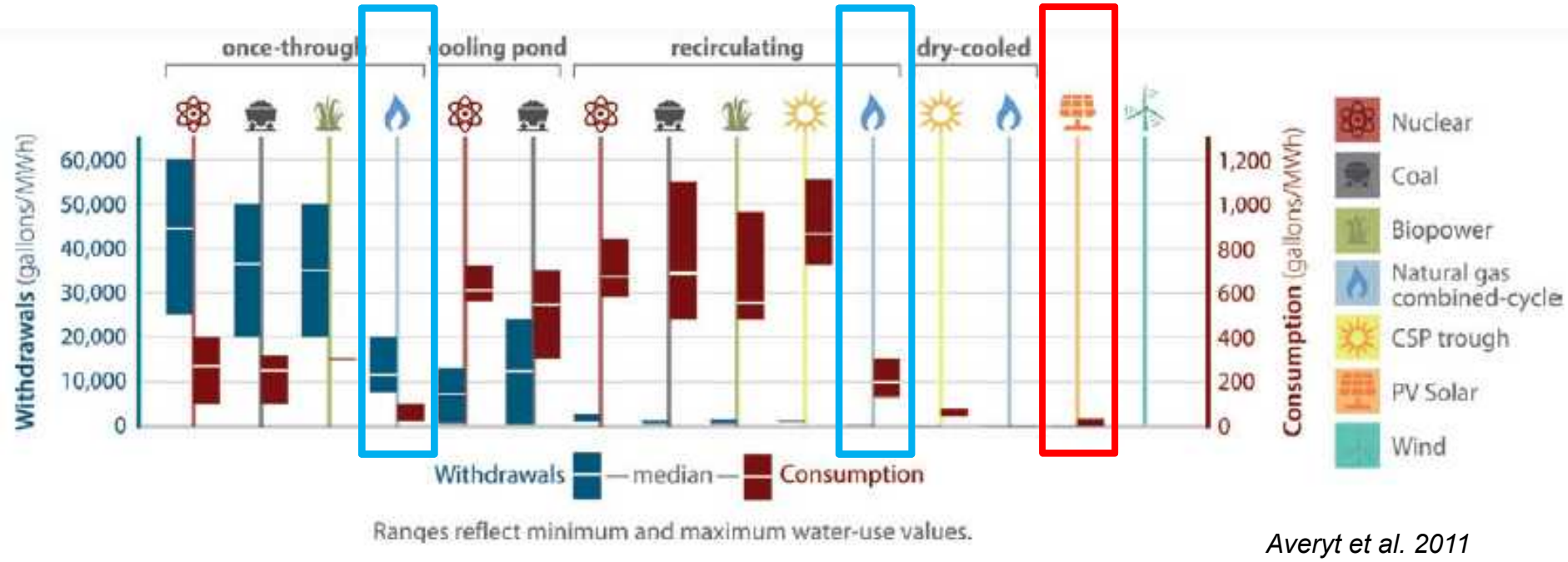
U.S. Freshwater Consumption, 100 Bgal/day



[USGS, 1998]

Energy uses 20 percent of all non-agricultural fresh water
AND has large potential for growth

Different water demand for different energy generation & cooling strategies:



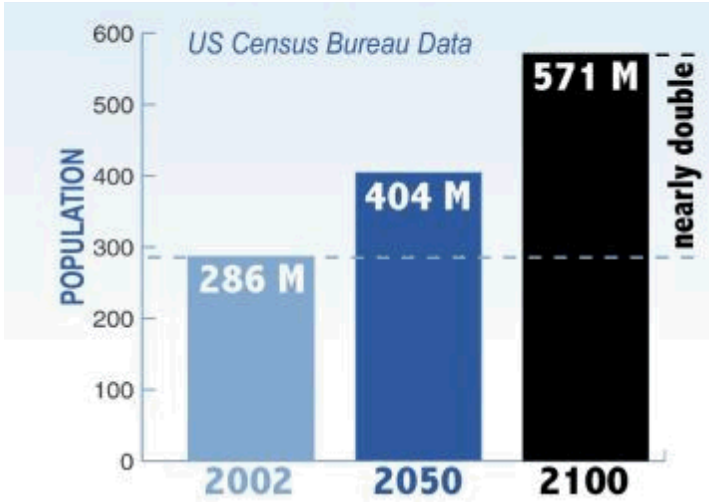
Averyt et al. 2011

Shale gas boom, (even considering demand for fracking water) has the potential to reduce energy related water demands.

PV solar uses very little water (some used to keep panels clean).

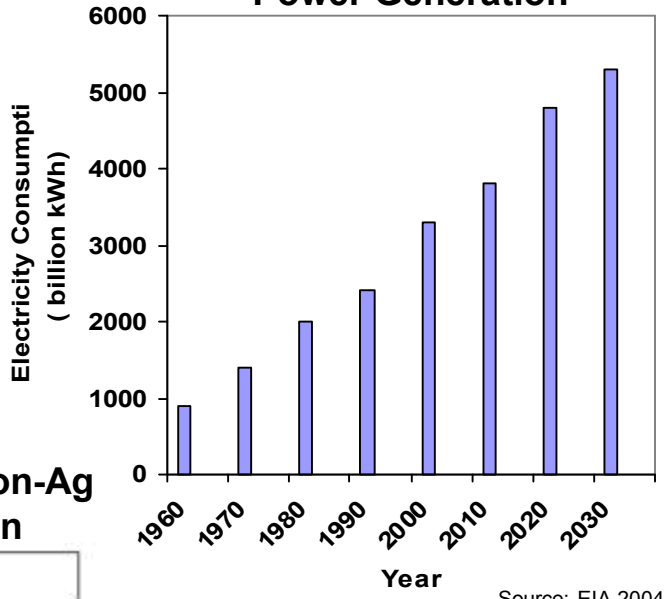
Energy-Water Tomorrow

Projected Population Growth



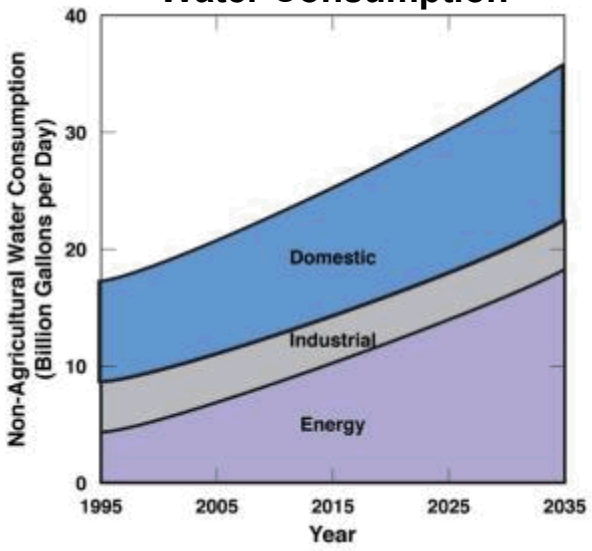
70 million more people by 2030

Projected Growth in Electric Power Generation



Source: EIA 2004

Projected Growth in non-Ag Water Consumption



Water Availability Is Already Impacting New Energy Development

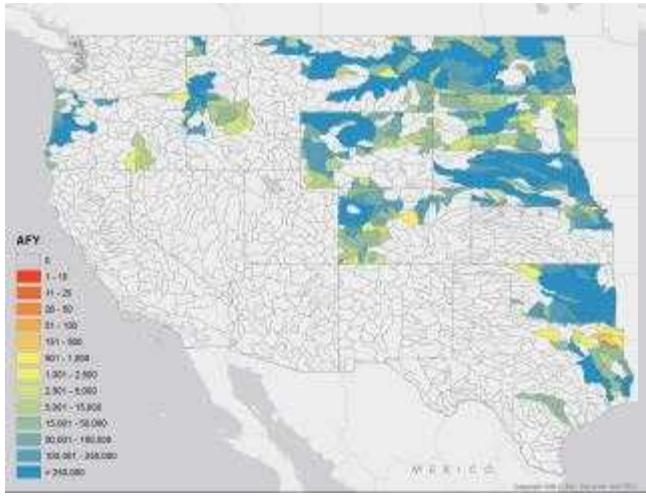
Source:
M. Hightower SNL

- 2001 & 2002 energy facility permitting issues due to water availability

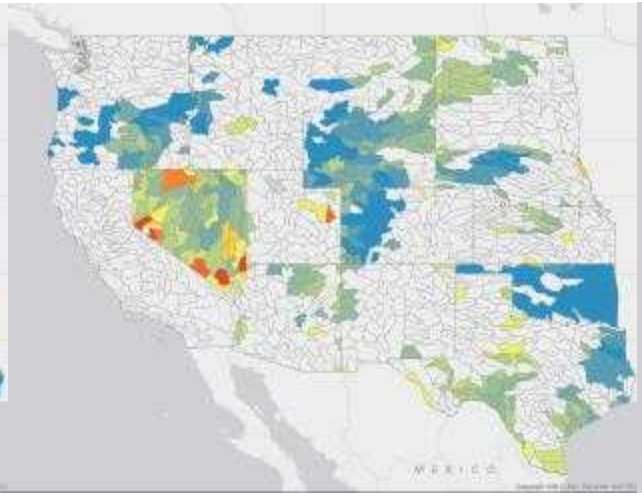
Water Availability

Source:
V. Tidwell SNL

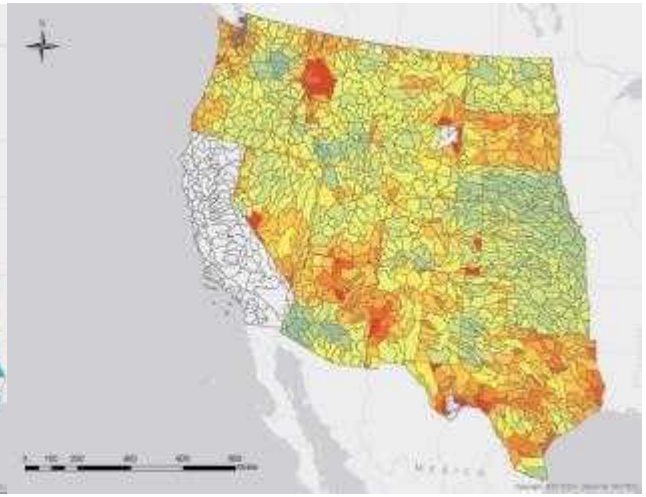
Unappropriated Surface Water



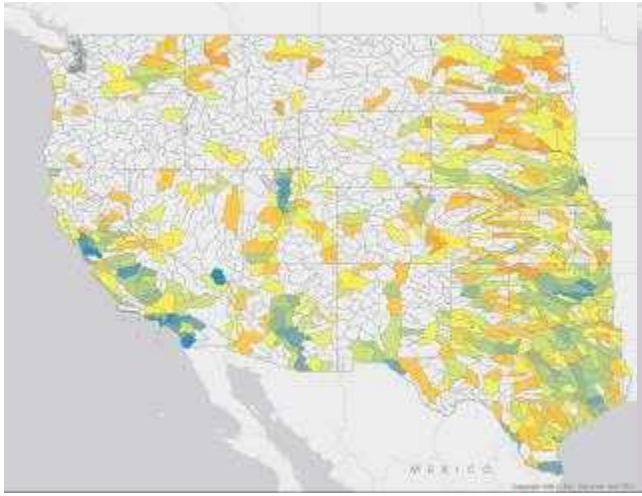
Unappropriated Groundwater



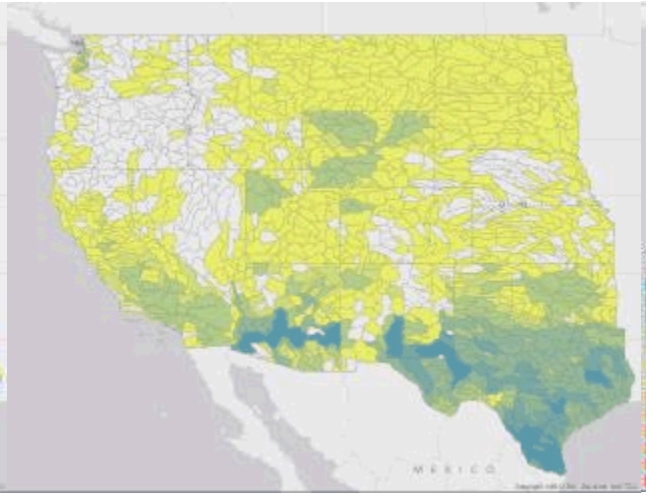
Appropriated Water



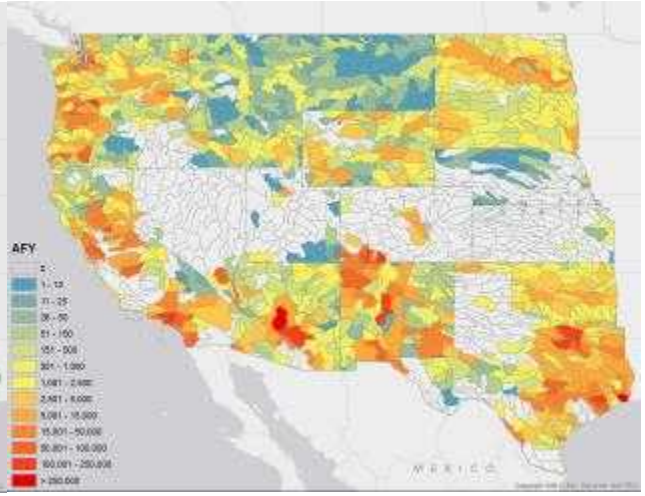
Municipal Wastewater



Brackish Groundwater



Consumptive Demand 2010-2030



Transitioning to Zero Freshwater Withdrawal

Retrofits considered: *average difficulty, according to EPA guidelines*

Recirculating cooling (first step for once-through cooling systems)

- Dry cooling
- Municipal waste water
- Brackish groundwater

Costs:

Capital

Operating and Maintenance (O&M) costs

Capture (e.g., conveyance costs for waste water, drilling and pumping costs for brackish groundwater)

Treatment

Parasitic energy losses

Availability:

Municipal waste water: within 50 miles

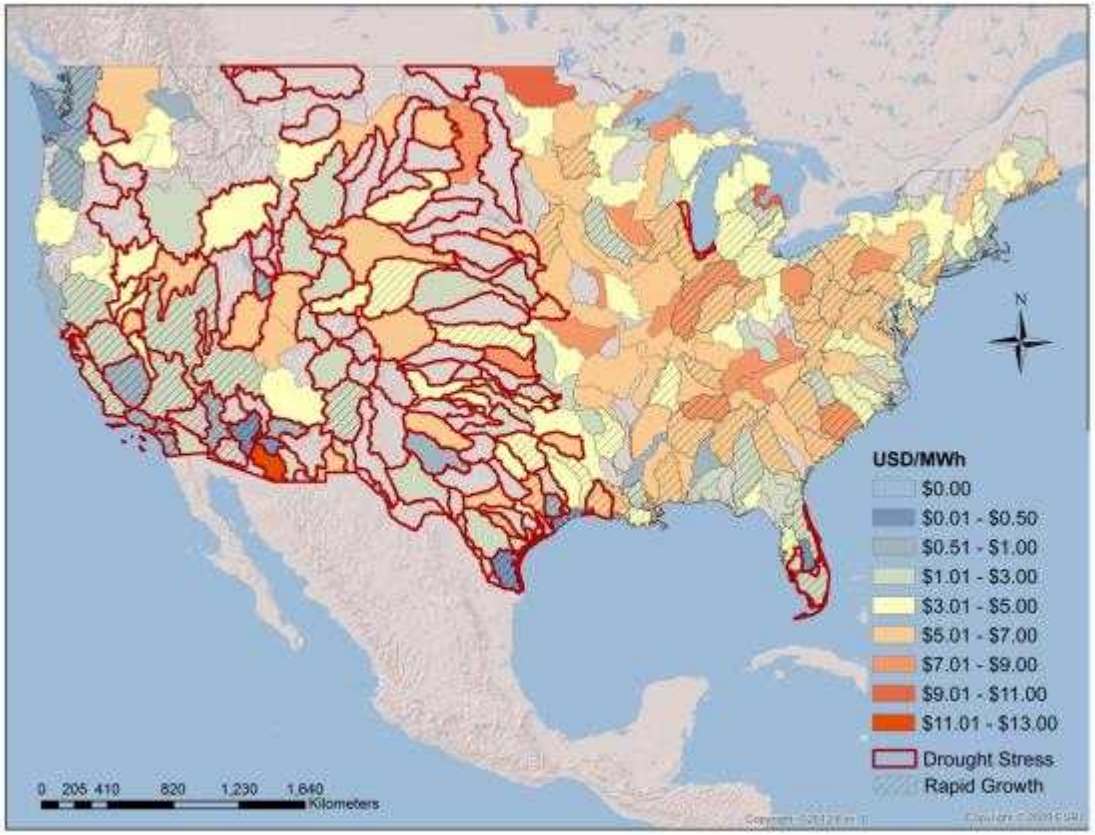
Brackish water: <2500 ft deep, salinities>10,000 TDS

* NOTE: not taking into consideration site-specific constraints such as land availability, local regulations, technology vintage

ΔLCOE Associated with Retrofit

Technology	Number of plants
Waste water	823
Brackish water	109
Dry cooling	246

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



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

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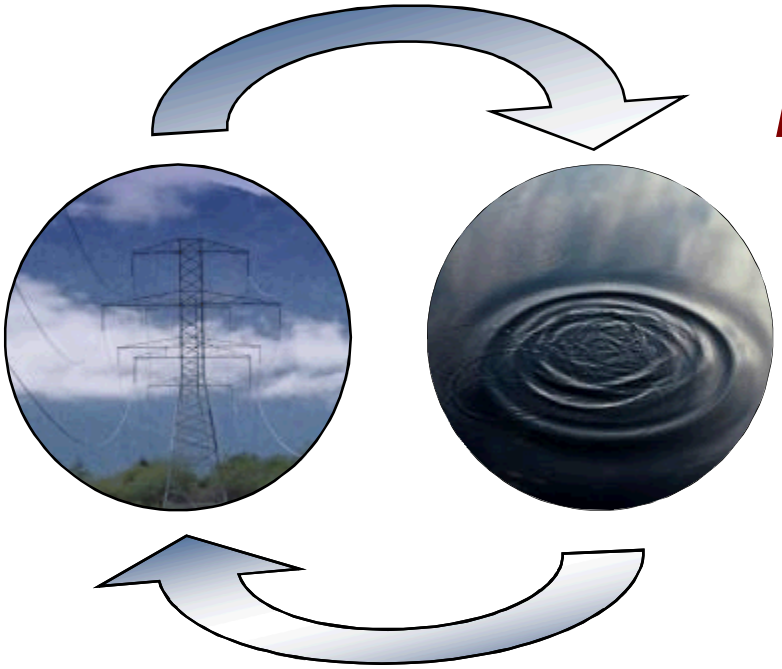

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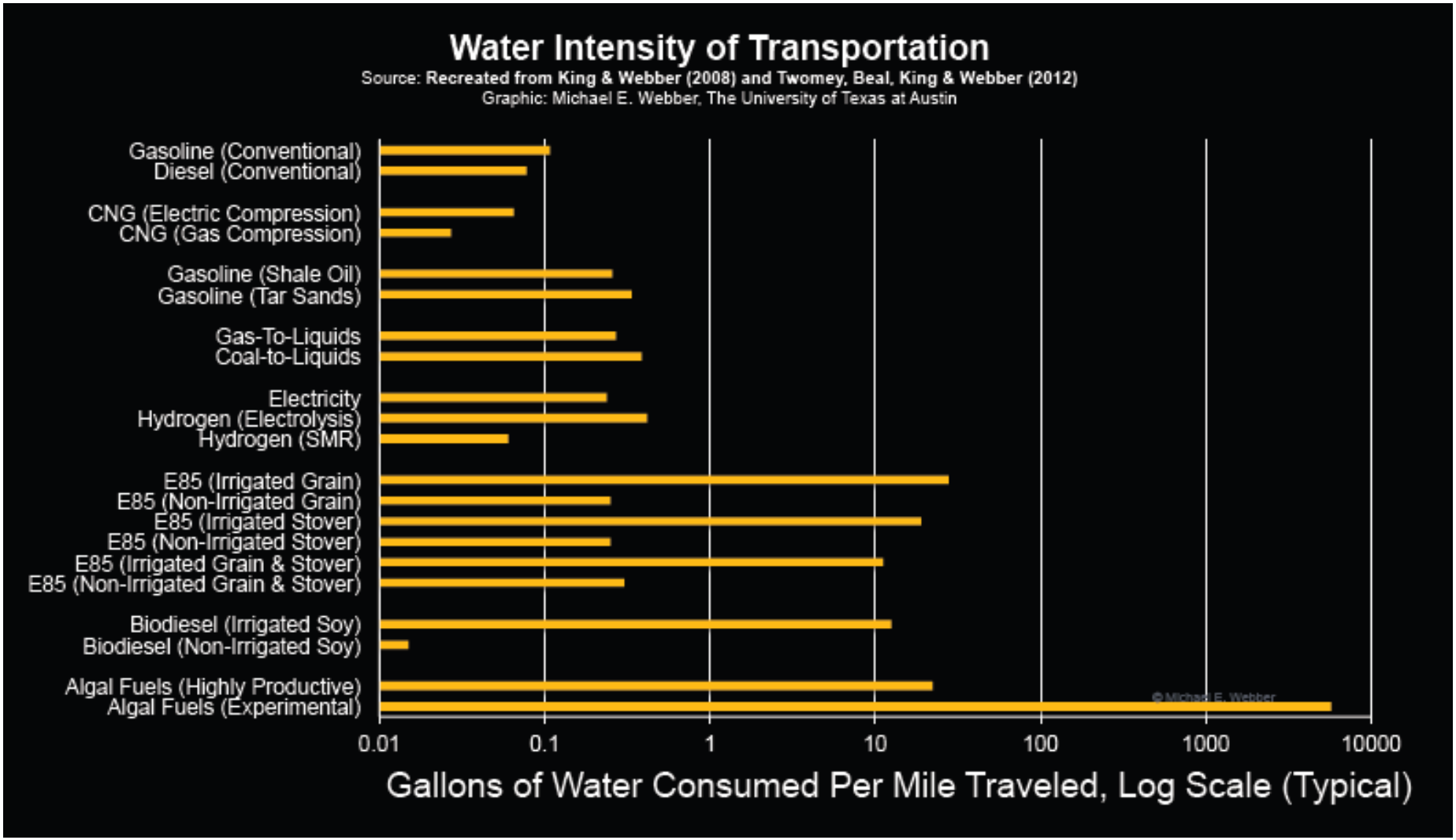
Water for Transportation Fuels



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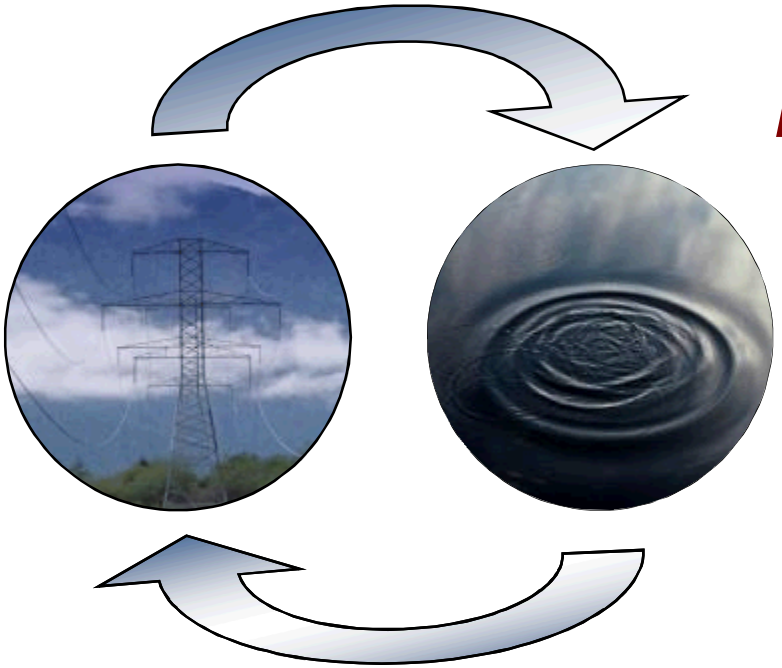

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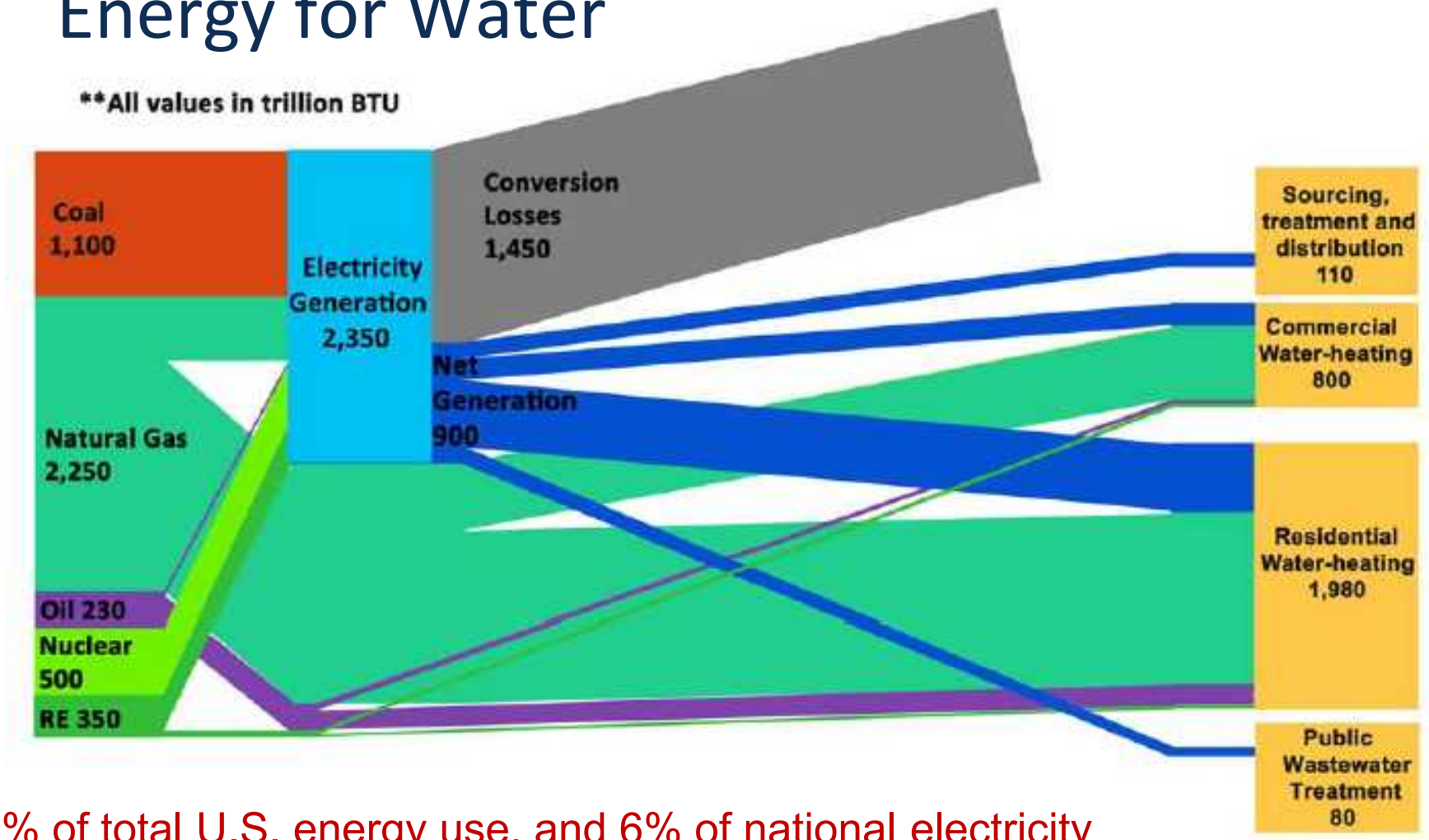
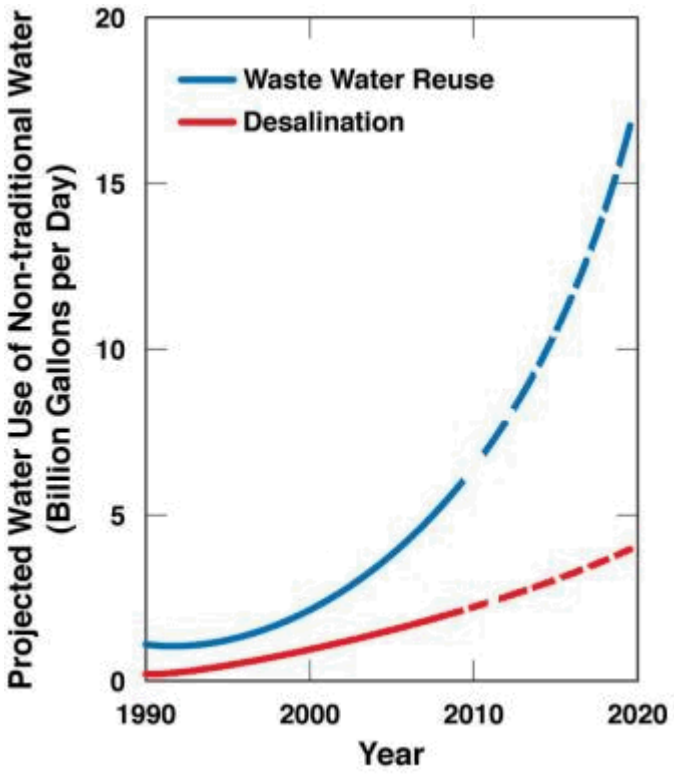


4% of total U.S. energy use, and 6% of national electricity generation goes to water related uses shown here.

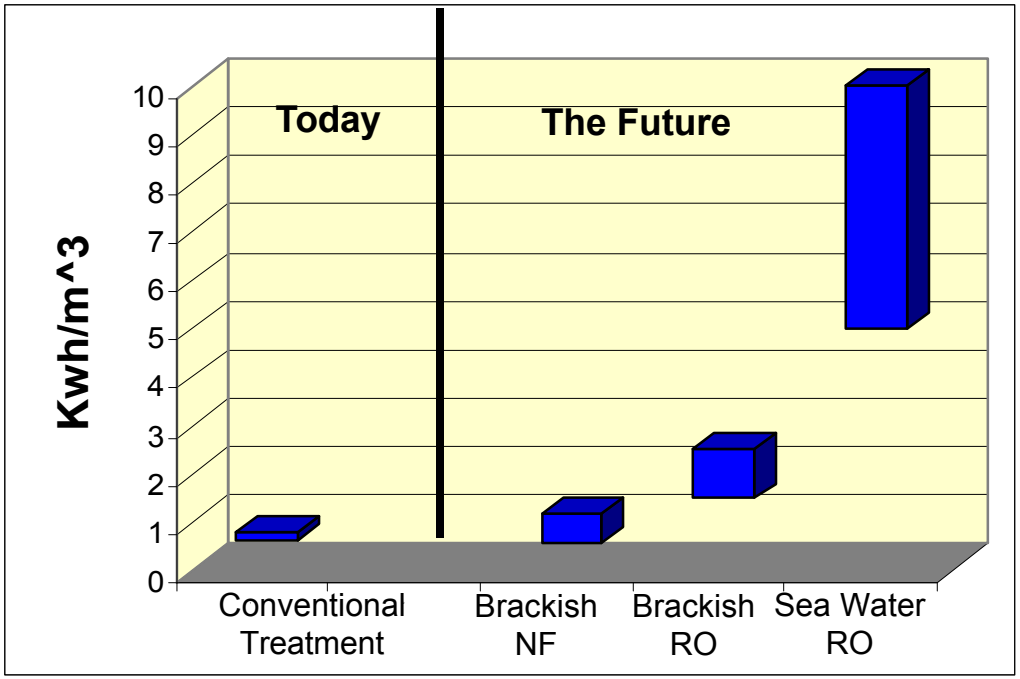
Of electricity use for water, ~12% is used to source, treat, and distribute potable water, ~8% is used for wastewater treatment, and ~80% for water heating

Energy for Water



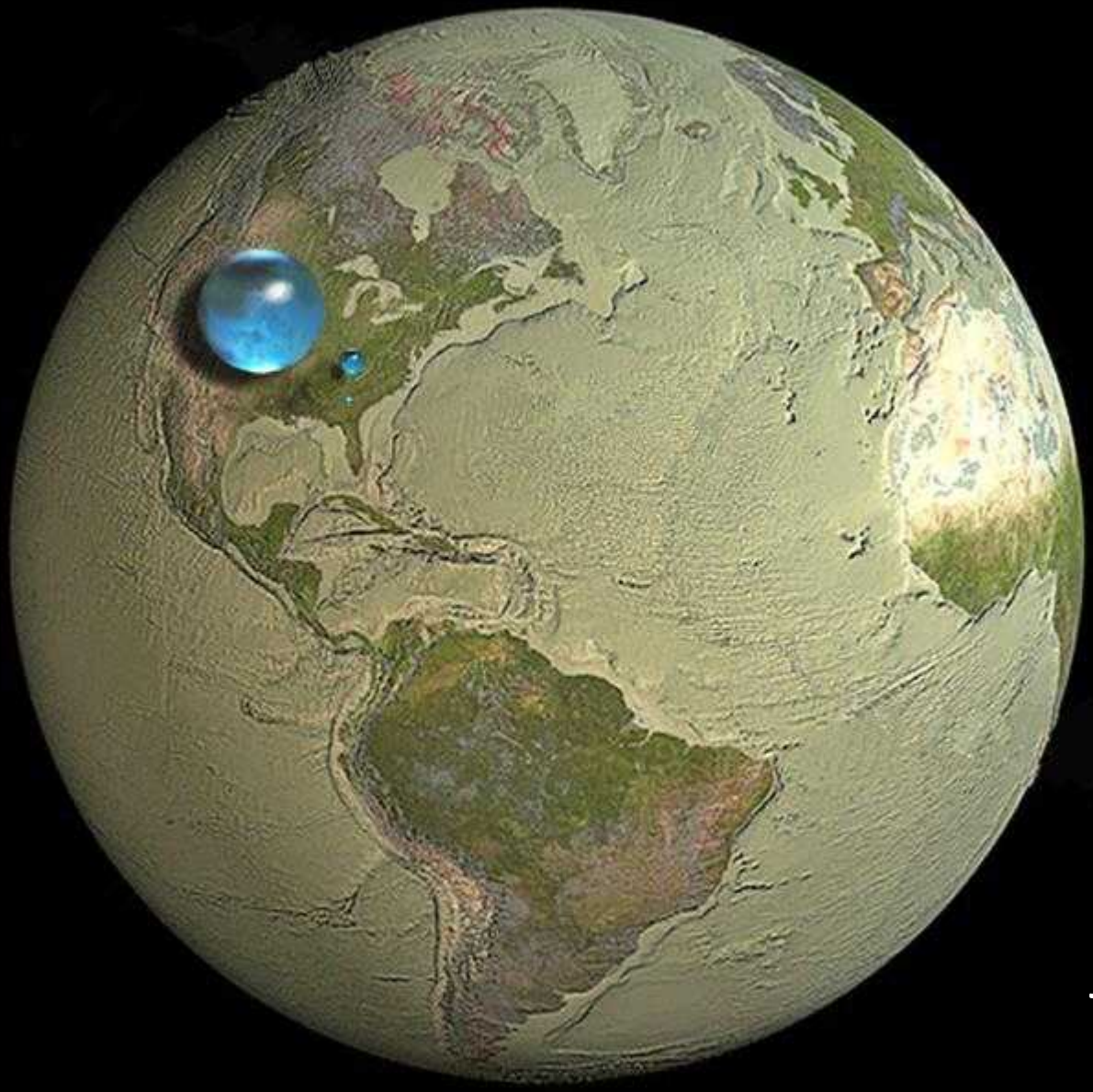
(**Modified from Water Reuse 2007, EPA 2004, Mickley 2003**)

Power Requirements For Treatment



(Einfeld 2007)

- Desal growing at 10% per year, waste water reuse at 15% per year
- Non-traditional water use is energy intensive



Thank You!

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Howard Perlman
http://ga.water.usgs.gov/edu/gallery/global-water-volume.html