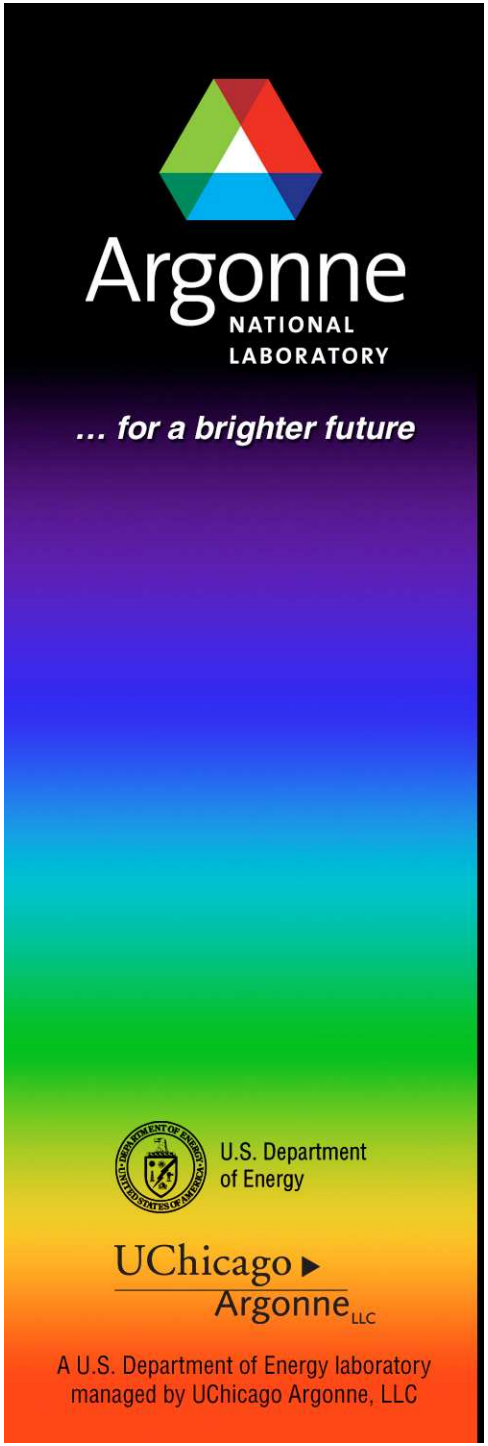


Challenges at the Energy-Water Nexus

Presented by:

John Veil

Argonne National Laboratory

To :

National Association of Clean Water Agencies

2009 Summer Conference and 39th Annual Meeting

July 17, 2009

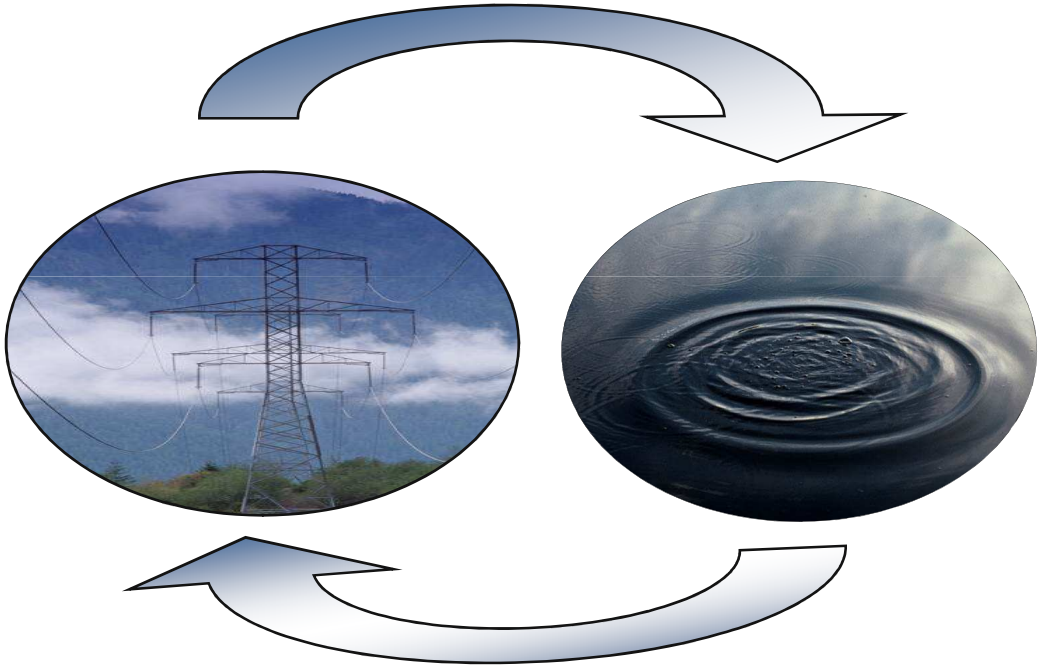
Energy and Water Are … Inextricably Linked

Water for Energy

and

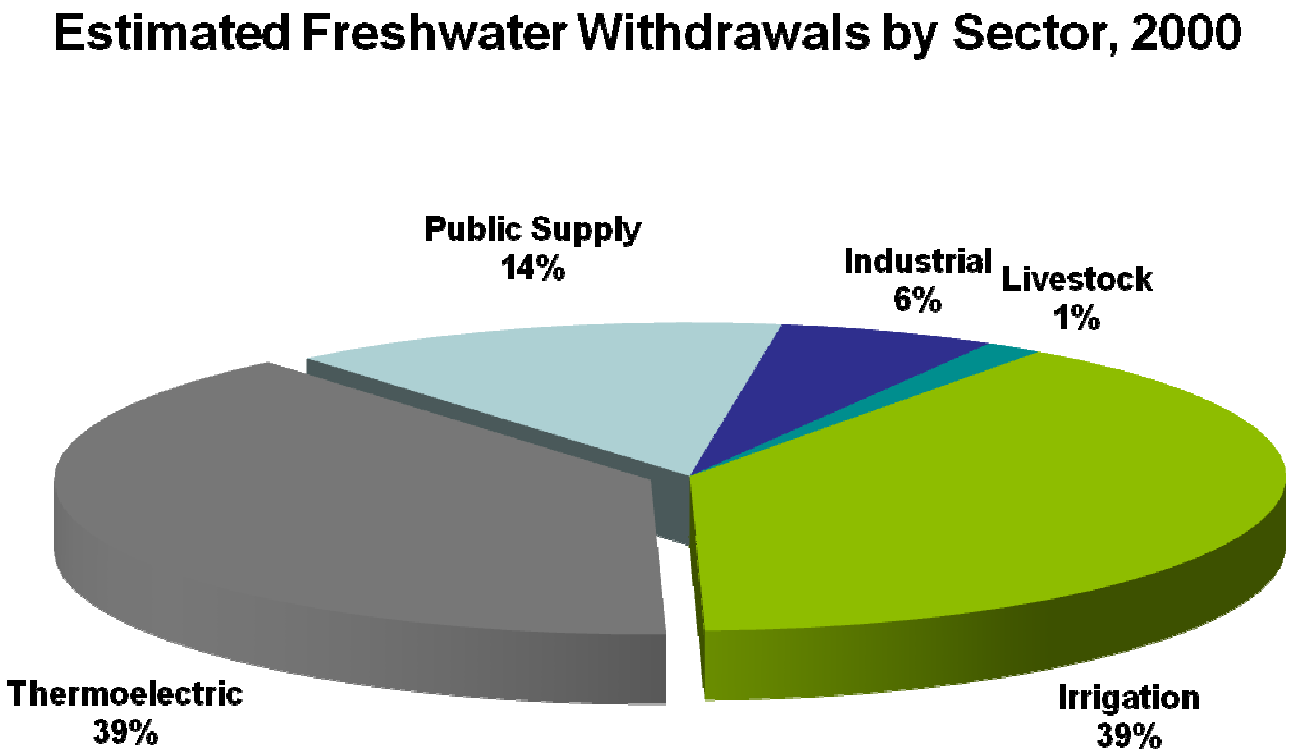
Energy for Water

- Thermoelectric cooling
- Hydropower
- Energy minerals extraction / mining
- Fuel Production (fossil fuels, H_2, biofuels/ethanol)
- Emission controls



- Pumping
- Conveyance and Transport
- Treatment
- Use conditioning

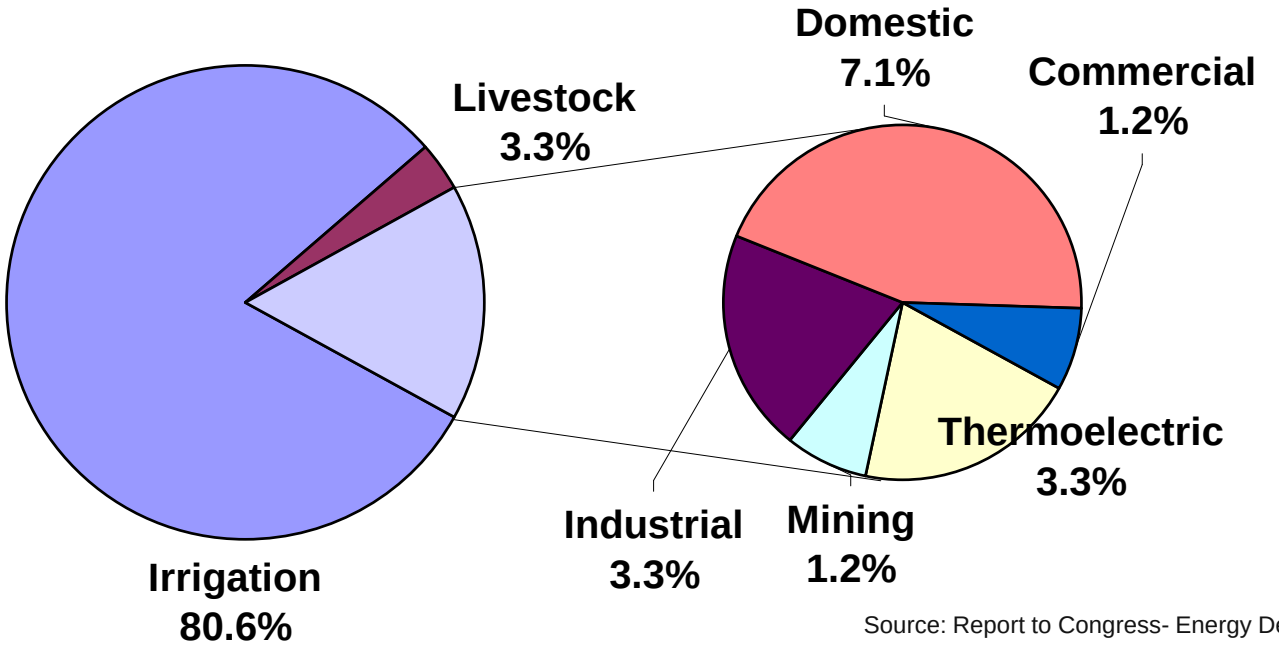
Energy and Agriculture Withdraw the Most Water in the U.S.



Source: USGS Circular 1268, March, 2004

Energy Accounts for a Growing Portion of Water Consumption

U.S. Freshwater Consumption, 100 Bgal/day

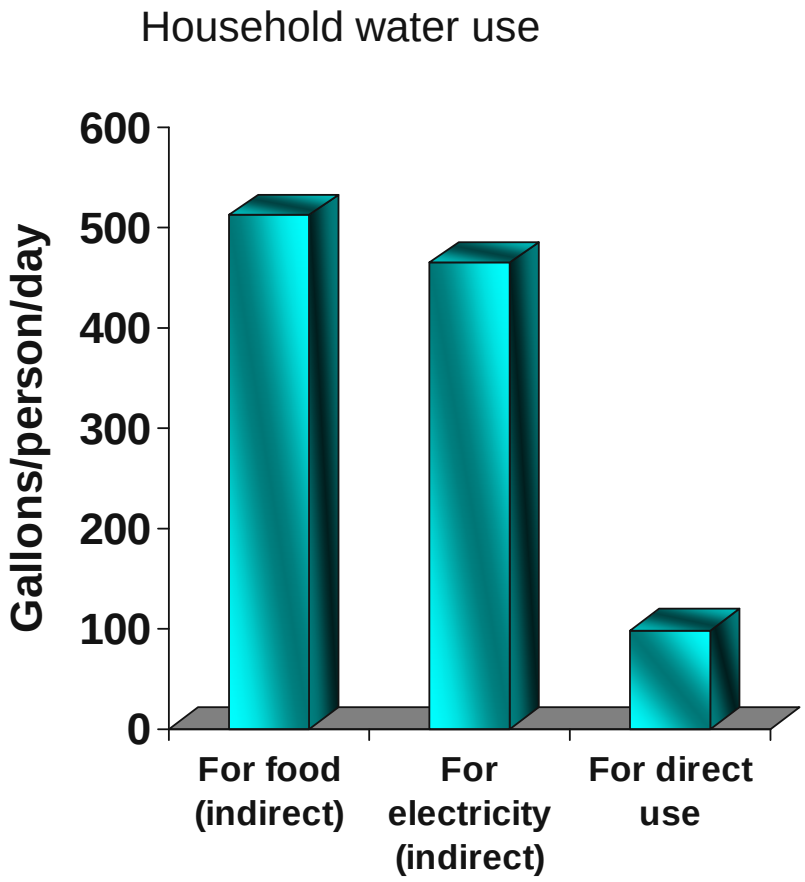


Source: Report to Congress- Energy Demands on Water Resources

Thermoelectric energy accounts for 27 percent of non-agricultural fresh water consumption
Biofuels production and processing not included here

Energy Requires Water

- WATER USAGE PER PERSON PER DAY
  - 100 gallons direct household use–includes bathing, laundry, lawn watering, etc.
  - 510 gallons for food production–includes irrigation and livestock
  - 465 gallons to produce household electricity–Range: 30 to 600 gallons depending on technology –Each kilowatt-hour of electricity requires on average about 25 gallons of water to produce



Derived from Gleick, P. (2002), *World's Water 2002-2003.*

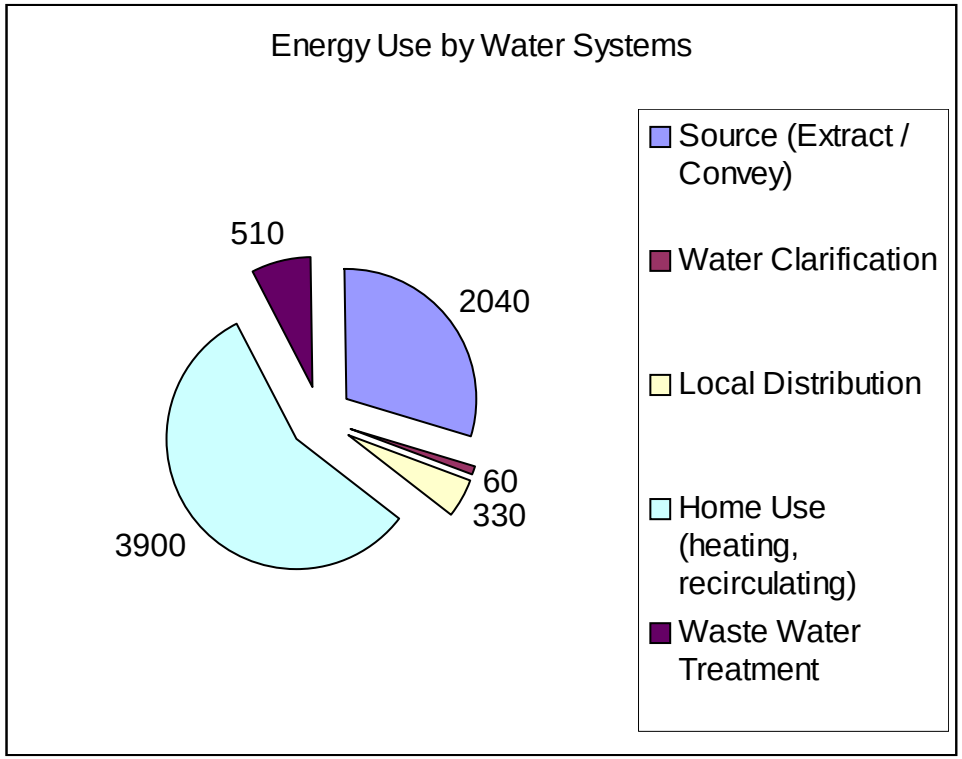
Water Requires Energy

- Pumping, treating distributing, end use of water requires significant energy expenditures

- 7% of California Electricity Consumption used for water pumping

- As much as 25% of California Electricity Consumption related to water use.

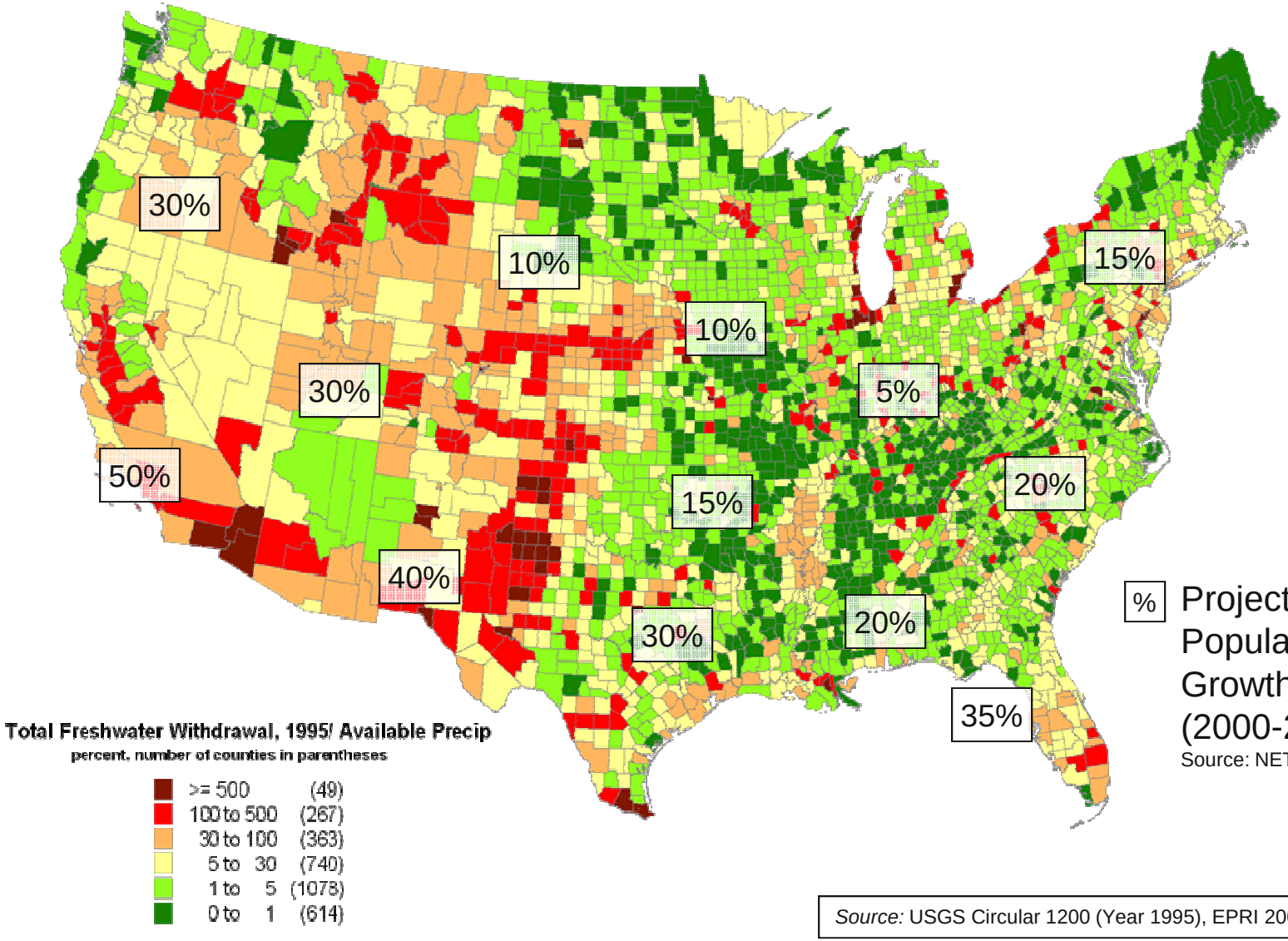
San Diego, CA



Total = 6840 kWh/af

Source: Pacific Institute, 2004

Water Challenges Are Nationwide

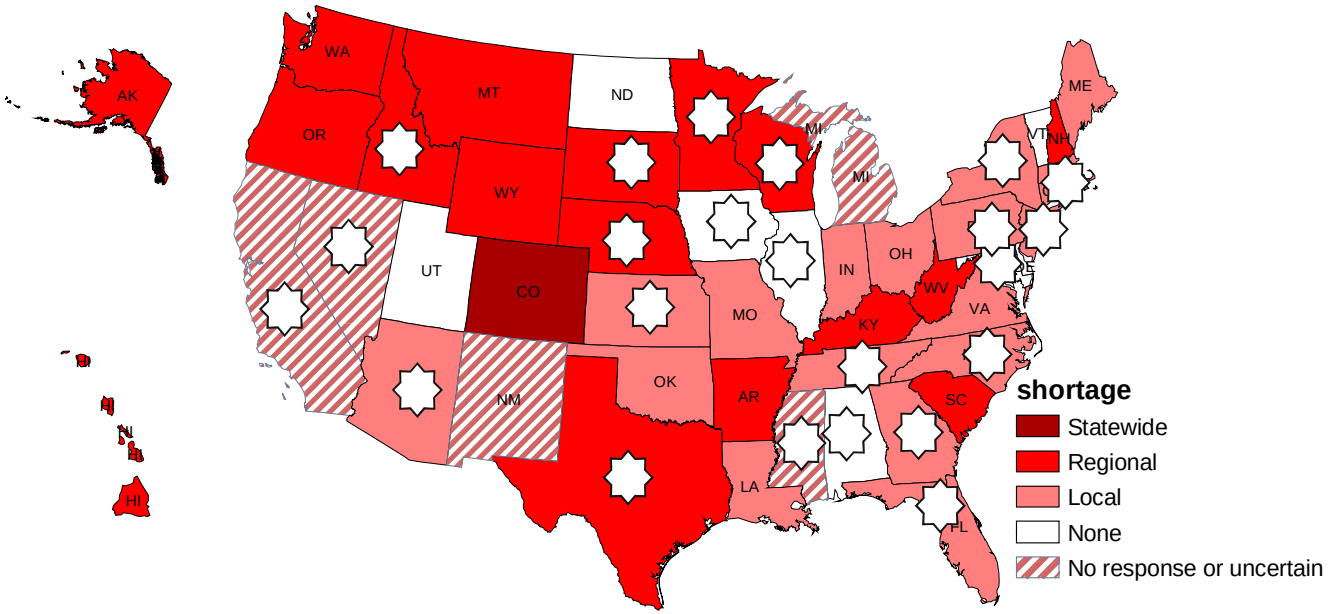


Source: USGS Circular 1200 (Year 1995), EPRI 2003

Most State Water Managers Expect Shortages over the Next Decade under Average Conditions

- 36 of 45 Reporting States anticipate water shortages during the next 10 years under average conditions

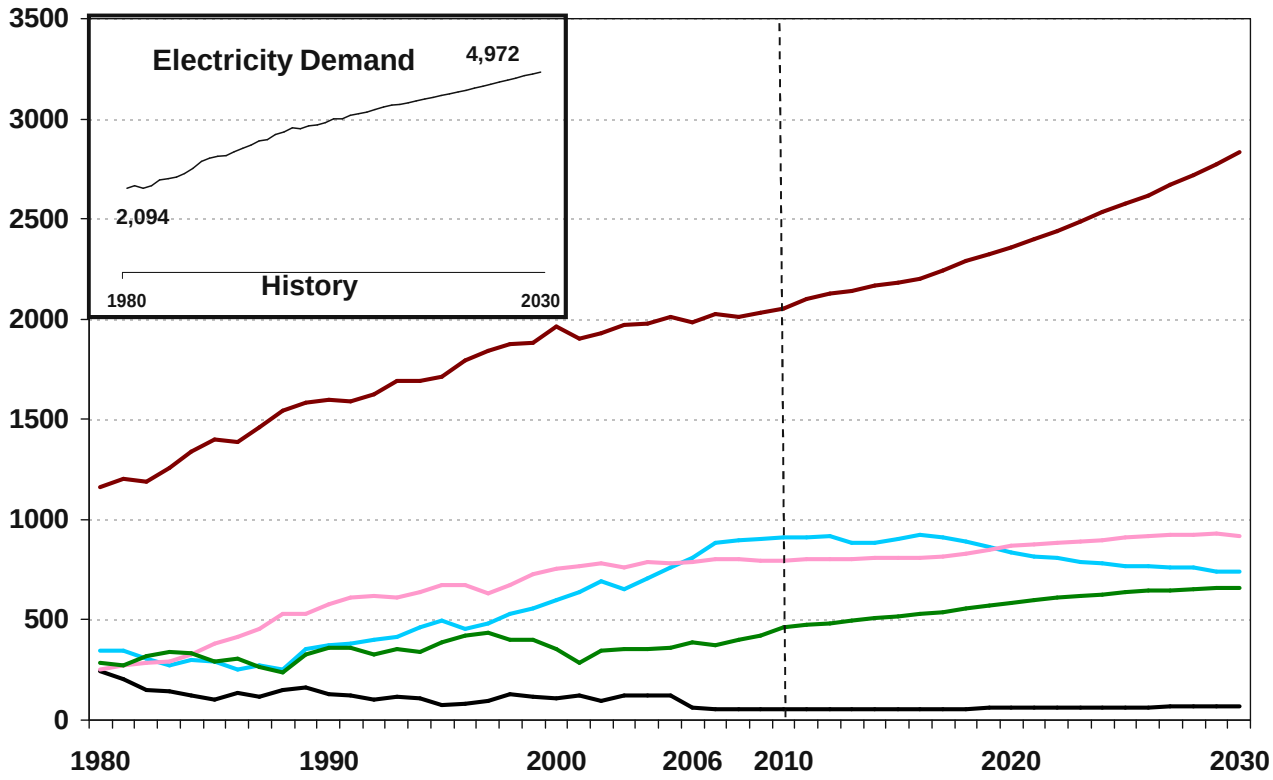
- Regional, statewide and local shortages are expected



Source: GAO 2003

The U.S. Will Need 30% More Electricity by 2030

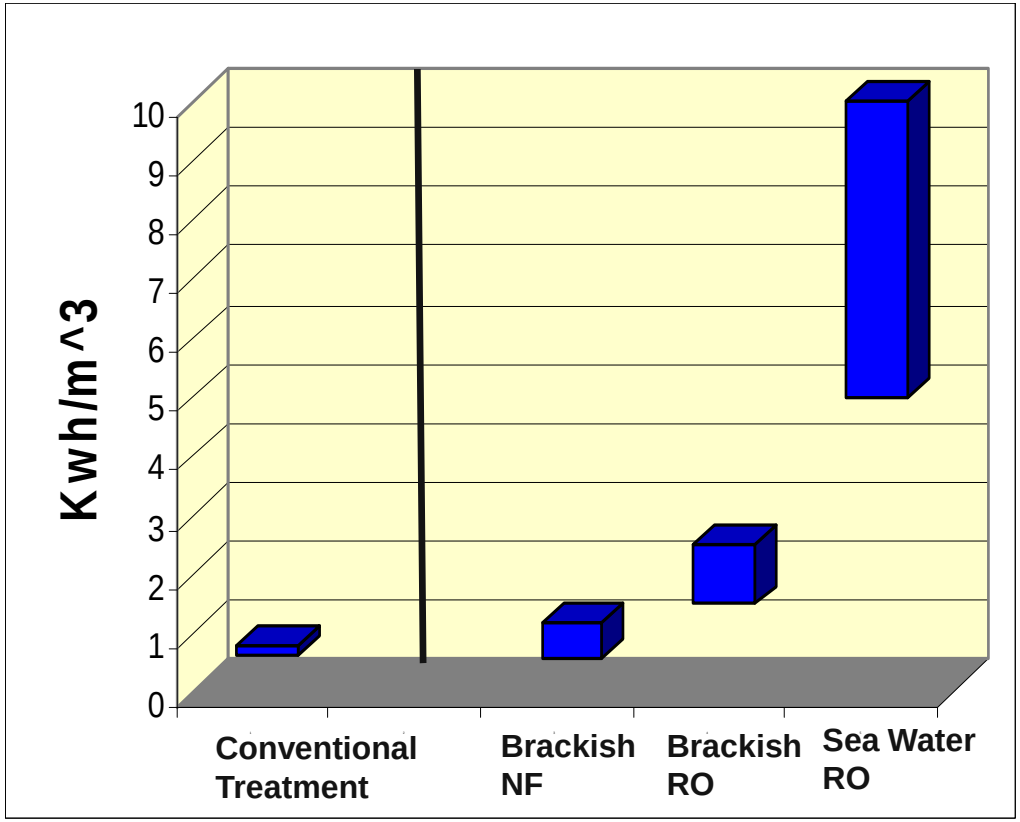
Electricity Generation by Fuel, 1980-2030 **(billion kilowatthours)**



Source: EIA Energy and Environment
Sustainability in a Carbon Constrained Future 2008

Future Water Supplies Will Require More Energy

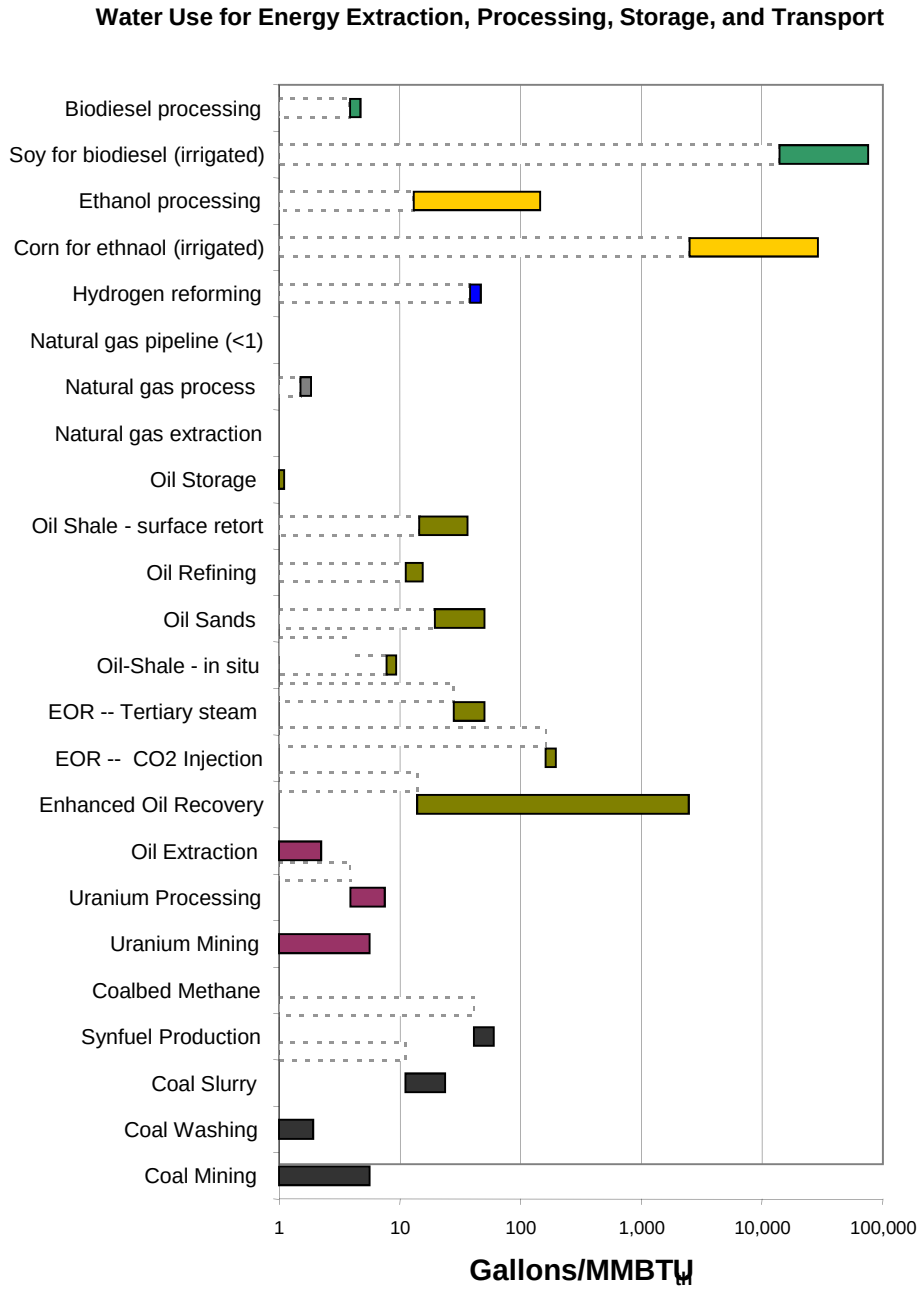
- Readily accessible water supplies have been harvested
- Treatment of future water supplies will be more energy intensive
- New technologies are required to reduce energy requirements to access non-traditional sources (e.g., impaired water, brackish water, or sea water)



Source: EPRI (2000), Water Desalination Task Force (2003)

Future Energy Development Will Put New Demands on Water

- Many newer technologies will be more water intensive
- Biofuels and hydrogen would require significantly more water than fossil transportation fuels (irrigated biofuels could add from 3-5 Bgal/day to energy-related water needs)
- CO_2 removal could add 1-2 Bgal/day to energy related water needs



Water Consumption for Current and Advanced Ethanol Technology

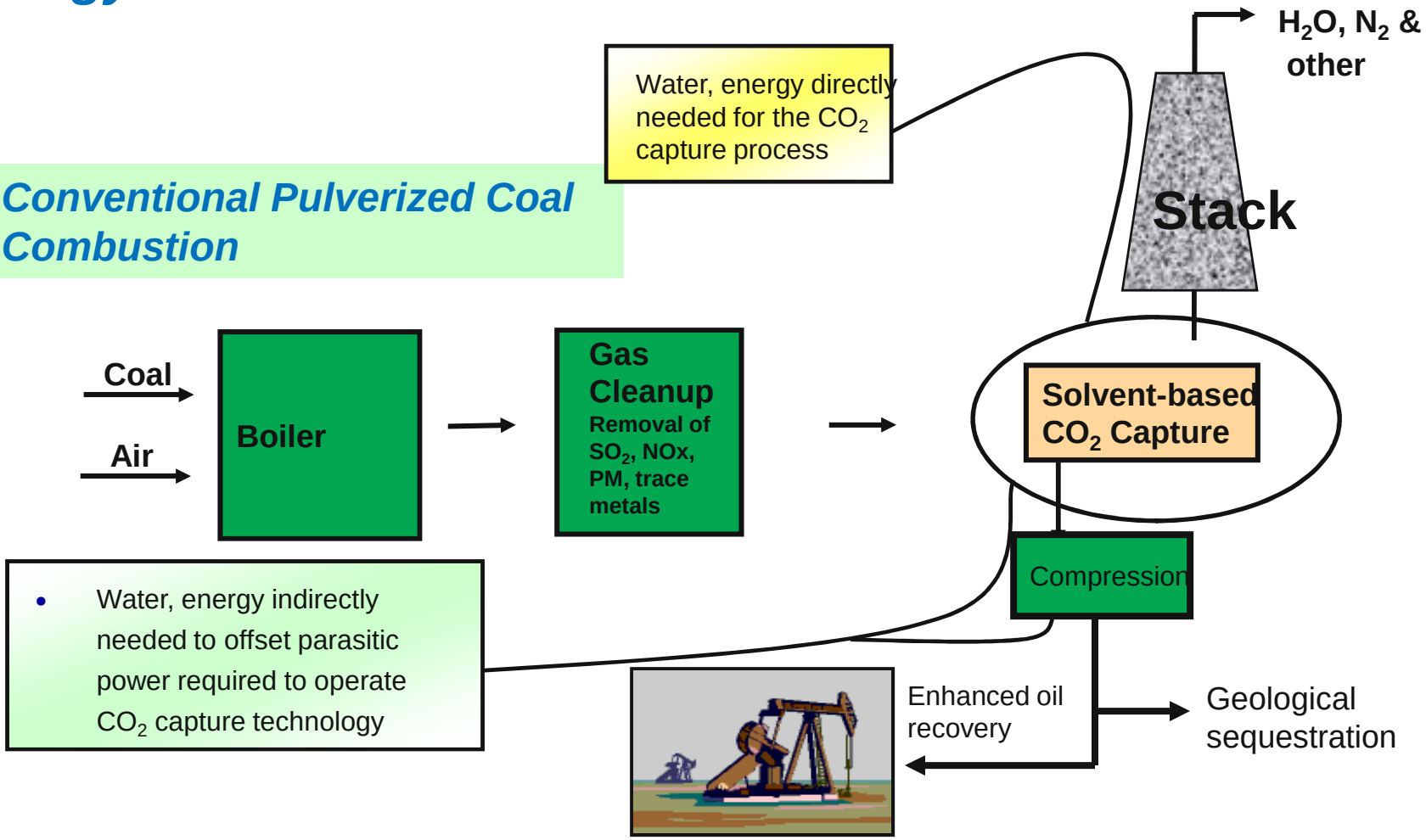
Corn Ethanol	USDA REGION	5	6	7
Corn Ethanol Water Consumption (gal. water/ gal. product)	Surface Water Irrigation	6.7	10.7	281.2
	Ground Water Irrigation	0.4	3.2	39.4
	Ethanol Production	3.0	3.0	3.0
	Total	10.1	16.9	323.6

Cellulosic Ethanol Water Consumption (gal. water/ gal. product)	
Biochemical	6.0 – 9.0
Thermochemical	2.0 – 5.0
Hybrid	1.0 – 5.0

Source: Wu et al., Argonne National Laboratory January 2009

Controlling Carbon Increases Demand for Water and Energy

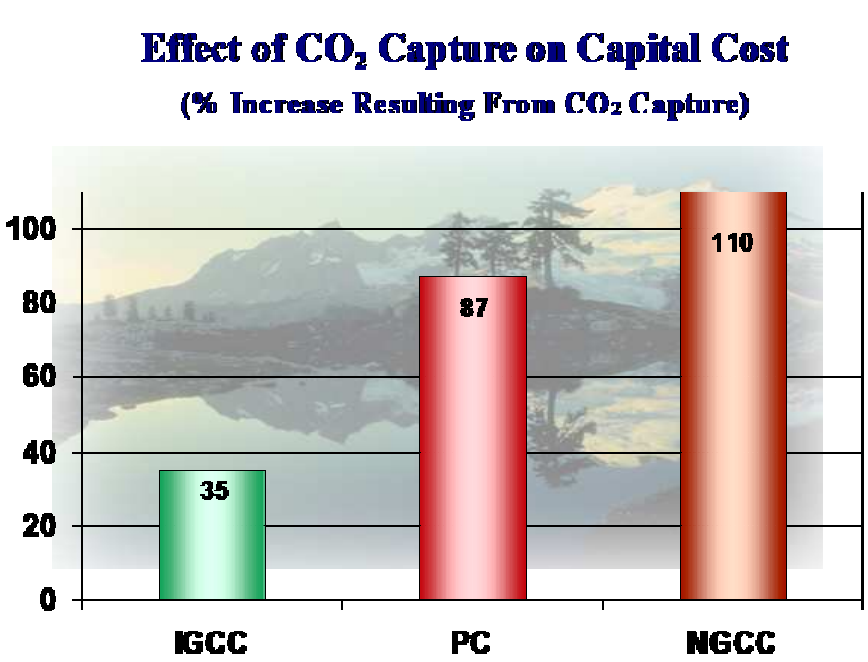
Conventional Pulverized Coal Combustion

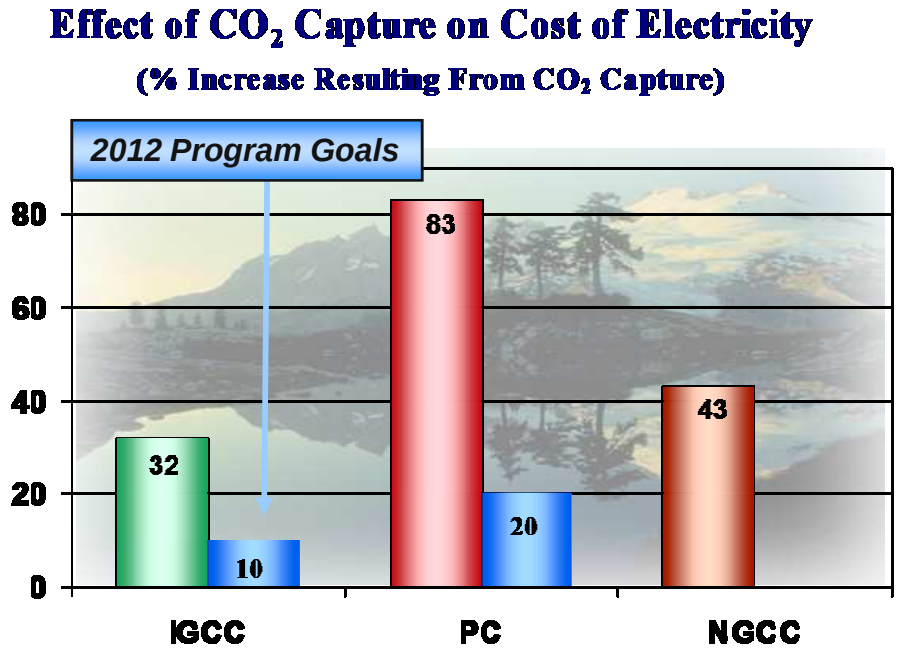


Source: NETL "2007 Pulverized Coal Oxyfuel Combustion Power Plants" August 2007 Final Report.

CCS Is Expensive !

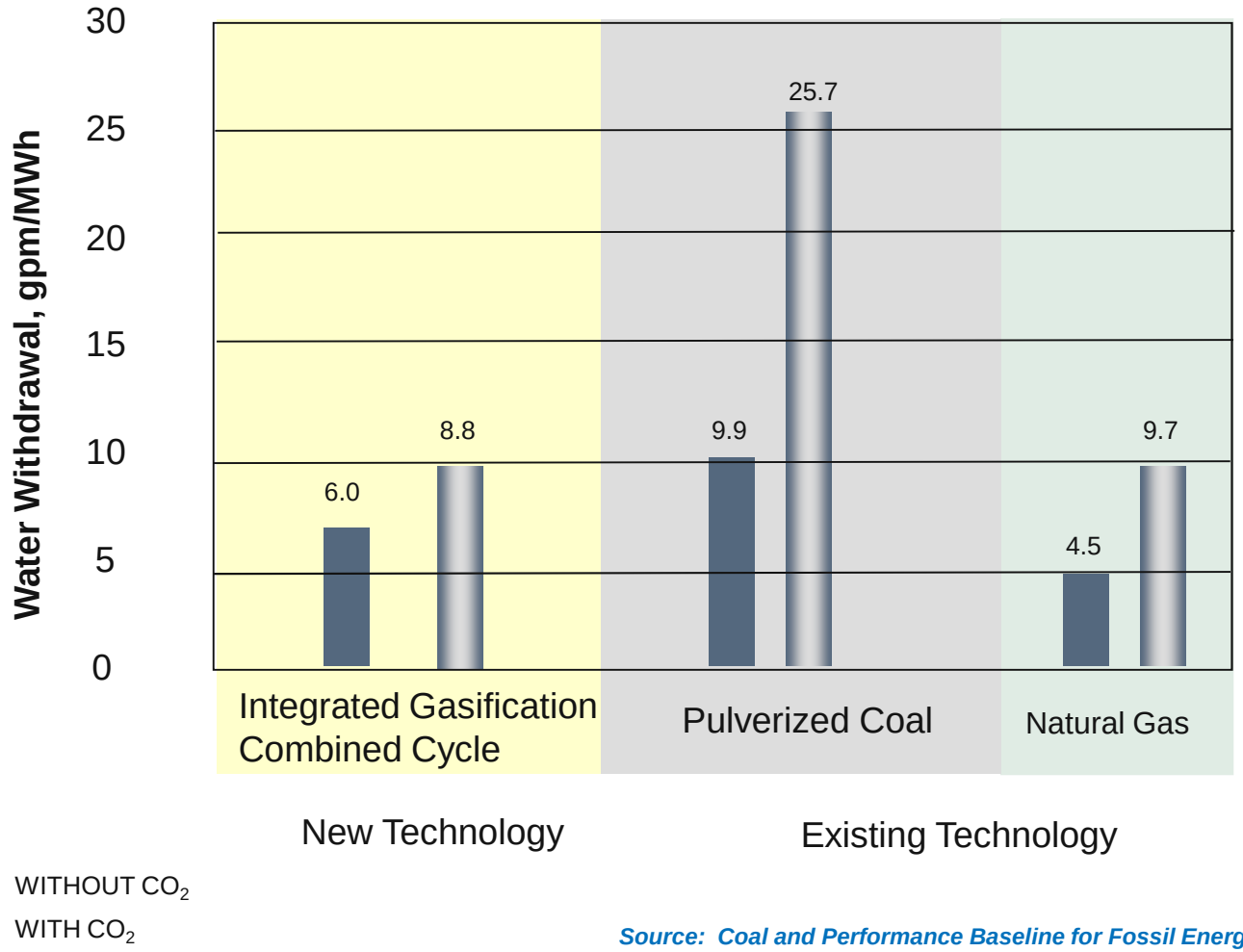
- 5–30% parasitic energy loss
- 35–110% increase in capital cost
- 30–80% increase in cost of electricity





Source: *Cost and Performance Baseline for Fossil Energy Power Plants study, Volume 1: Bituminous Coal and Natural Gas to Electricity.*

Power Plant Water Withdrawal Requirements with and without CO_2 Capture



Source: Coal and Performance Baseline for Fossil Energy Power Plants, Volume 1: Bituminous Coal and Natural Gas to Electricity; NETL, May 2007

Broader Factors Increase Uncertainty at the Energy Water Nexus

- Economic Activity

- Weather

- Climate

Climate Change Shifts the Basis for Energy and Water Planning

- Energy use is the primary driver on climate change
- Changes to the water cycle (precipitation and run-off, modified by withdrawals) may be one of the most significant impacts of climate change
- Some water supply solutions require additional energy for long-distance transfers or desalination
- Hydro-electric systems (12% in US, much more in some countries) may not function as designed
- Water-energy shortages may interact so as to amplify the economic impacts of climate change
  - Example: 2003 heat wave in Europe

2003 Heat Wave Impacted European Economic and Electric Power Systems and Public Health

- Loss of 7 to 15% of nuclear generation capacity for 5 weeks
- Loss of 20% of hydro generation capacity
- Purchase of large amount of electricity on wholesale power market
- Large-scale load shedding and shut off transmission to Italy
- Sharp increase of spot-market prices: $1000 - 1500/MWh for most critical days
- Increase in excess deaths

Bort-les-Orgues Reservoir

Normal conditions in August

August 27, 2003

Source: April 2008 SNL presentation to LERDWG

And the Challenges Are?

- Water and energy are interdependent
- Maintaining a sustainable water supply in the future without greatly increasing energy use
- Supplying sufficient energy (especially electricity and biofuels) in the future, with limited water supplies
- Practices to manage these resources also overlap extensively with land-use, air-quality, and other core environmental issues

Meeting Energy Water Nexus Challenges Require Rethinking Our Approaches

- **To water supply**
  - Water reuse and reclamation on a larger scale
  - Alternative storage (e.g., groundwater recharge)
  - Reallocation of water through water markets
  - Develop integrative water planning and management tools

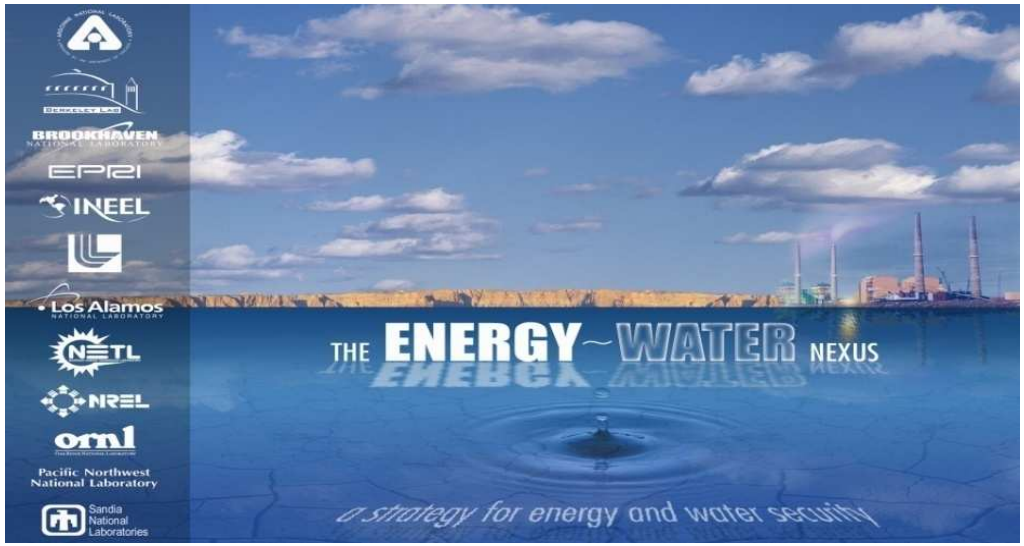
- **To energy intensity of water**
  - Use recycled water
  - Desalination
  - Use of water for cooling
  - Heat recovery (cogeneration**)**

Source: Jeffrey Koseff presentation to CCST, May 12, 2008

Department of Energy National Laboratories Are Conducting Initial Assessments and Research at the Energy-Water Nexus

Energy-Water Nexus Team

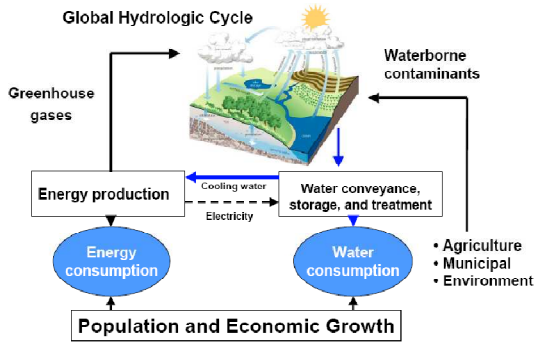
- DOE Report to Congress
- DOE Energy-Water R&D Roadmap
- Regional Studies
- DOE program-specific studies

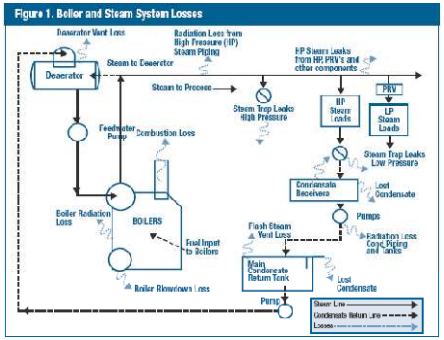


Representation from all DOE Multi-Program Laboratories

A Wide Range of R&D Can Help to Address Energy-Water Nexus Challenges

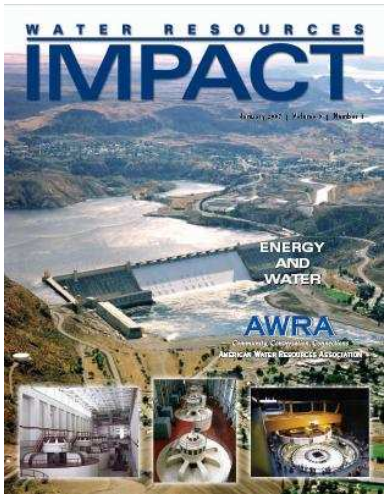
- Better understand supplies and demands
  - Integrated regional energy and water resource planning and decision support tools
  - Improved water supply and demand characterization, monitoring, and modeling
  - Improved sensors and data management systems
  - Modeling and decision support tools for improved resource management and utilization
- Make new supplies available
  - New materials and separation processes
  - Oil and gas produced water treatment for use
  - Impaired water treatment and use
- More efficient use
  - Infrastructure, regulatory and policy assessment for improved energy/water efficiency
  - System and process design

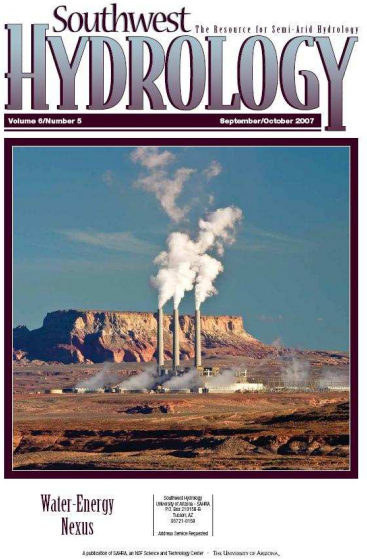


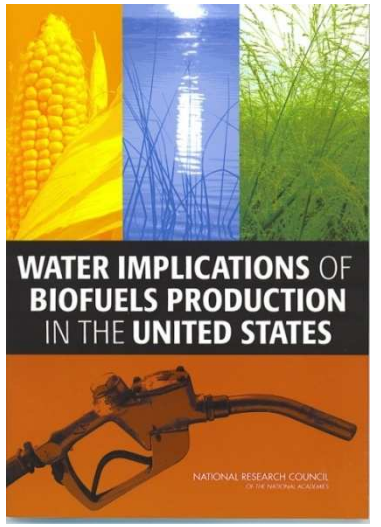


Emerging Interest in Energy Water Nexus Challenges

- Federal government
  - 2005 Energy Policy Act
  - 2006 DOE Report to Congress
  - 2007 National Science and Technology Council
  - 111th Congress: 15 related bills to date
- NGO's
  - EPRI, AWRI, GWPC, ASME
- Increased media interest
  - NATURE, ECONOMIST, Scientific American
  - Technical magazines
- Growing international concerns
  - Europe, Australia, Asia, Canada







Challenges at the Energy-Water Nexus

- Availability and cost of one directly impacts other
- Existing conflicts will likely increase in number and impact
- New approaches are needed
  - Science can be part of solution
  - Informed planning
  - Alternative resources
  - Technology management

More information:

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Water for Energy and Energy for Water