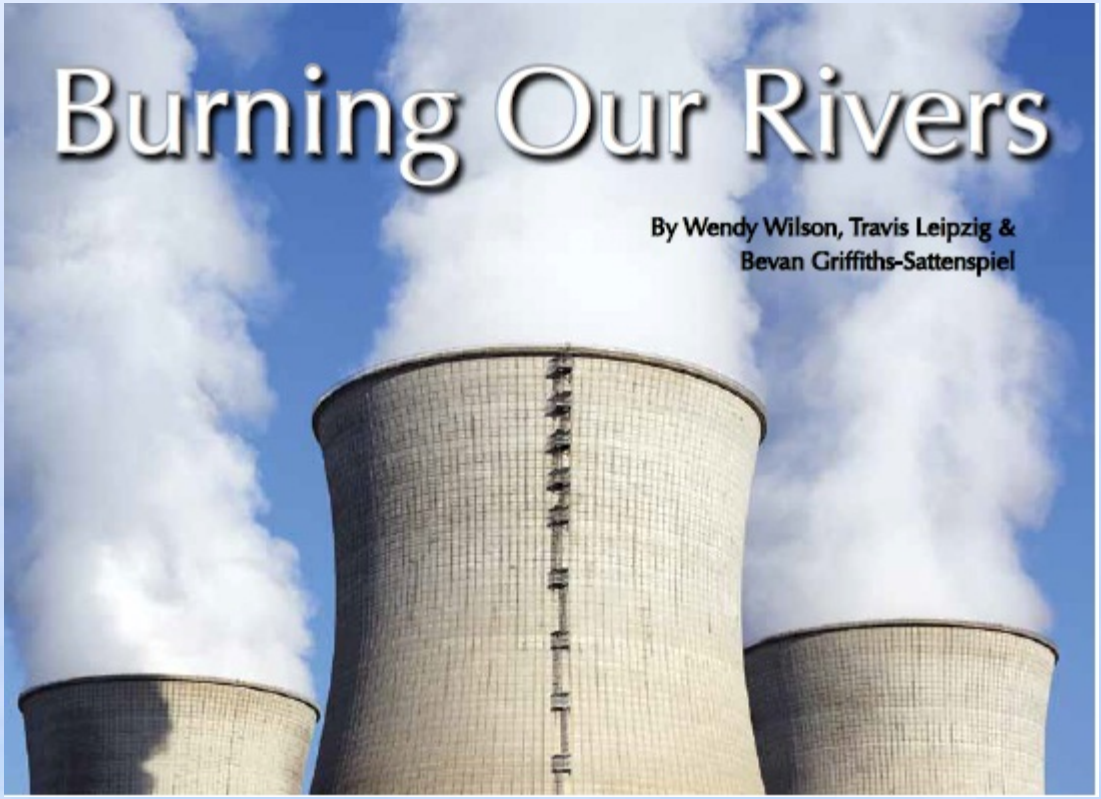
The Water Footprint of Electricity



Presentation by Wendy Wilson, Sept 27, 2012
River Network

Water- Energy Nexus

Nexus Positive

Actions that "break bonds" between energy and water use.

- Public education
- Green Infra-structure
- Net metering
- Reporting
- Water Monitoring
- Conservation cost recovery

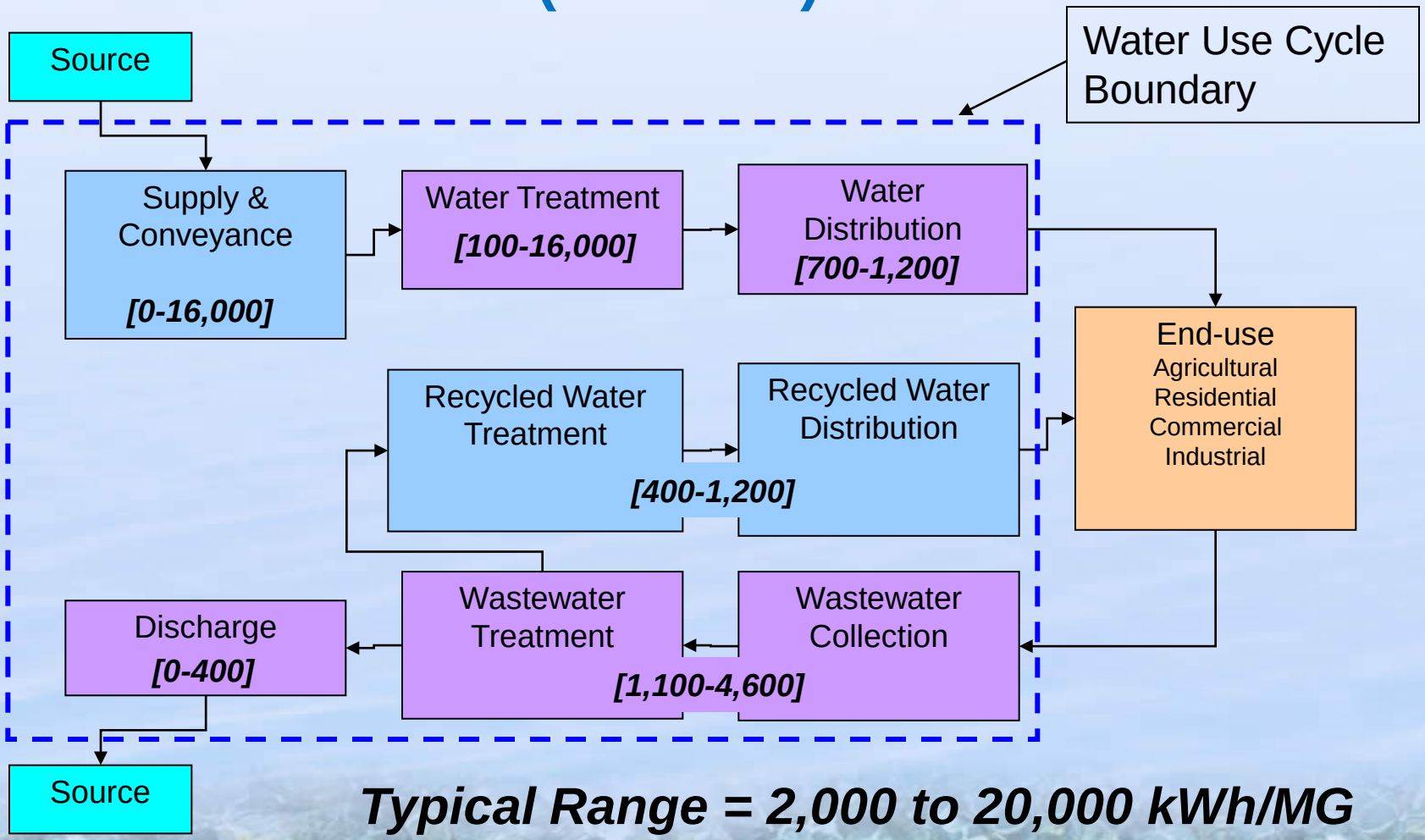
Nexus Negative

Actions and inactions that strengthen bonds:

- Professional siloes.
- Water supply leakage
- De-sal and trans-basin water pipelines
- Old building codes
- Free water
- No price on carbon

Energy Intensity of Water Supplies

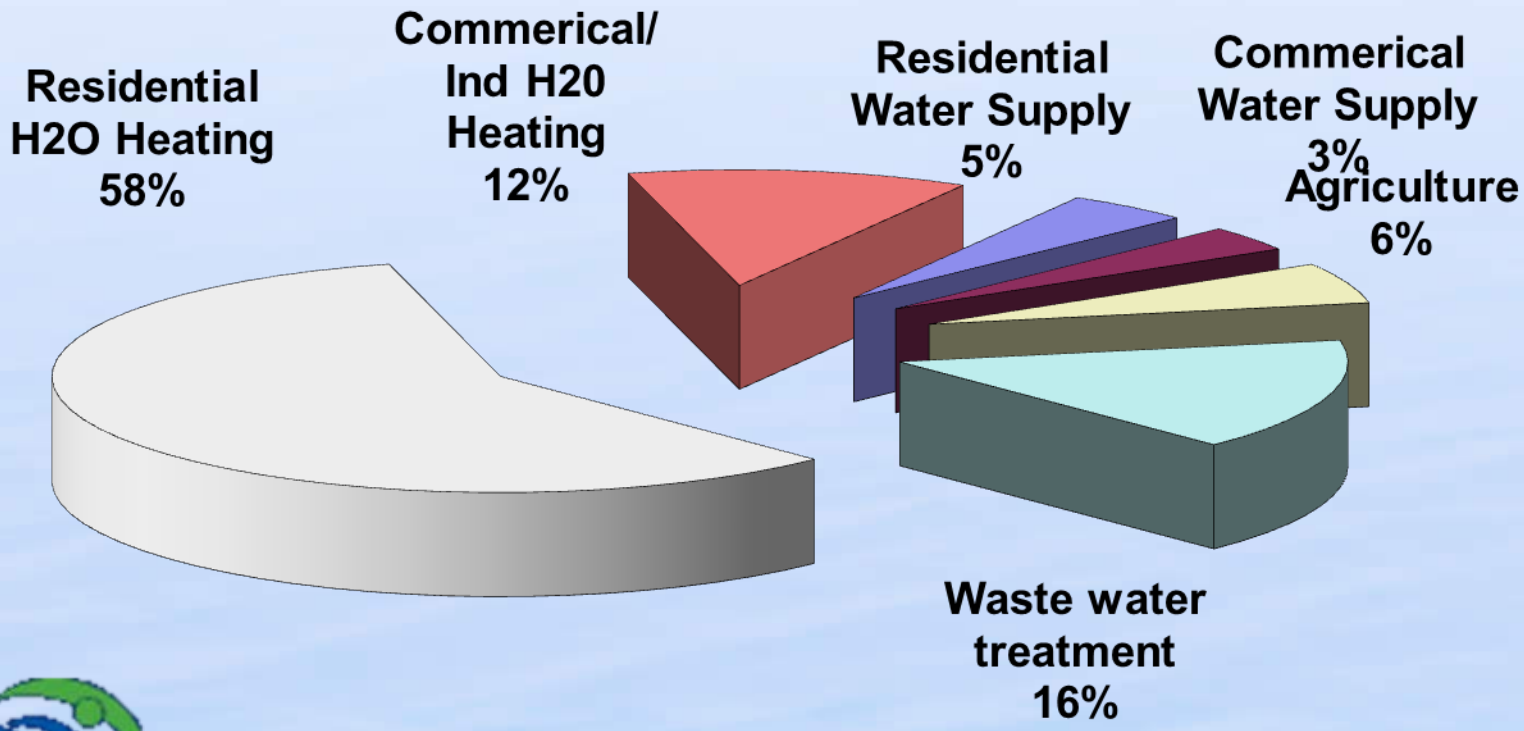
(kWh/MG)



Typical Range = 2,000 to 20,000 kWh/MG

Source: California Energy Commission, 2005 Integrated Energy Policy Report

Carbon Footprint of Water is more than 13% of U.S. electric use



National Water-Related Carbon Emissions
(290 million metric tons)

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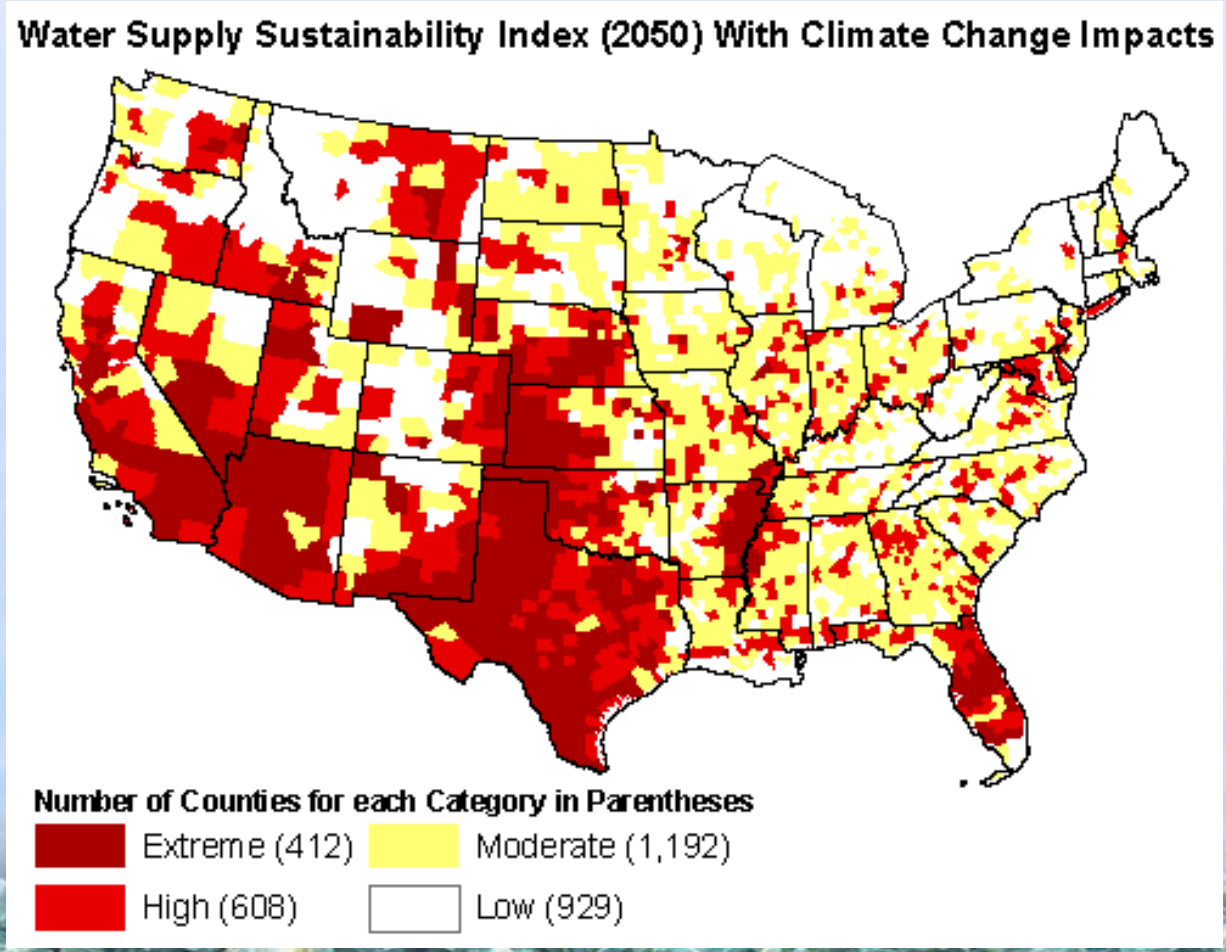
Connecting People, Saving Rivers



Thermoelectric uses…

- As much as all agricultural water
- 53% of all fresh surface water withdrawals *(USGS, 2010)*

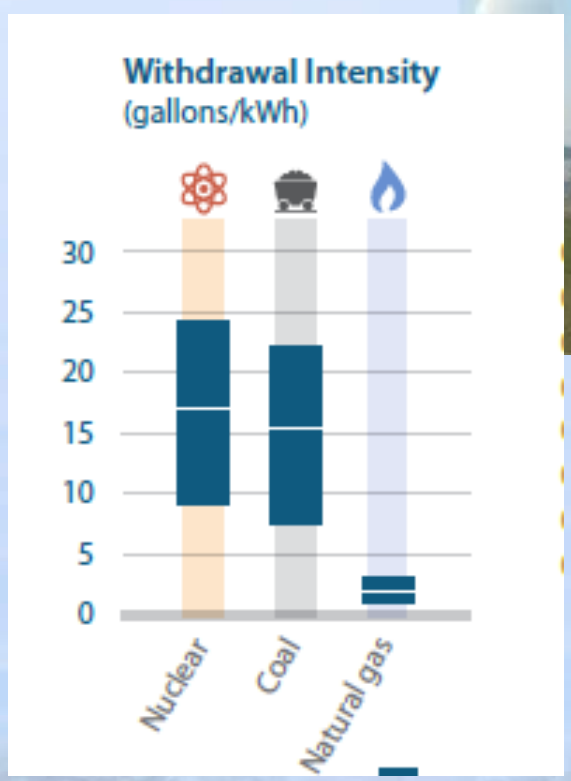


Chart Source: Union of Concerned Scientists, Energy and Water in a Warming World, 2011

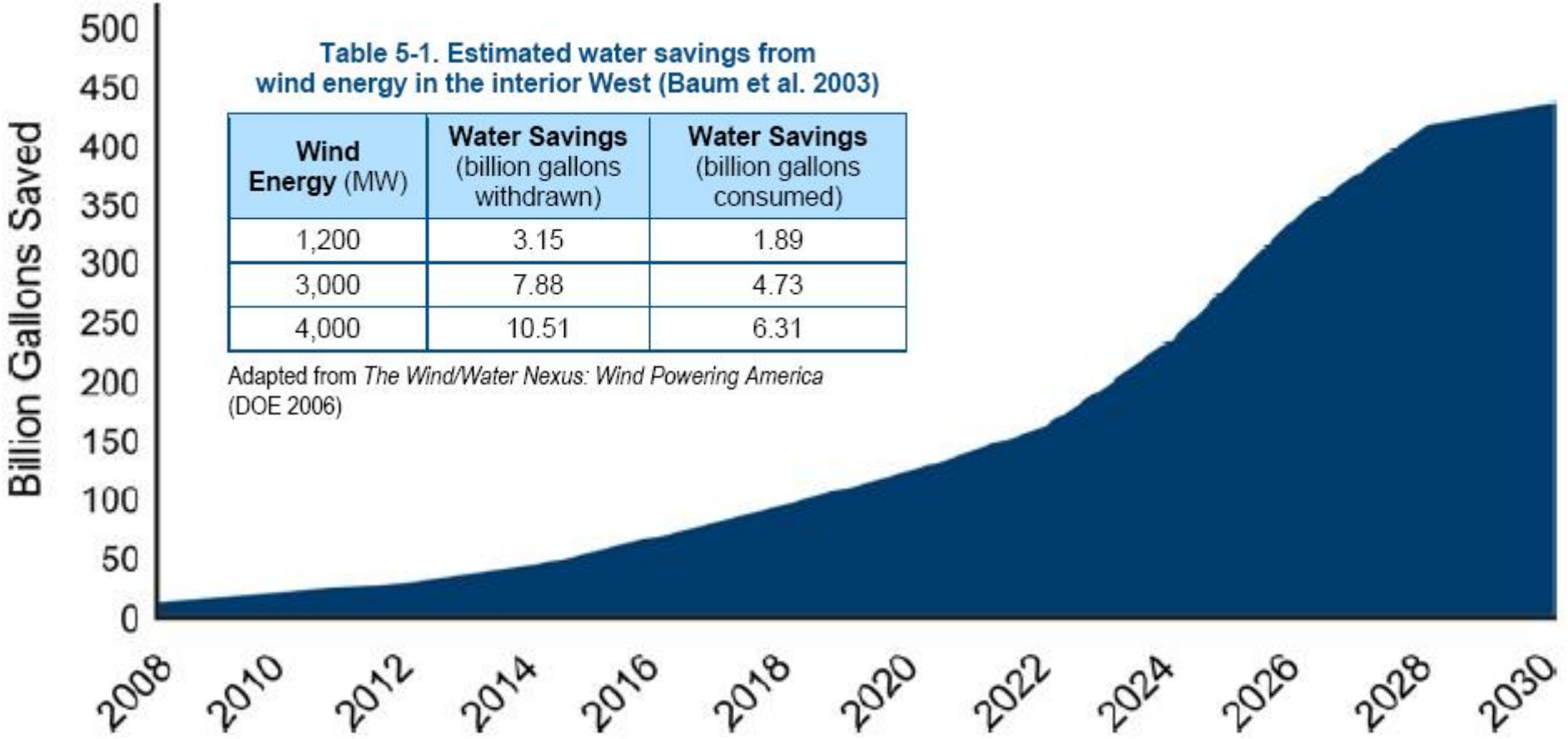
Renewables save water

Figure A-19. Annual water consumption savings due to deployment of wind energy

Table 5-1. Estimated water savings from wind energy in the interior West (Baum et al. 2003)

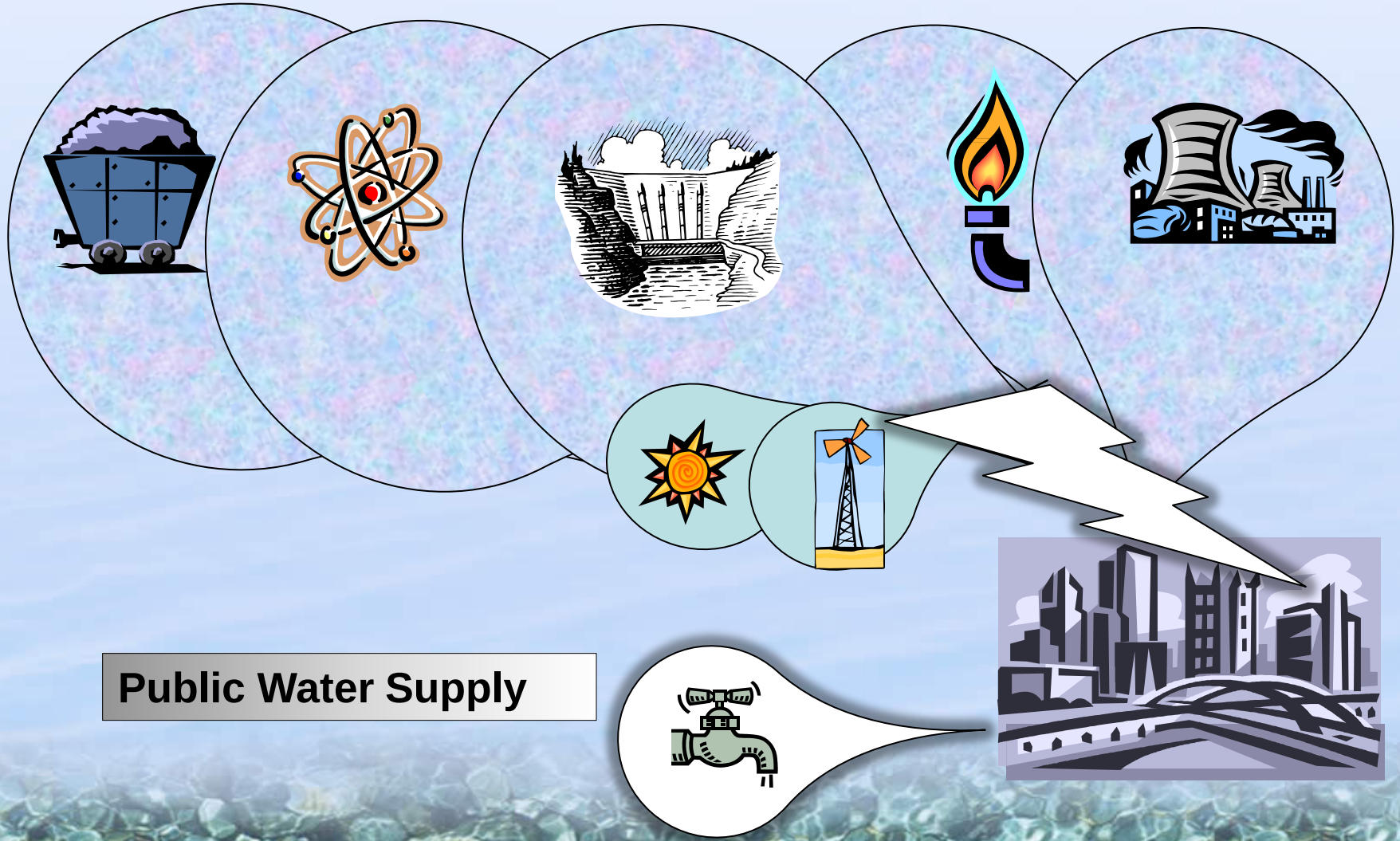
Wind Energy (MW)	**Water Savings** (billion gallons withdrawn)	**Water Savings** (billion gallons consumed)
1,200	3.15	1.89
3,000	7.88	4.73
4,000	10.51	6.31

Adapted from *The Wind/Water Nexus: Wind Powering America* (DOE 2006)



Source: U.S. Department of Energy, 20% Wind Energy by 2030 <http://www.20percentwind.org/20p.aspx?page=Report>

The Water Footprint of Electricity



Public Water Supply

Energy-related Water Stress is here

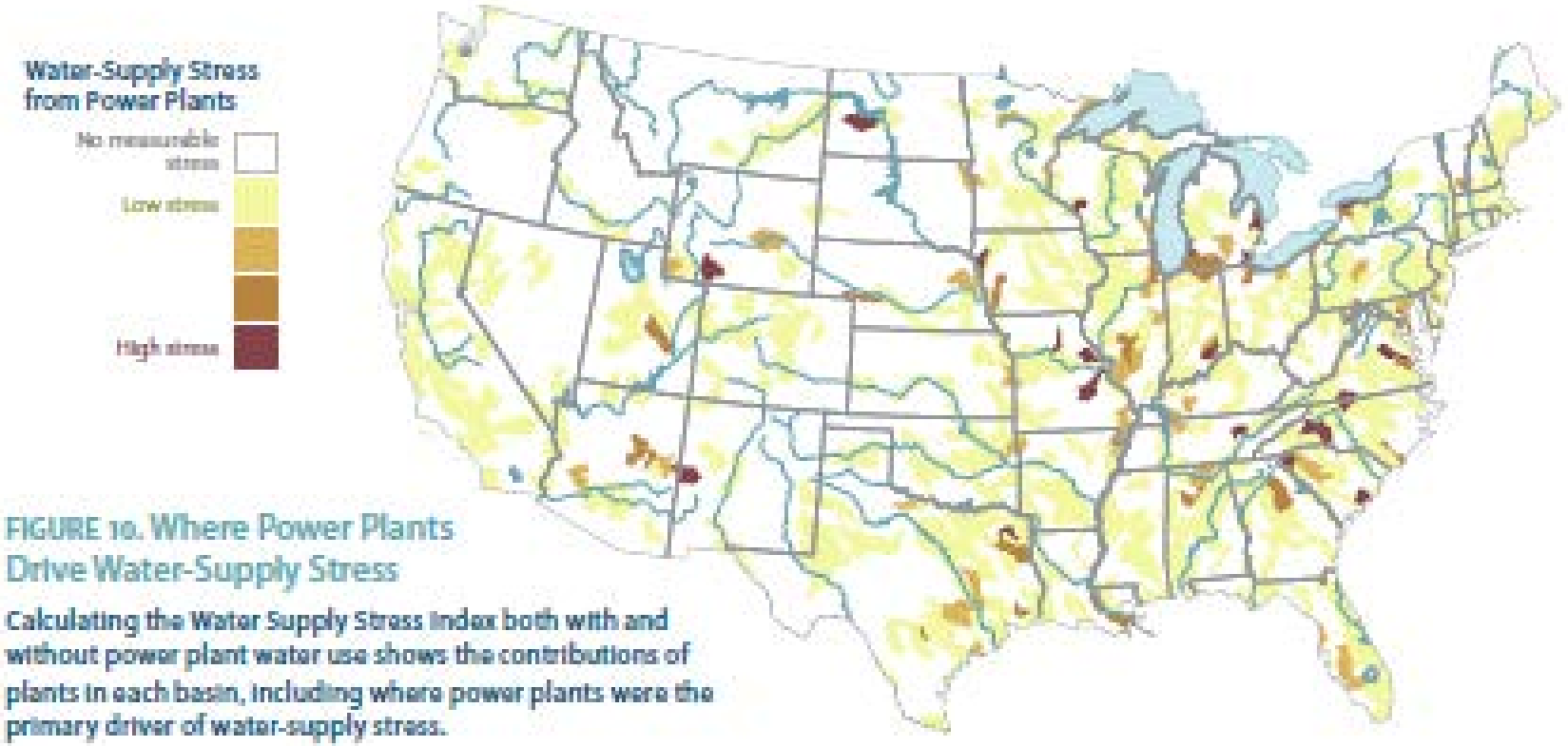
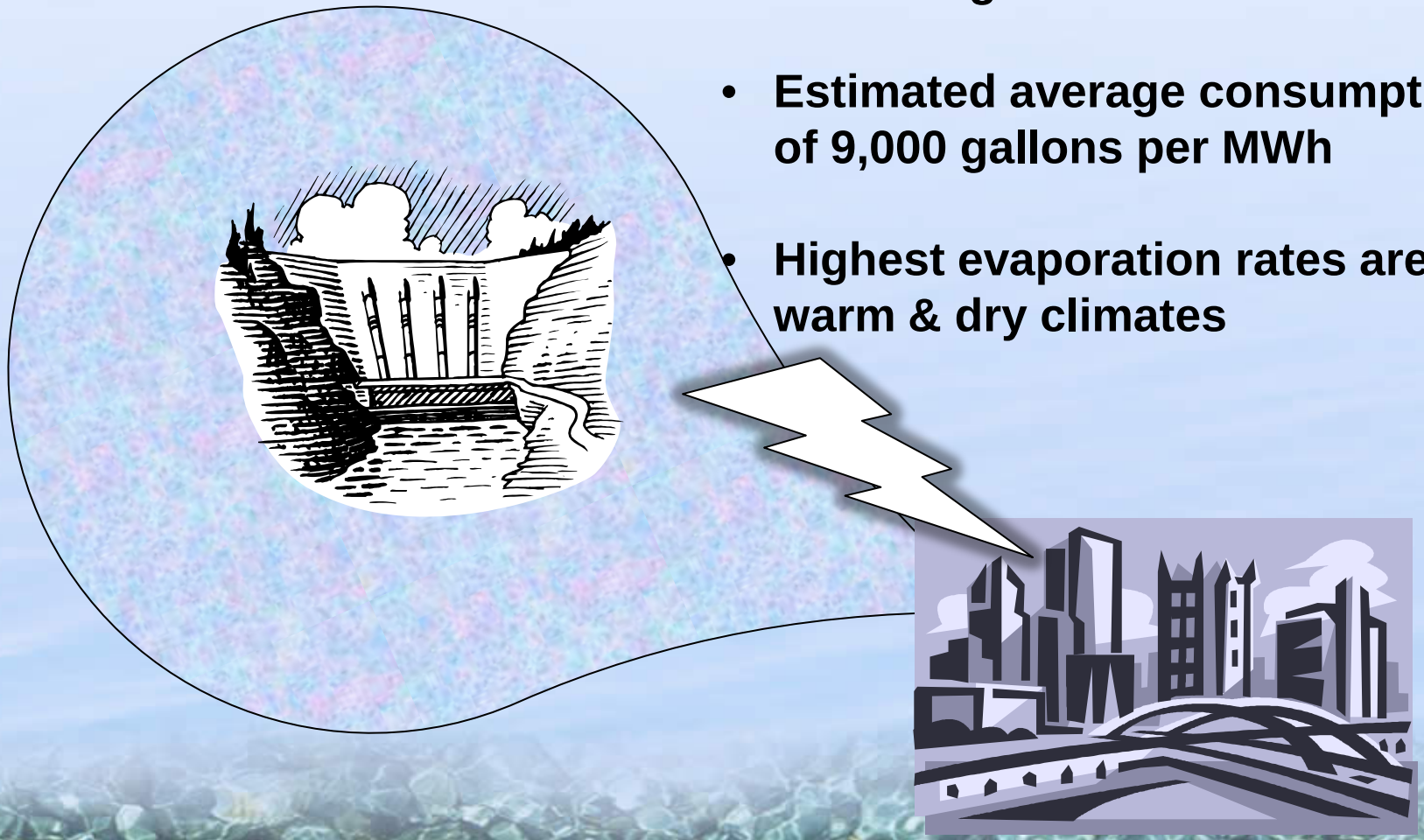


FIGURE 10. Where Power Plants Drive Water-Supply Stress

Calculating the Water Supply Stress Index both with and without power plant water use shows the contributions of plants in each basin, including where power plants were the primary driver of water-supply stress.

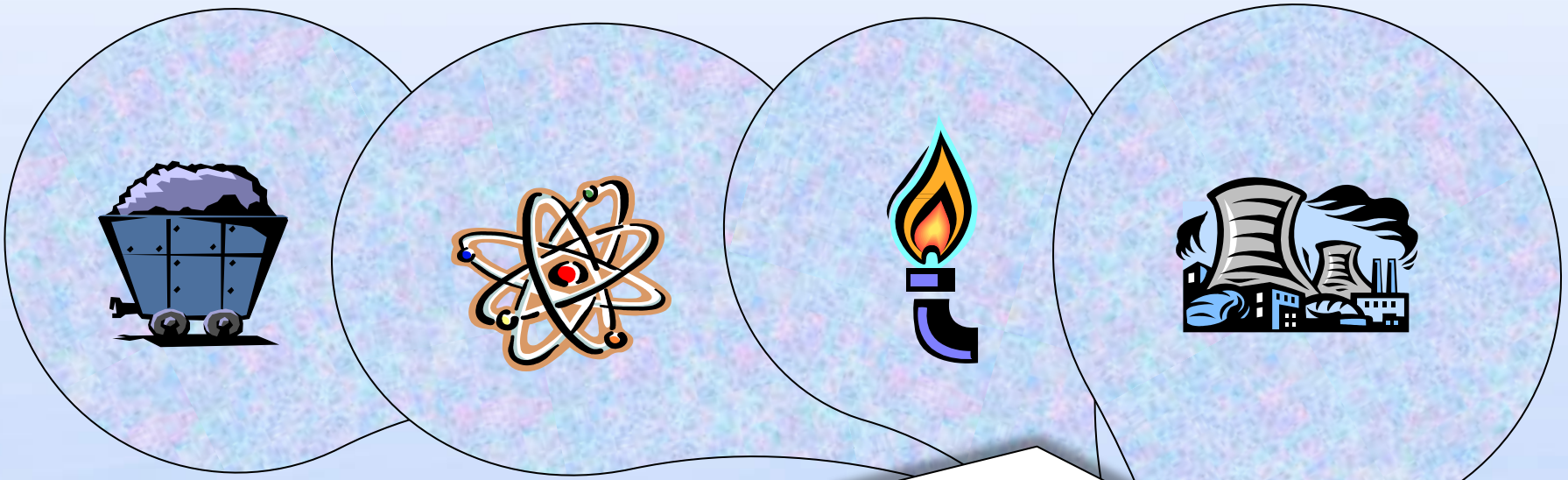
Source: Union of Concerned Scientists: 2011

Water Footprint of Hydropower



- Dams and reservoirs have largest water use and consumption of all electric technologies
- Estimated average consumption of 9,000 gallons per MWh
- Highest evaporation rates are in warm & dry climates

Water Footprint of Thermoelectricity



- **Fastest growing water use sector**
- **Thermal pollution contributes to algae blooms**
- **Plants may experience more shutdowns as water-intake temperatures increase**

Water Footprint of Coal

40% of coal plants use once-through

- **U. S. grid was 44.5% coal in 2009**
- **Total water use of 16,052 gallons per MWh Consumption = 692 gallons/MWh**
- **Causes acid rain, mercury, coal ash disposal problems.**
- **Carbon sequestration increases water use**

Water Footprint of Natural Gas

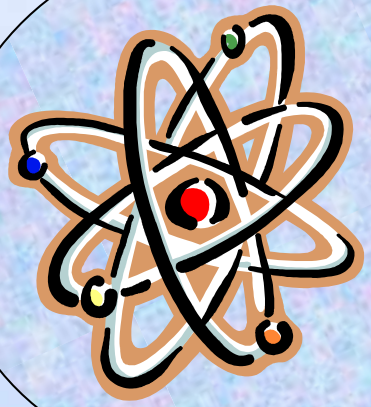
- **On average in 2009, producing electricity from Natural gas used 6,484 gallons per MWh**

Combined cycle technology uses less than single cycle

Report does not include "fracking" water withdrawals or consumption

"*Methane emissions are at least 30% more than conventional gas. Compared to coal, the footprint of shale gas is at least 20% greater and perhaps more than twice as great on the 20-year horizon.*"
– Climatic Change, Robert Howrath, et al., DOI 10.1007/s10584-011-0061-5

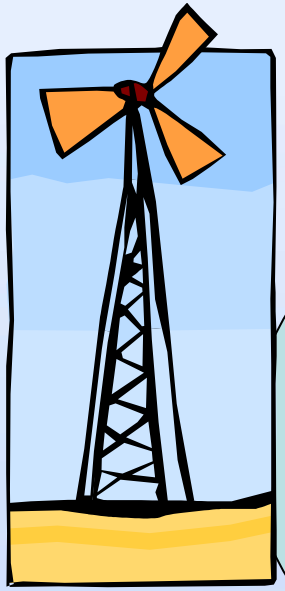
Water Footprint of Nuclear Energy



38% of plants in 2009 were “Once through”

- **Nuclear was 20% of grid in 2009**
- **Direct consumption is greater than coal**
- **Average need 14,811 gallons per MWh**
- **Water impacts of waste disposal unknown**

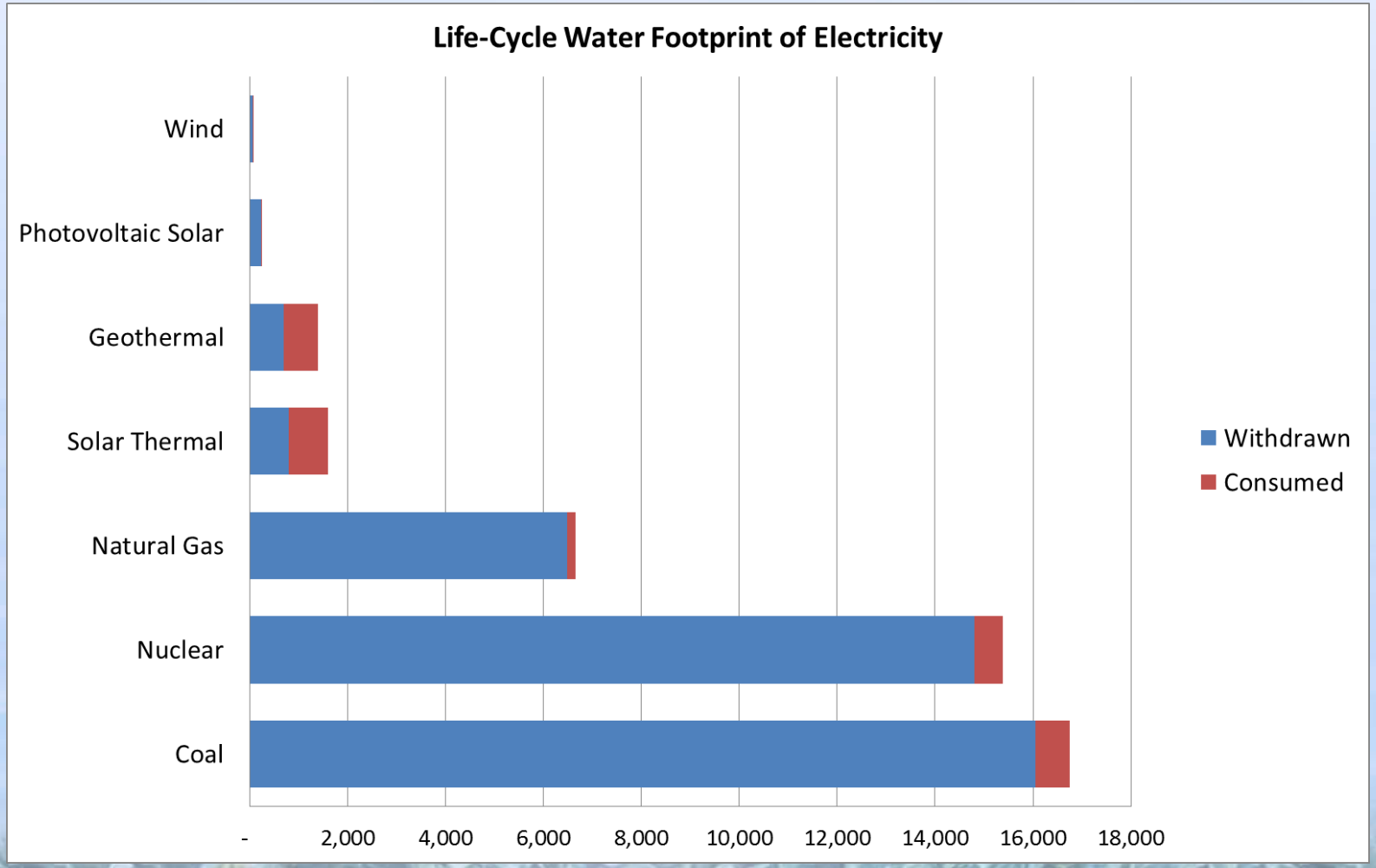
PV Solar and Wind



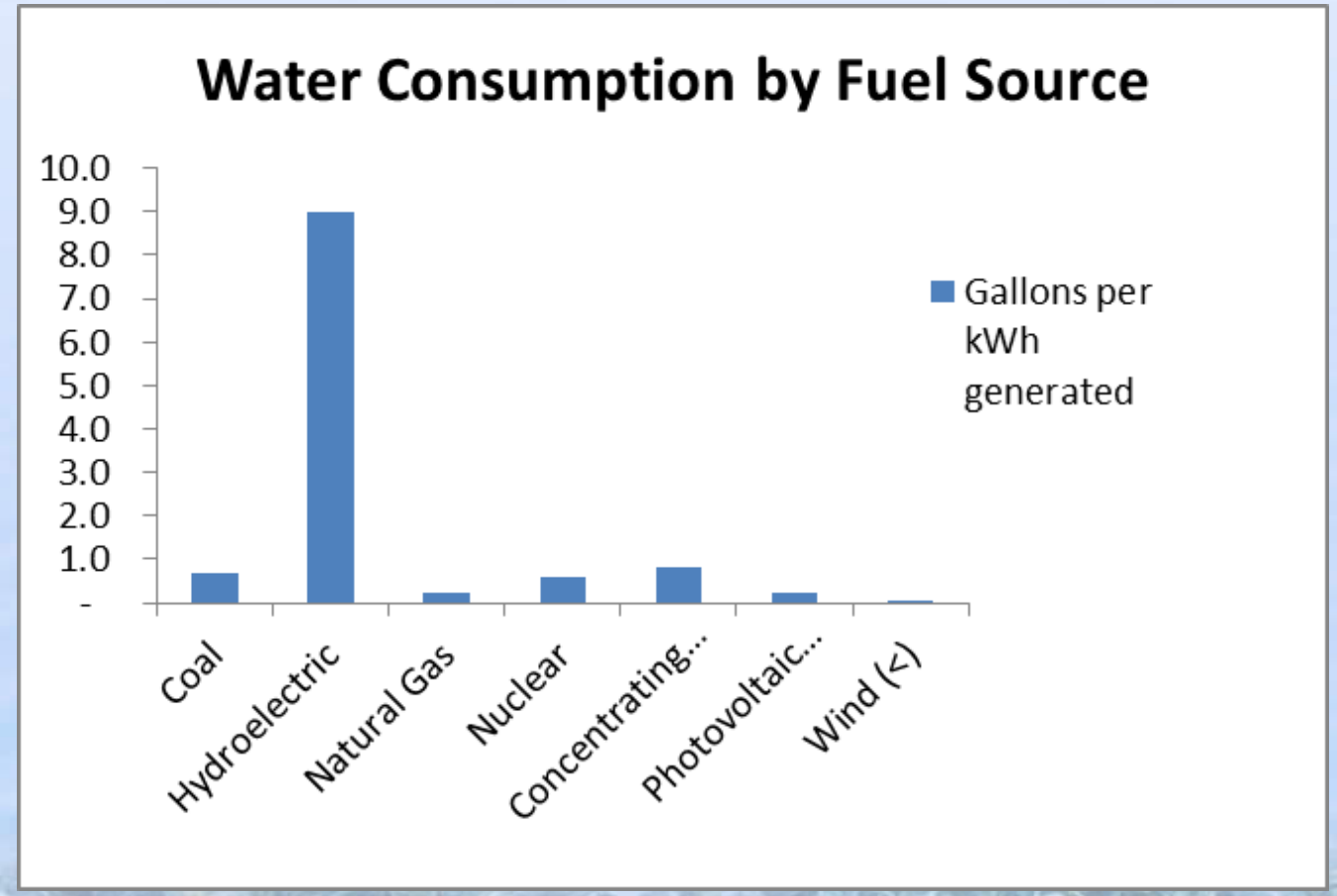
1. **Wind has lowest water use (less than 61 gall per MWh)**
2. **WF of PV solar is next lowest at 231 gallons per MWh**
3. **“Upstream” water use is larger than on-site use.**

Concentrated Solar Thermal can have a relatively high water footprint

Comparing energy options



Water consumption for 1 kWh



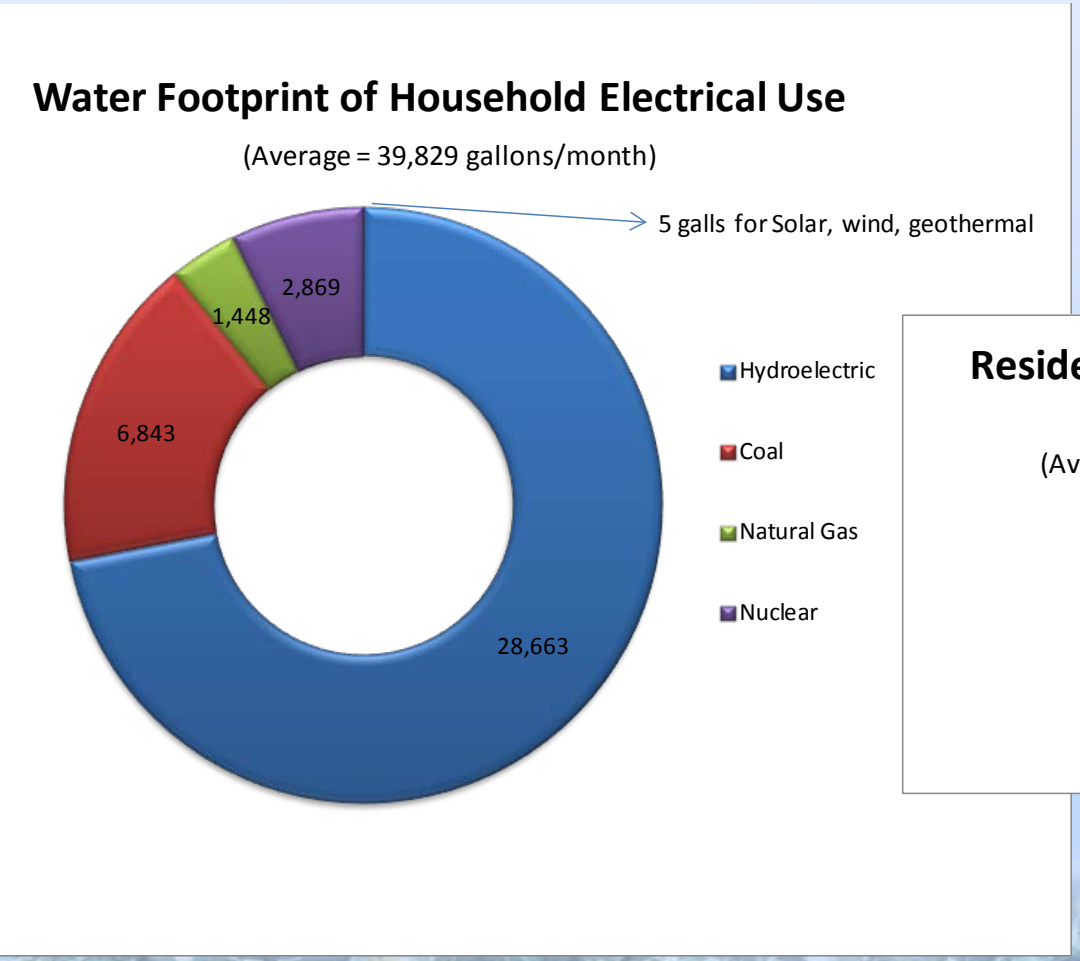
Water needed to make 1 MWh

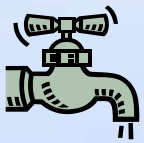
Table 2: Water Footprint of Electricity
(gals/MWh weighted national average)

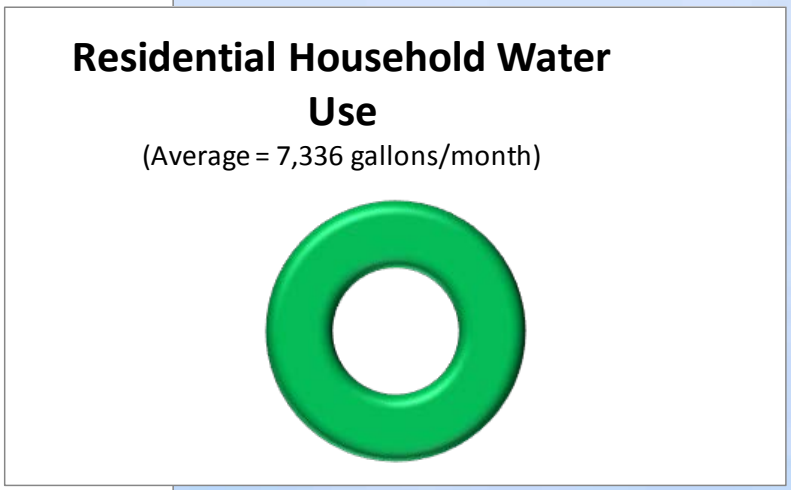
Fuel	Percent of 2009 U.S. grid	"Blue Water" Consumption	"Gray Water" (Additional Non-consumptive)	Total Water Footprint
Coal	**45%**	308	6,835	**7,143**
Hydroelectric	**7%**	612	29,308	**29,920**
Natural Gas	**23%**	40	1,472	**1,512**
Nuclear	**20%**	116	2,880	**2,995**
Geothermal	**0%**	2	-	**2**
Solar	**1%**	0.01	2	**2**
Wind	**2%**	0.02	1	**1**
Other	**2%**	-	-	**-**
Total U.S. gal/MWh		1,078	40,498	**41,575**
Total U.S. gal/kWh		1.1	40	**41.58**

Indirect household water

Five times as much as direct water use







Policy Discussion:
How do we get more water?

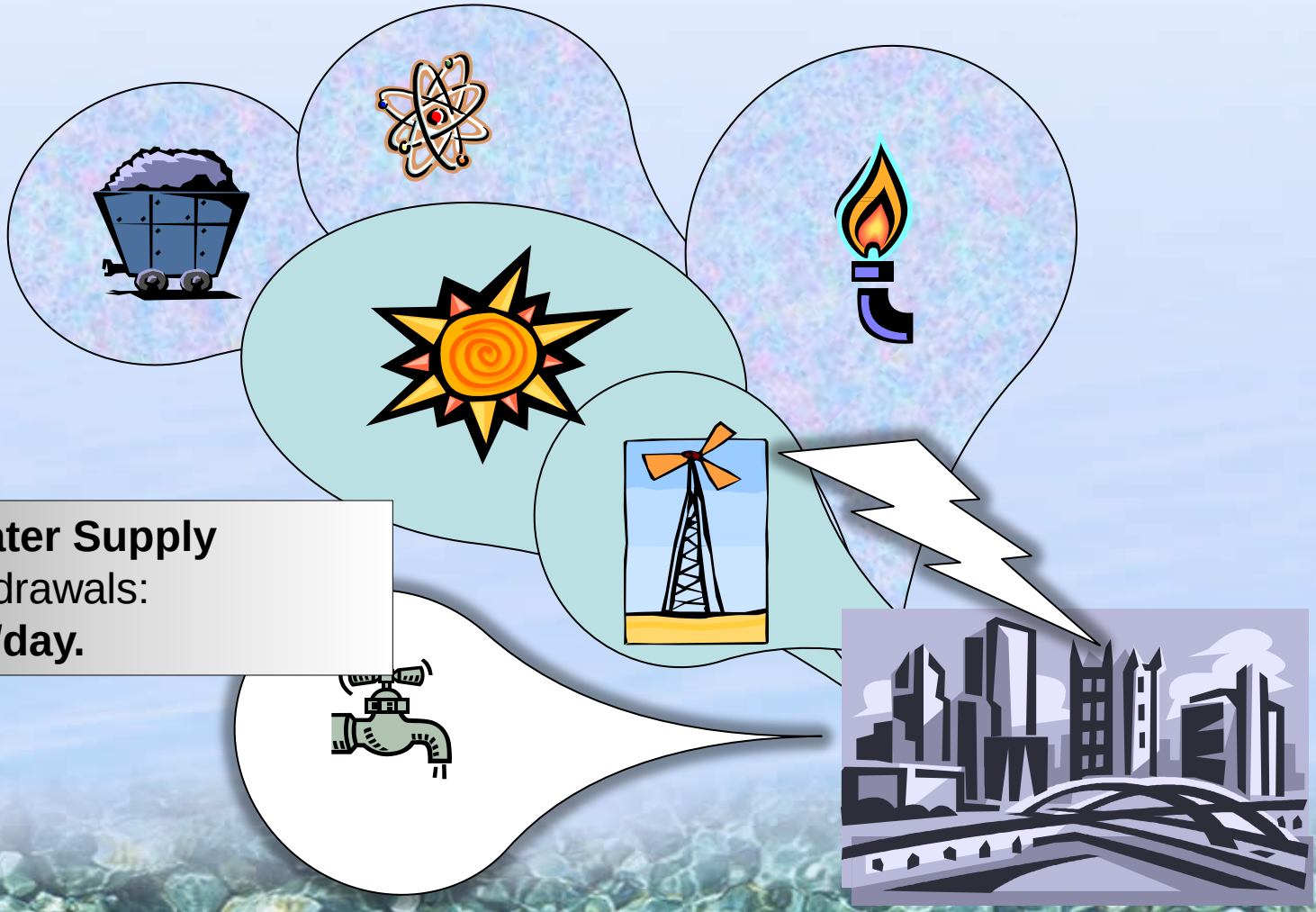
- Save energy.
- Review management of existing dams to help meet changing needs
- Increasing wind & solar to 40% of grid would reduce U.S. thermoelectric WFE by 60% (& reduce consumptive use by 11%)
- Eliminating once-through cooling -- **by itself** -- could reduce thermoelectric portion of WFE by 68%, but may increase thermoelectric consumptive use by 20%.
- Eliminating “once-through” cooling AND increasing low-water renewables to 40% of the grid could reduce thermoelectric water use by 83% and consumption by 27%.

Potential for Change?

Thermoelectric water use: 201 Bgal/day

X.83

Potential savings: **166 Bgal/day**



Public Water Supply
Total Withdrawals:
44.2 Bgal/day.

Nexus Positive:
"What Ifs"

- What if an energy company's **"Energy-Return-on-Water-Invested"** had to be reported to state energy regulators?

- What if water wasn't free – but had a **societal or "opportunity cost"** which was considered in energy regulation and "least-cost" planning?

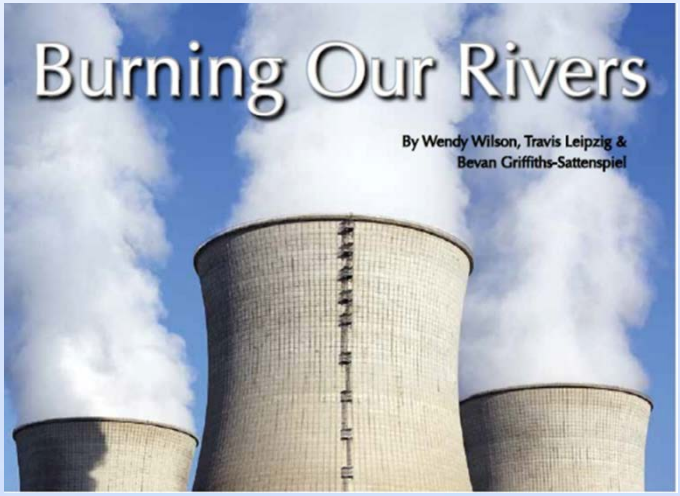
- What if energy companies had to pay for carbon and could get credit for strategies that save water as well?

“Nexus Positive” Monitoring

- Water Supply and instream impacts
- Gauging / Water use reporting?
- CWA --316(a) and 316(b) requirements?
- FERC/ State Instream flow requirements
- Temperature (NPDES and TMDL requirements)
- Mixing zone conditions
- Dissolved Oxygen TMDLs
- Heavy metals & toxic substances
- What else?

Recommendations

1. Conservation first - Saving energy saves water
2. Improve water use reporting and monitoring at existing power plants
3. Help dam-affected rivers respond to change Improve cooling technologies/ phase out “once-through”
4. Incentivize low-water energy sources
5. Look at future water needs of CCS
6. “Energy-Return-on-Water-Invested” protocol
9. Level playing field -- close oil and gas exemptions to environmental laws
10. Increase public involvement and collaboration between energy and water sectors



Full report:
http://www.rivernetwork.org/burning-rivers

Contact:
wwilson@rivernetwork.org