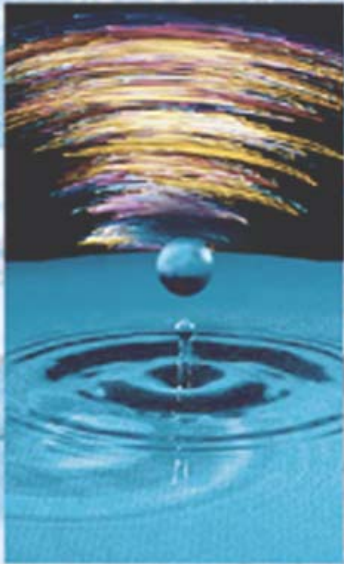


The Energy-Water Nexus



James E. (“Jim”) McMahon
LBNL
(JEMcMahon@LBL.gov)

Presented at
Council on Competitiveness
June 3, 2008



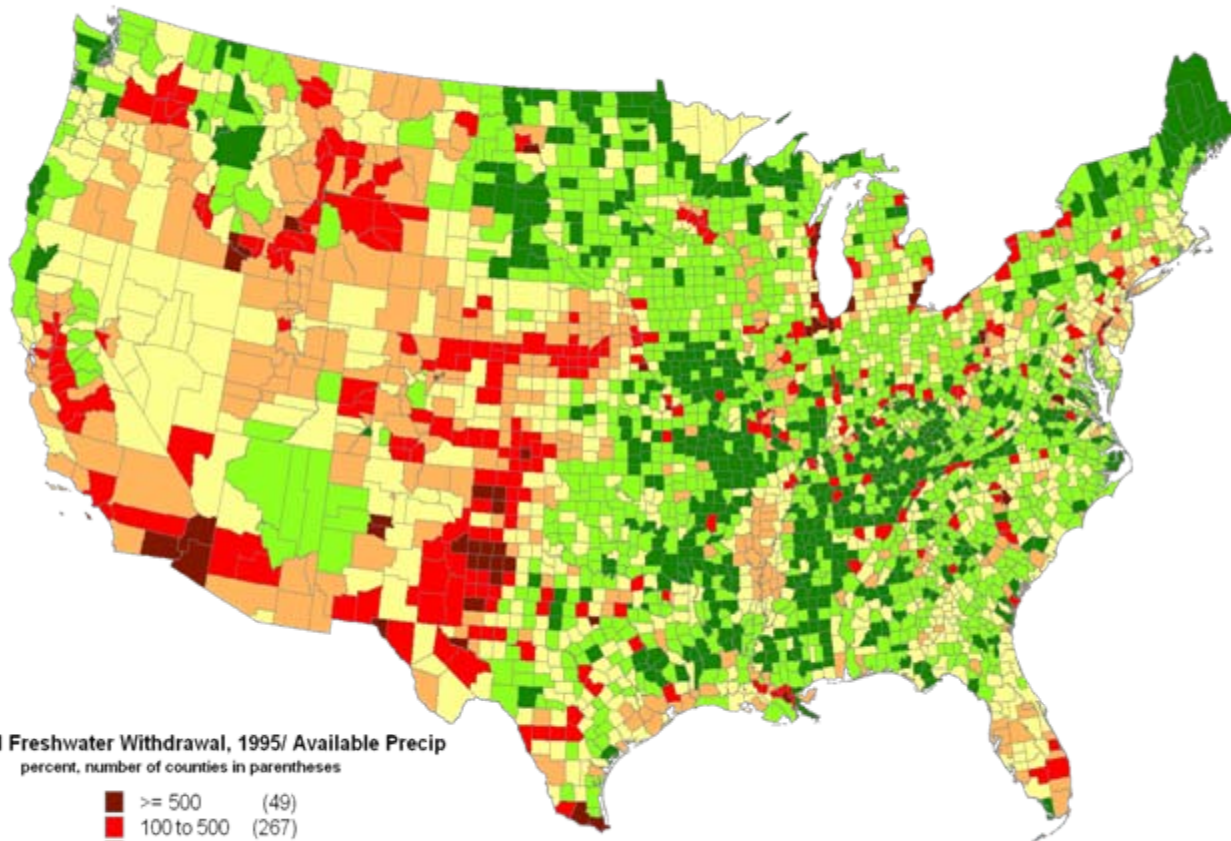
Pacific Northwest
National Laboratory



THE ENERGY ~ WATER NEXUS

a strategy for energy and water security

Current withdrawals of freshwater may not be sustainable



Total Freshwater Withdrawal, 1995/ Available Precip
percent, number of counties in parentheses

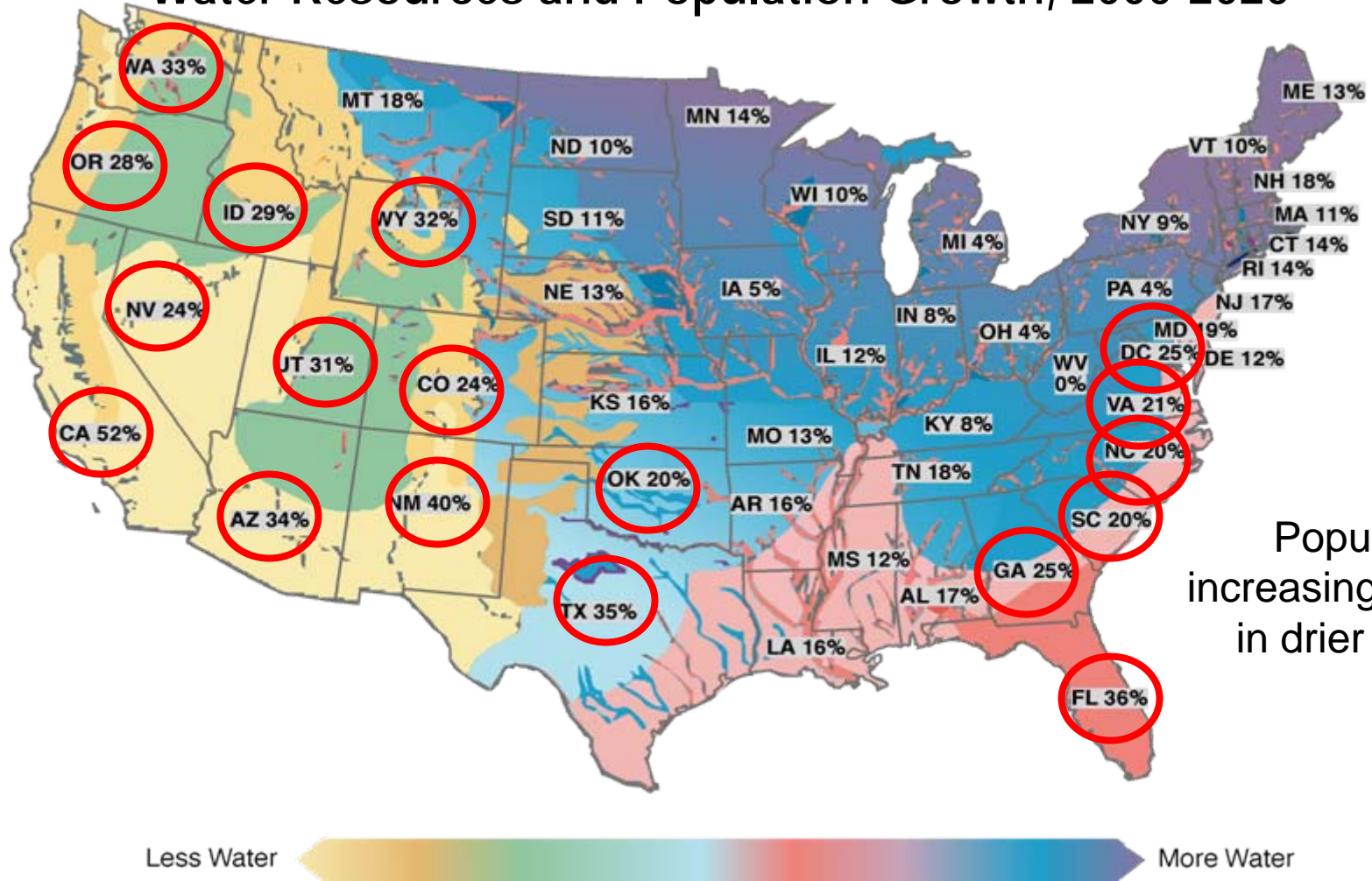
Dark Red	>= 500	(49)
Red	100 to 500	(267)
Orange	30 to 100	(363)
Yellow	5 to 30	(740)
Light Green	1 to 5	(1078)
Dark Green	0 to 1	(614)

In the red counties, more water is withdrawn for human use than is supplied annually by precipitation.

Source: EPRI

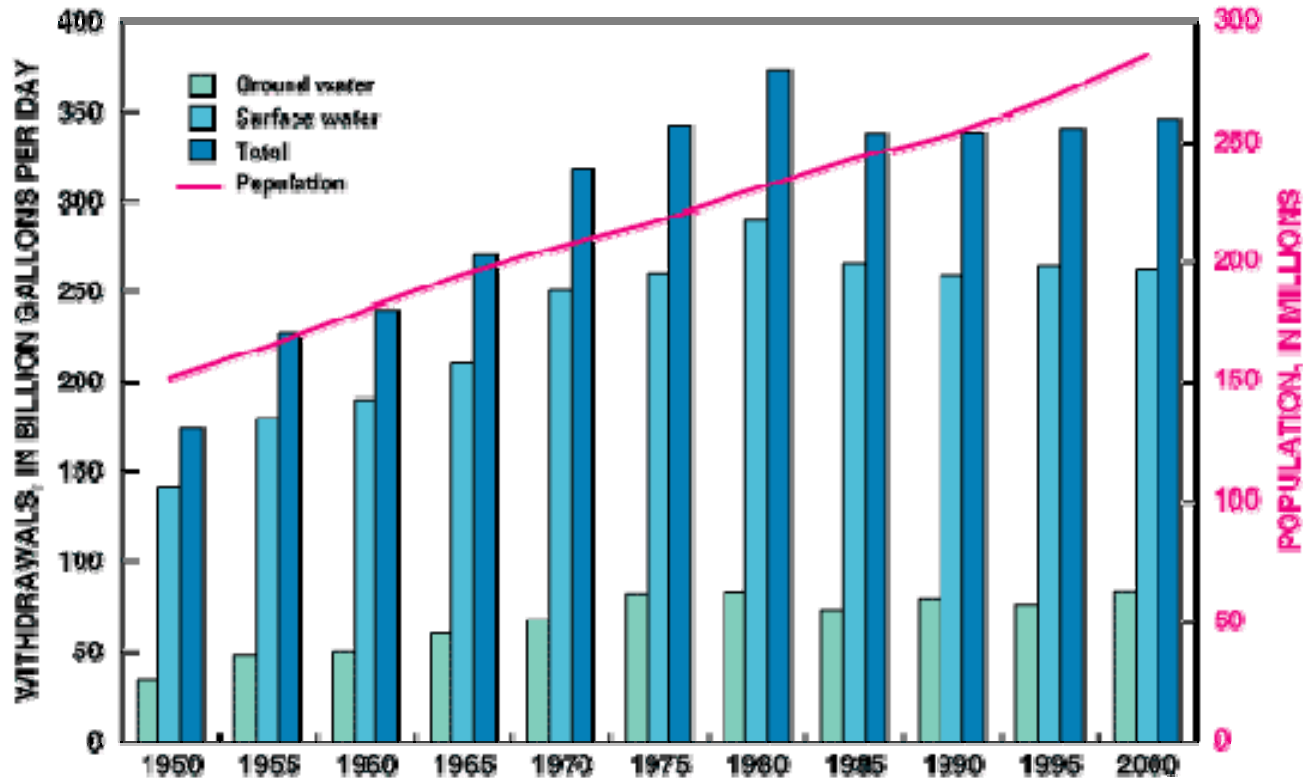
Economic (and energy) development are increasingly in conflict with water availability

Water Resources and Population Growth, 2000-2020



Source: DOE/NETL (M. Chan, July 2002)

Is a water crisis coming?



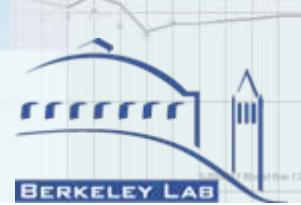
- Population is growing
- Use of ground water is increasing (especially by agriculture)
- Total water use has been surprisingly stable for 20 years
 - Source: USGS, 2003, "Estimated Use of Water in the United States in 2000 "

What is the problem?

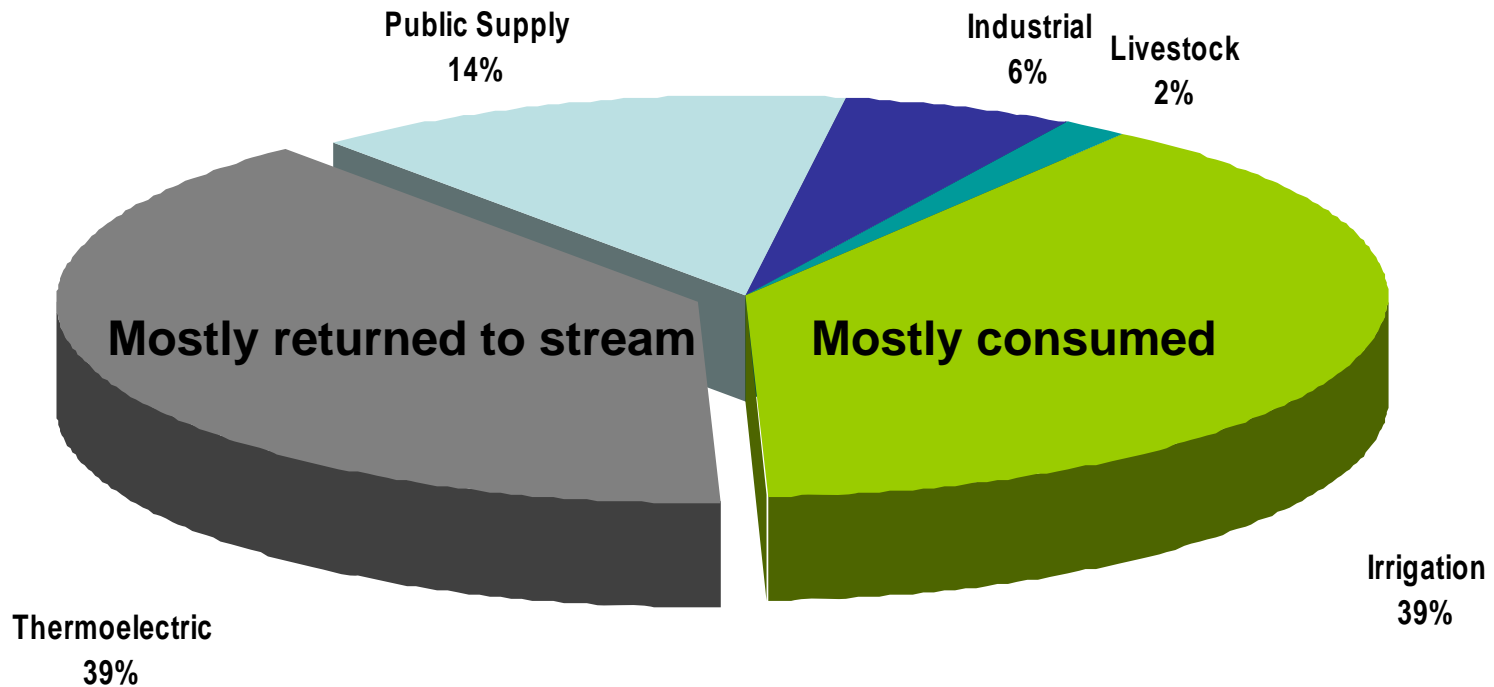


- **Water and energy are interdependent**
- **Maintaining a sustainable water supply in the future without greatly increasing energy use is a challenge**
- **Supplying sufficient energy (especially electricity and biofuels) in the future, with limited water supplies, is a challenge**
- **Practices to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

As Much Freshwater Is Withdrawn For Producing Electricity As For Agriculture



Estimated Freshwater Withdrawals by Sector, 2000



Competition For Water Is Limiting Energy



- **Georgia Power Loses Bid to Draw Water from Chattahooche**
— *Miami Herald, February 2002*
- **EPA Orders Mass. Power Plant to Reduce Water Withdrawals**
— *Providence Journal, RI, July 2002*
- **Idaho Denies Water Rights Request for Power Plants**
— *U.S. Water News Online, August 2002*
- **Duke Power Warns Towns in Charlotte, N.C., Area to Cut Water Use**
— *The Charlotte Observer, NC, August 2002*
- **Company Ends Fight for Power Generator on NJ-NY Border**
— *The Record, NJ, September 2002*
- **New Mexico Utility Plans to Increase Power, Use No More Water**
— *Albuquerque (NM) Journal, June 2003*
- **Pennsylvania Nuclear Power Plant to Use Wastewater from Coal Mines**
— *The Philadelphia Inquirer, July 2003*



2003 Heat Wave Impact on French Electric Power System



- 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

Bort-les-Orgues Reservoir



Normal conditions
in August



August 27, 2003

Source: April 2008 SNL presentation to LERDWG

Impact of 2008 Southeast U.S. Drought on Nuclear Power Production

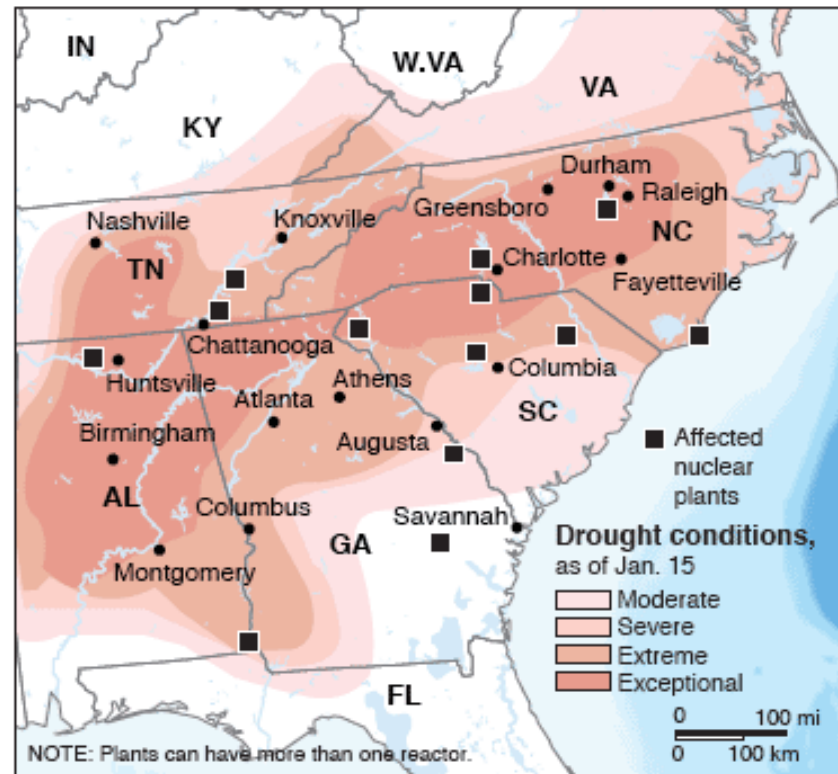
AP Associated Press

Jan. 23, 2008

LAKE NORMAN, N.C. - Nuclear reactors across the Southeast could be forced to throttle back or temporarily shut down later this year because drought is drying up the rivers and lakes that supply power plants with the awesome amounts of cooling water they need to operate.

Drought affecting nuclear plants

Twenty-four of the nation's 104 nuclear reactors are in areas experiencing the most severe levels of drought. Rivers and lakes supply power plants with the cooling water necessary to operate.



SOURCES: Nuclear Regulatory Commission; TerraServer USA

AP

Source: April 2008 SNL presentation to LERDWG

Water as a driver for energy companies



- **For electricity supply:**
 - water consumption will increase 45-63% by 2030 from 3.7 billion gallons per day in 2005
 - withdrawals will decrease by 4-22% by 2030 from 146.6 billion gallons per day in 2005
 - EXPLANATION: use of recirculation in new plants, and retirement of plants with once-through cooling*

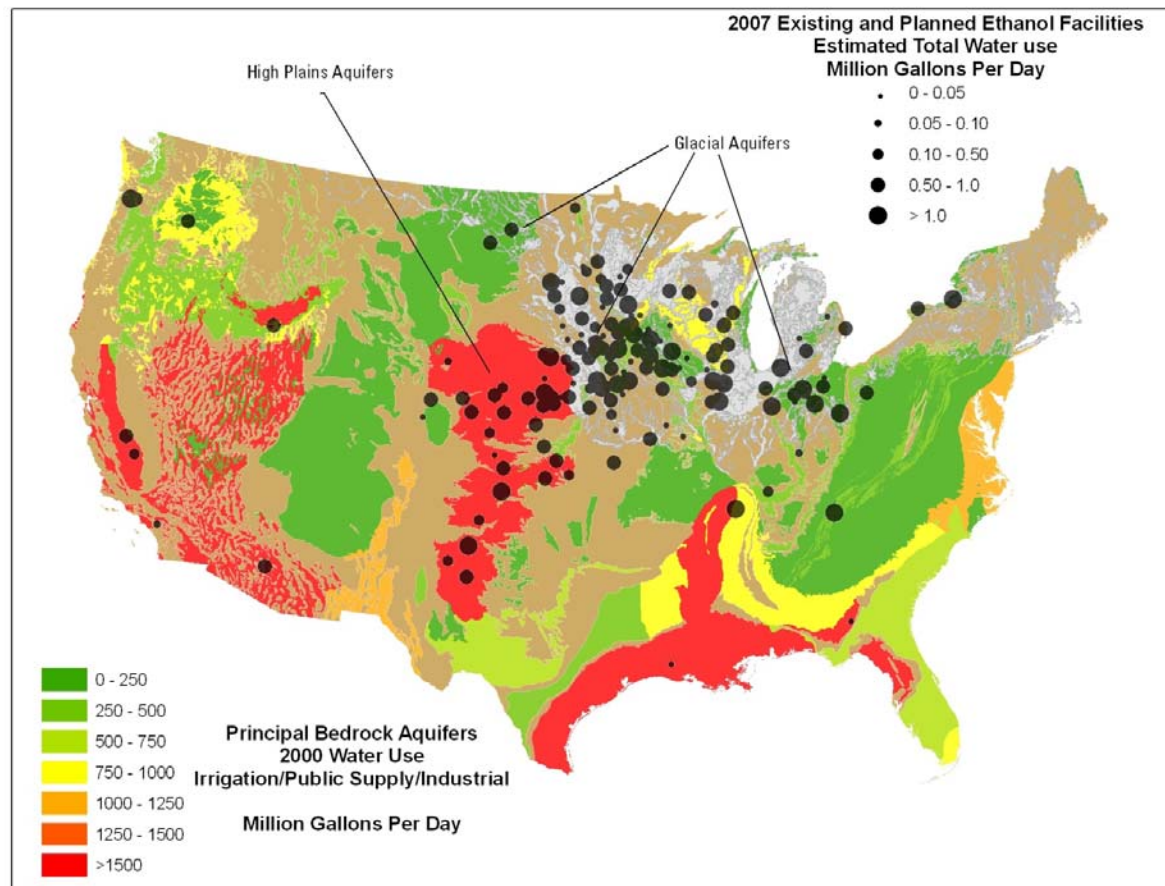
(Source: NETL, Estimating Freshwater Needs to Meet Future Thermoelectric Generation Requirements, May 8, 2008)

- **For fossil supply: Large volumes of water will be produced by energy suppliers (harvesting oil, gas, & coal-bed methane)**
 - This water is either disposed of as environmental waste or potentially useful*

Ethanol Production Growth and Feedstock Irrigation Issues



- Irrigated corn requires 2000-4000 gal/bushel
- Move to cellulosic ethanol will move production south and east
- Amount of irrigation needed for fuel reliability of dedicated energy crops is uncertain
- Concerns over ethanol production plant impacts on groundwater quality and availability



Ref: Schnoor, ACS, 2008

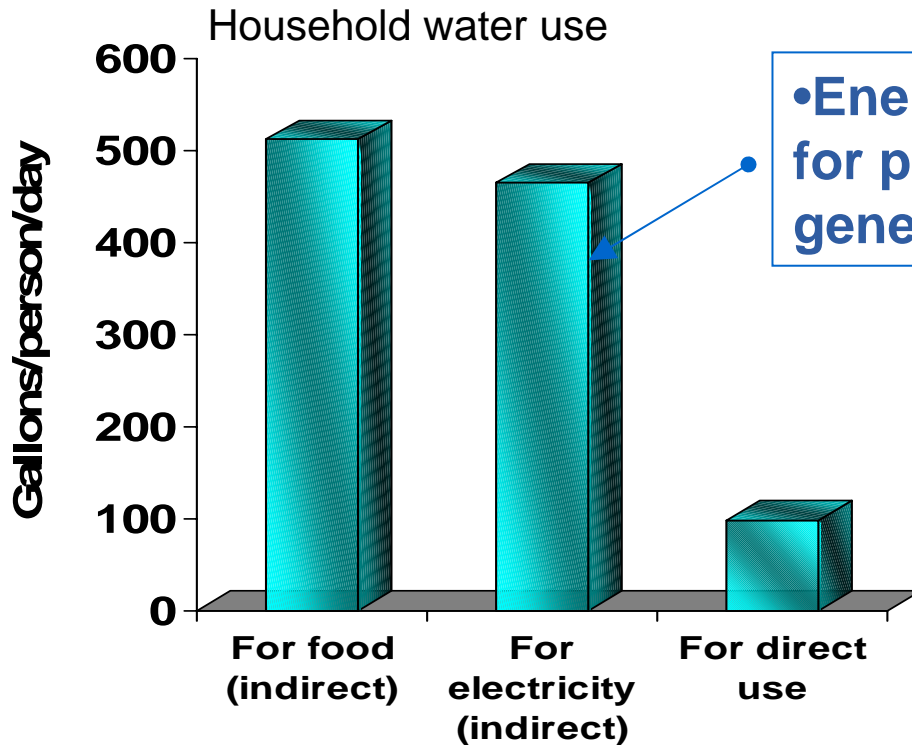
Source: April 2008 SNL presentation to LERDWG

Additional drivers



- **The cost of water supply has been subsidized by large government projects (dams, reservoirs, aqueducts)**
 - *Water prices are likely to increase in future*
- **Desalination is likely to provide an increasing share of freshwater, from brackish groundwater or seawater**
 - *At present, this is more expensive than many alternatives (efficiency, reuse, etc.)*

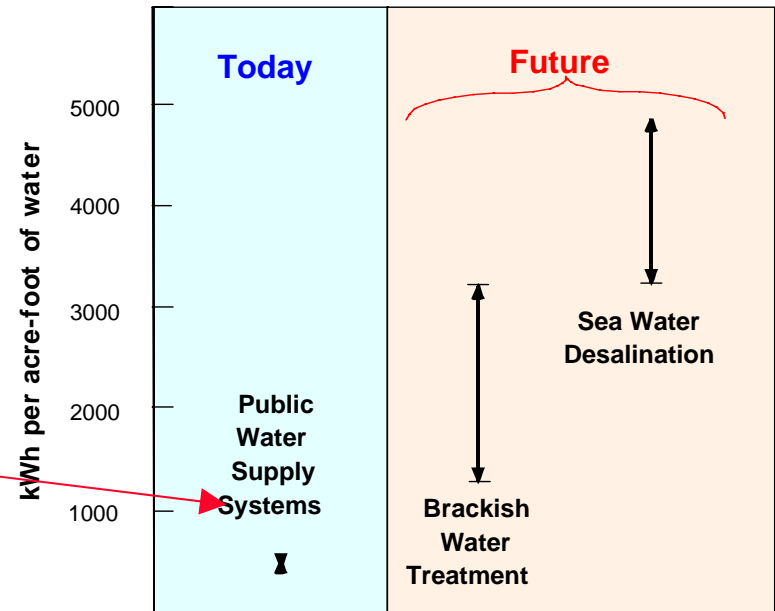
Energy requires Water. Water requires Energy.



• Energy requires water for production and generation

• Water requires energy for pumping, treating and delivery and will need more in future

Power requirements for Current and Future Water Supply



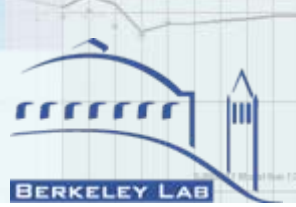
Rethinking our approach



- **To water supply**
 - Water reuse and reclamation on a larger scale
 - Alternative storage
 - More local harvesting
 - More local treatment
 - Reallocation of water through water markets
 - Develop integrative management and water planning tools
- **To energy intensity of water**
 - Use recycled water
 - Groundwater recharge
 - Desalination
 - Use of water for cooling
 - Heat recovery (cogeneration)

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

Climate change changes the basis for energy and water planning

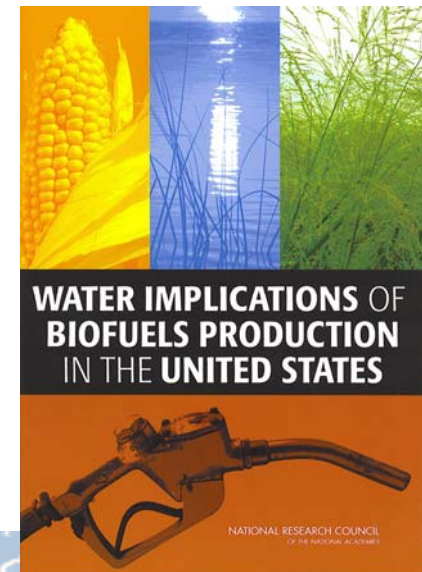
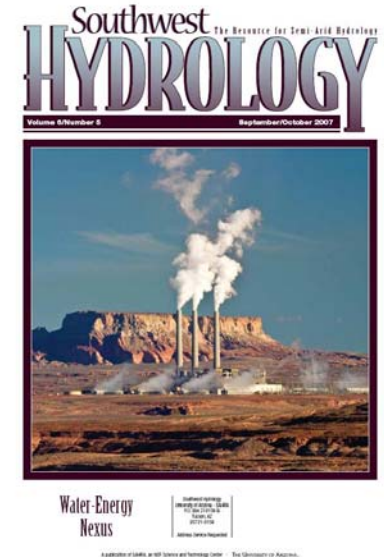
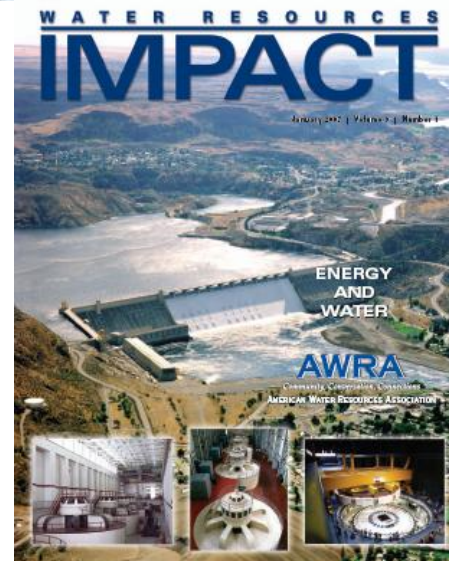


- **Energy use is the primary driver on climate change**
- **Changes to the water cycle (precipitation and run-off, modified by withdrawals) may be one of the most significant impacts of climate change**
- **Some water supply solutions require additional energy for long-distance transfers or desalination**
- **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**

Emerging Interest in Energy and Water Issues and Challenges



- **Federal government**
 - 2006 DOE Report to Congress
 - 2007 National Science and Technology Council
 - 2008 USGS proposal for Water Census
- **Increased media interest**
 - NATURE, ECONOMIST
 - Technical magazines
- **Growing international concerns and challenges**
 - Europe, Australia, Asia, Canada



- **LBNL Websites:**

- Water Energy Technologies Team
<http://Water-energy.LBL.gov>
- esd.lbl.gov (Earth Sciences Division)
- eetd.lbl.gov (Environmental Energy Technologies Division)
- Eetd.lbl.gov/EA.html (Energy Analysis)

- **Contact:**

- Jim McMahon (JEMcMahon@LBL.gov), EETD
 - Phone: (1) 510 486 6049

