NREL
NATIONAL RENEWABLE ENERGY LABORATORY

Wind Power Answer In Times of Water Scarcity

Windpower 2010
Dallas, Texas

Larry Flowers,
Sandra Reategui

NREL

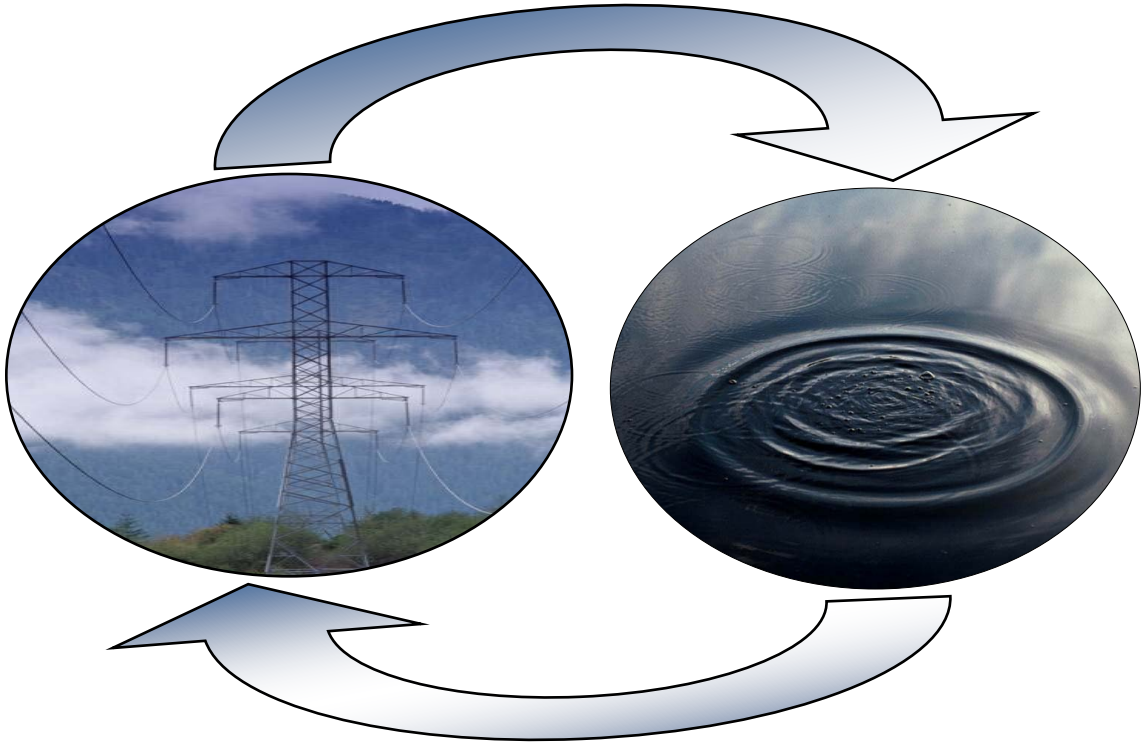
May 25, 2010

NREL/PR-7A2-47914

The Energy-Water Nexus

Humanity's Top Ten Problems for the Next 50 Years

1. Energy
2. Water
3. Food
4. Environment
5. Poverty
6. Terrorism & War
7. Disease
8. Education
9. Democracy
10. Population



Water is necessary to produce energy, and energy is necessary to obtain water

Source: Nobel laureate Richard Smalley

Istockphoto # 8471430

"Global Warming, deforestation, pollution, and other environmental pressures are shrinking the planet's clean water supply, making people look at fresh water as they never have before"

- National Geographic, April 2010

Photo Courtesy of Randy Udall

This pier used to reach the waters of Lake Mead. Now it is a long way from the lake and may never reach the waters again.

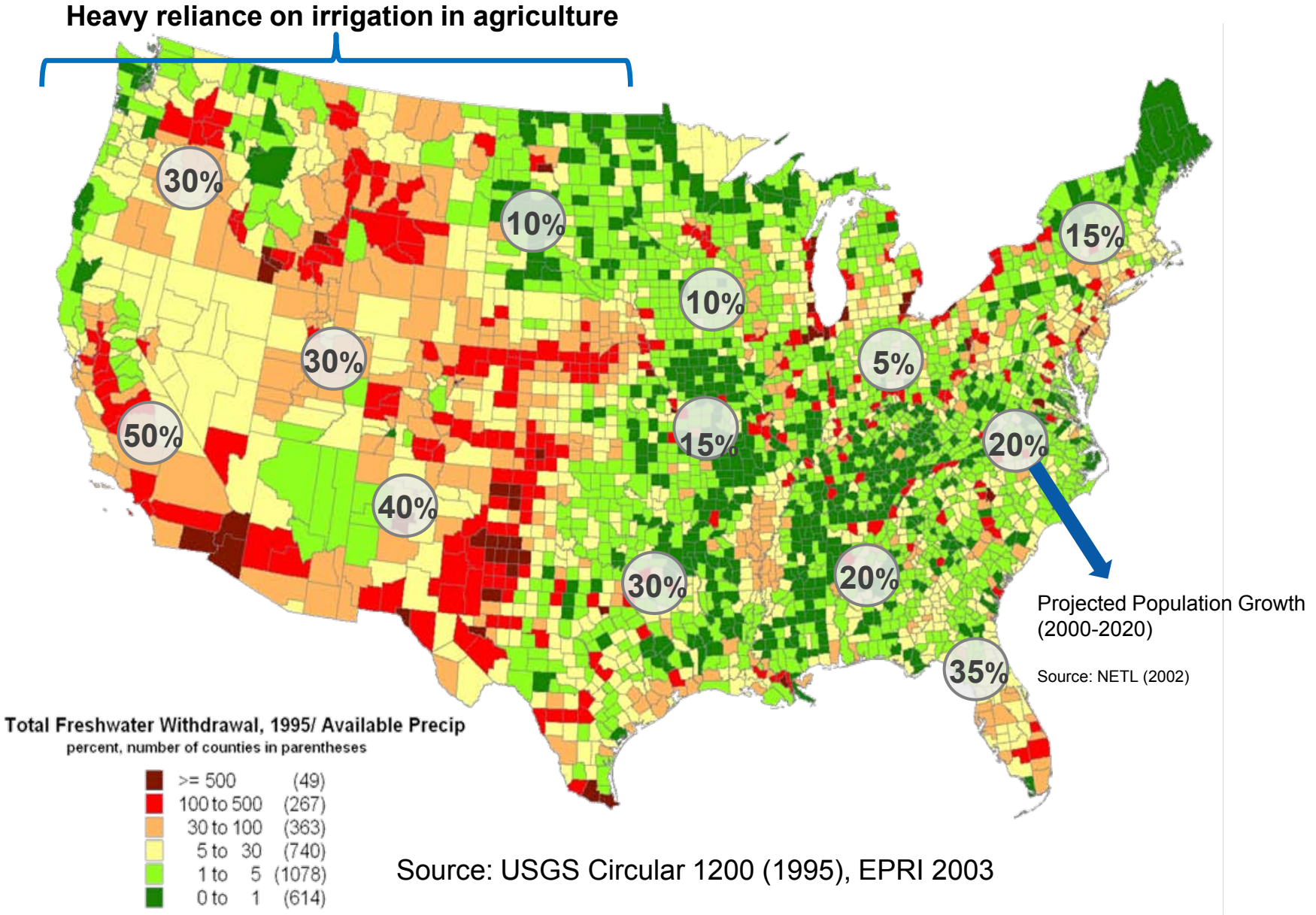
Important Facts

- Americans use about 100 gallons of water at home each day *(per person)*
- Millions of the world's poorest subsist on fewer than 5 gallons
- 46% of the world's people do not have water piped to their homes
- Women in developing countries walk an average of 3.7 miles to get water
- In 15 years, 1.8 billion people will live in regions of severe water scarcity

Istockphoto.com #3264601

Source: National Geographic, April 2010

Sustainable Withdrawal of Freshwater Is a National Issue



Source: USGS Circular 1200 (1995), EPRI 2003

U.S. Water Withdrawals by Category, 2005

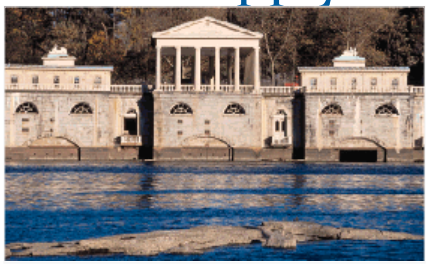
Livestock

<1 percent

Domestic

1 percent

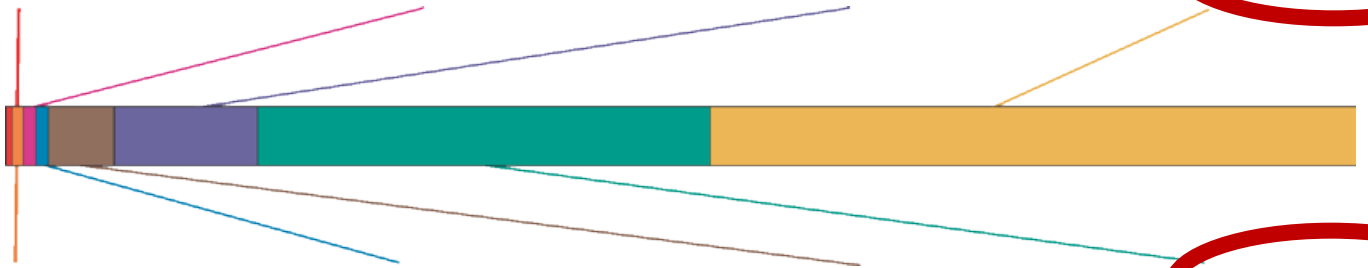
Public Supply



11 percent

Thermoelectric

49 percent



1 percent

Mining

2 percent

Aquaculture

4 percent

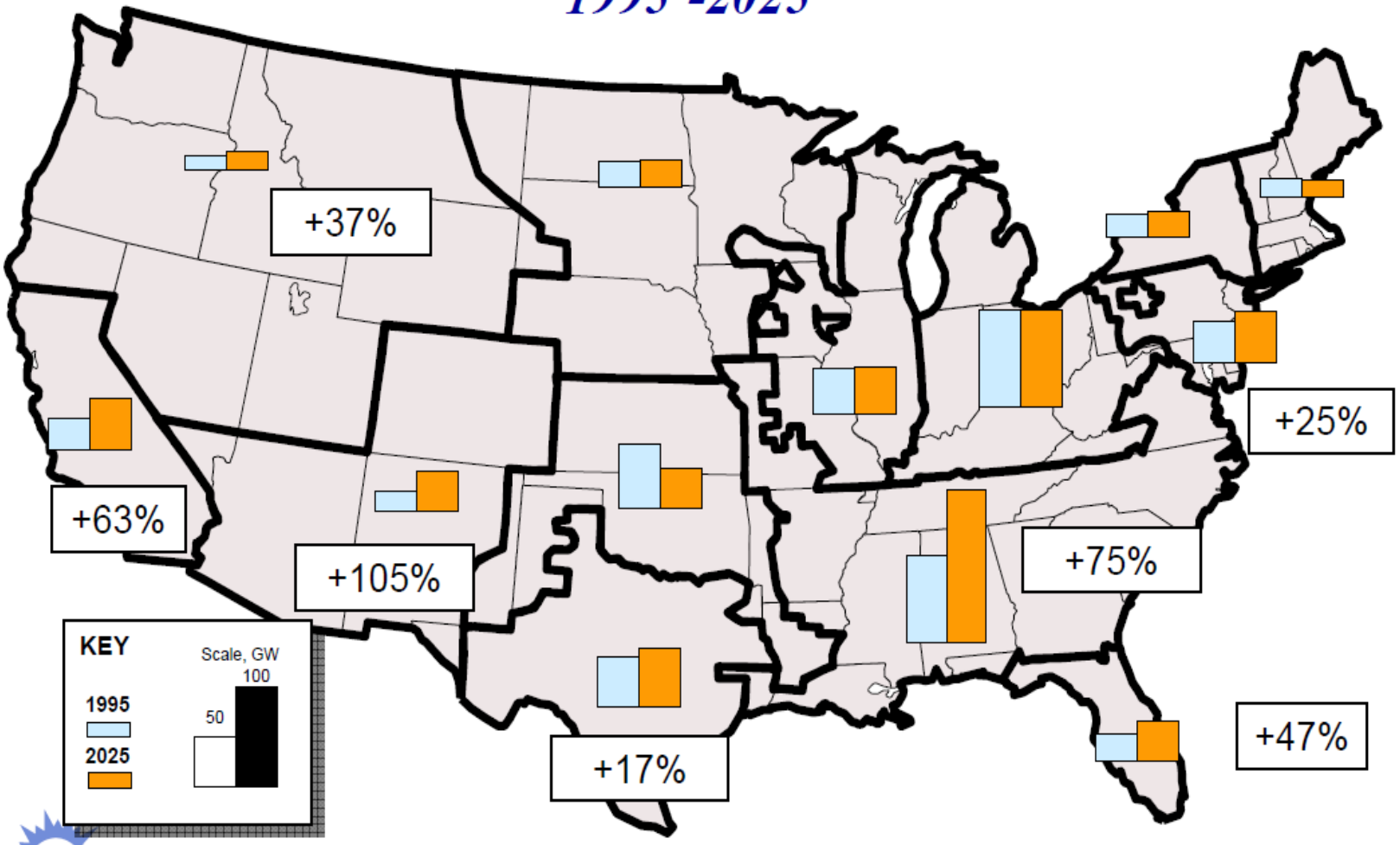
Industrial

31 percent

Irrigation

Source: USGS Circular 1344 (September, 2009)

Comparison of Regional Thermoelectric[1] Generation Capacity by North American Electric Reliability Council Region, 1995[2]-2025[3]

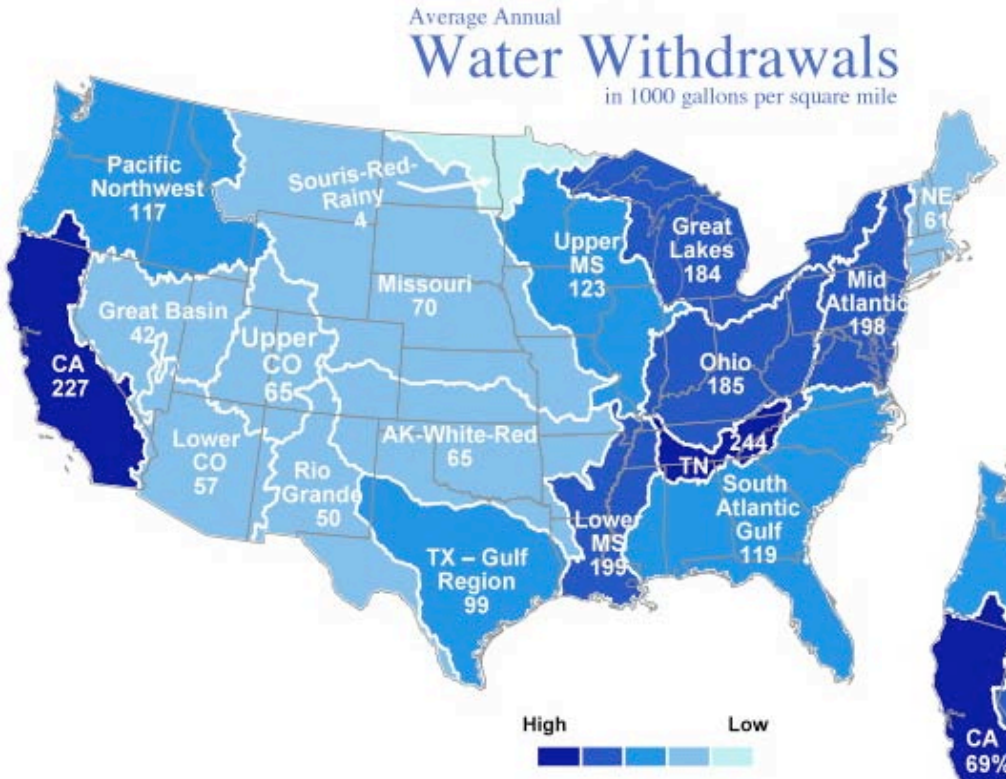


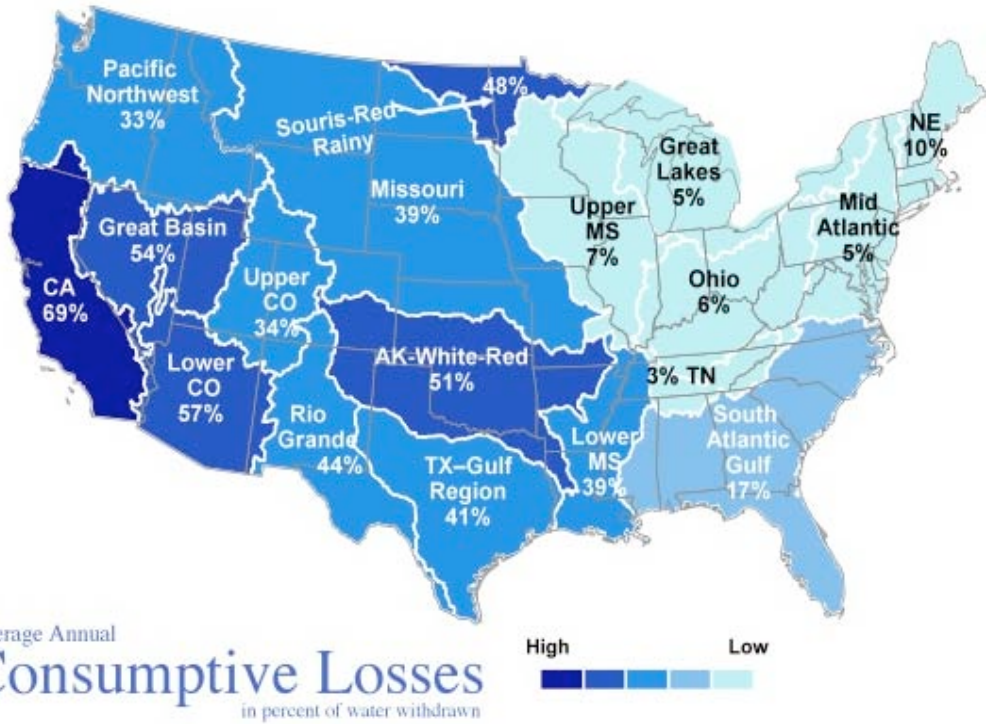
Notes 1. For combined-cycle capacity, thermoelectric capacity is assumed 1/3 of generation capacity.
2. Source: Energy Information Agency, AEO 1997
3. Source: Energy Information Agency, AEO 2005

SWRR Ann Arbor April 2005

Examples of Recent Energy Plants with Water-related Permitting Issues

U.S. Water Withdrawals and Consumption





USGS

Source: 1995 Data from USGS 1200

amid dry skies, wells

Eastern plains farmers confronted by uncertain future as drought, cities' relentless thirst threaten agriculture

By Jerd Smith ■ Photos by Darin McGregor ■ Rocky Mountain News

Border Street: A new spirit despite immigration bill's demise. NEWS 34

Dive instructor pulls elderly man from beneath capsized boat. NE

One-tank road trips can be a gas no matter what your car's mpg. SPOTLIG

Rocky Mountain News

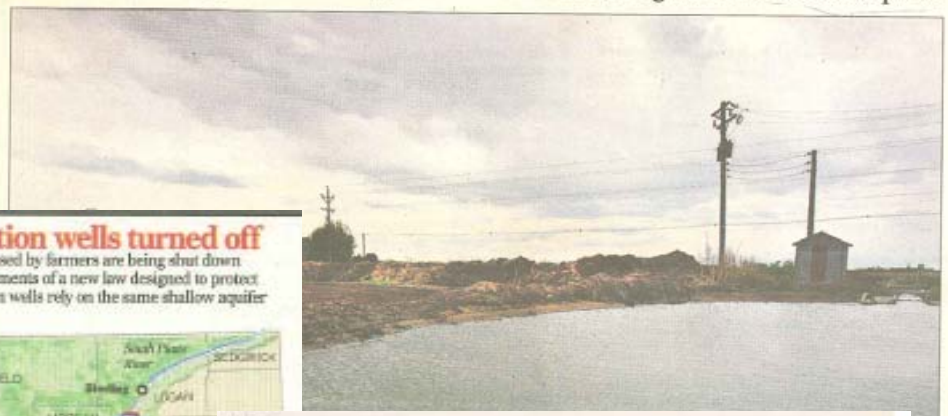
SHADOW OF A DROUGHT

New laws, legal fights and a long dry spell shut dow wells and changed a way of life on the eastern plains For many, the next steps remain uncertain. NEWS 6

Arnie Good, 57, the well that irri been idled. At to

Farms high and dry

■ **State shutting 400 wells** to preserve South Platte; 200 growers could lose crops. 4A



South Platte irrigation wells turned off

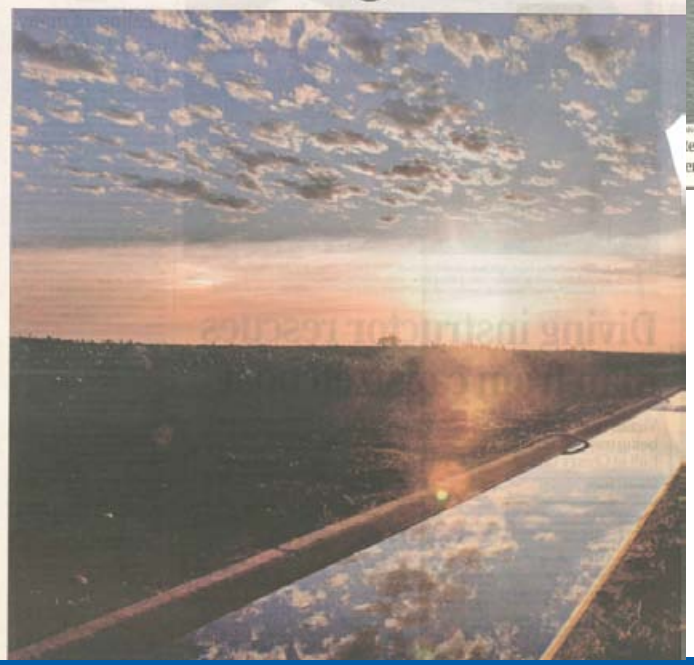
More than 400 irrigation wells used by farmers are being shut down because they can't meet the requirements of a new law designed to protect the South Platte River. The irrigation wells rely on the same shallow aquifer that helps supply the river.

Harry Strohauer walks near a h his potato farm in La Salle. Wells ar

6 NEWS ROCKY MOUNTAIN NEWS MONDAY [illegible]

RUNNING DRY

Water crisis grows dire



Farmers sweating over lack of water

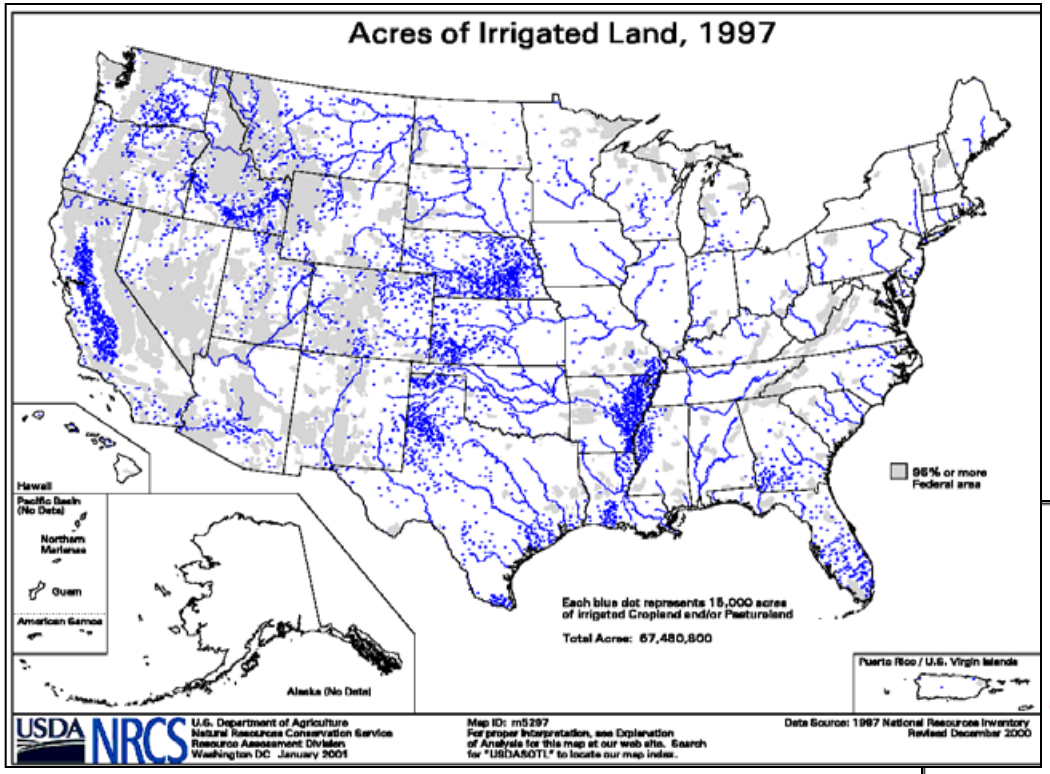
Growers mop brows after state edict to shut down wells

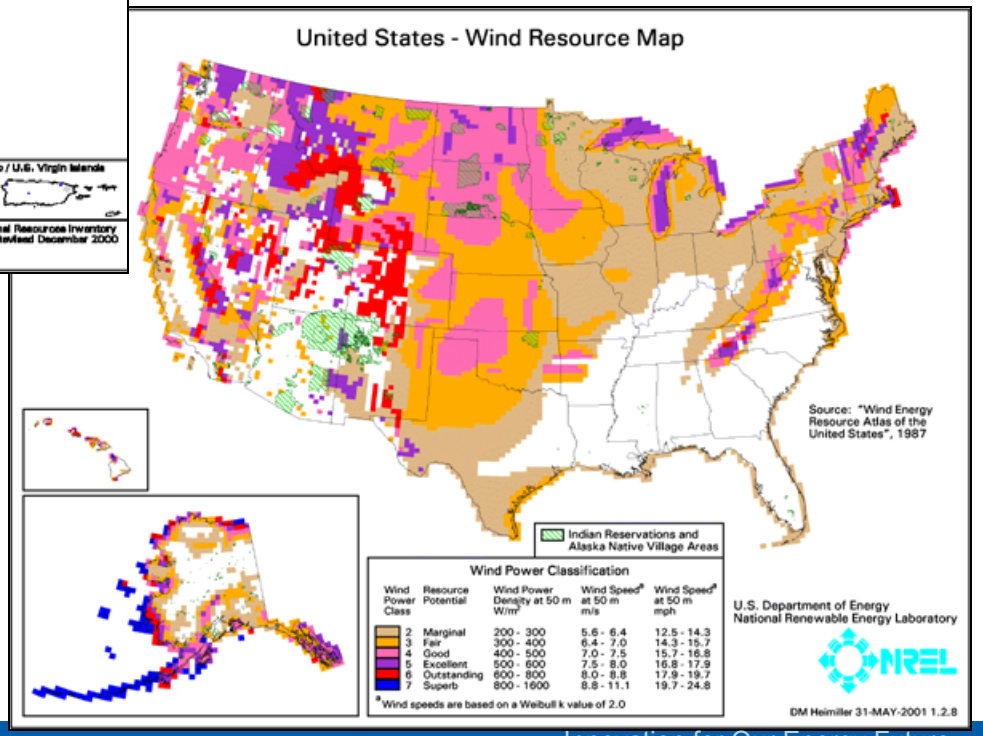
By Jerd Smith
ROCKY MOUNTAIN NEWS

The state ordered more than 400 powerful irrigation wells shut down this week to protect the South Platte River, triggering a crisis for about 200 farms from Brighton to Fort Morgan.

"It's the toughest decision I've ever had to make," said State Engineer Hal Simpson, Colorado's top

Irrigated Lands Have Great Wind Resource





Policy Challenges:

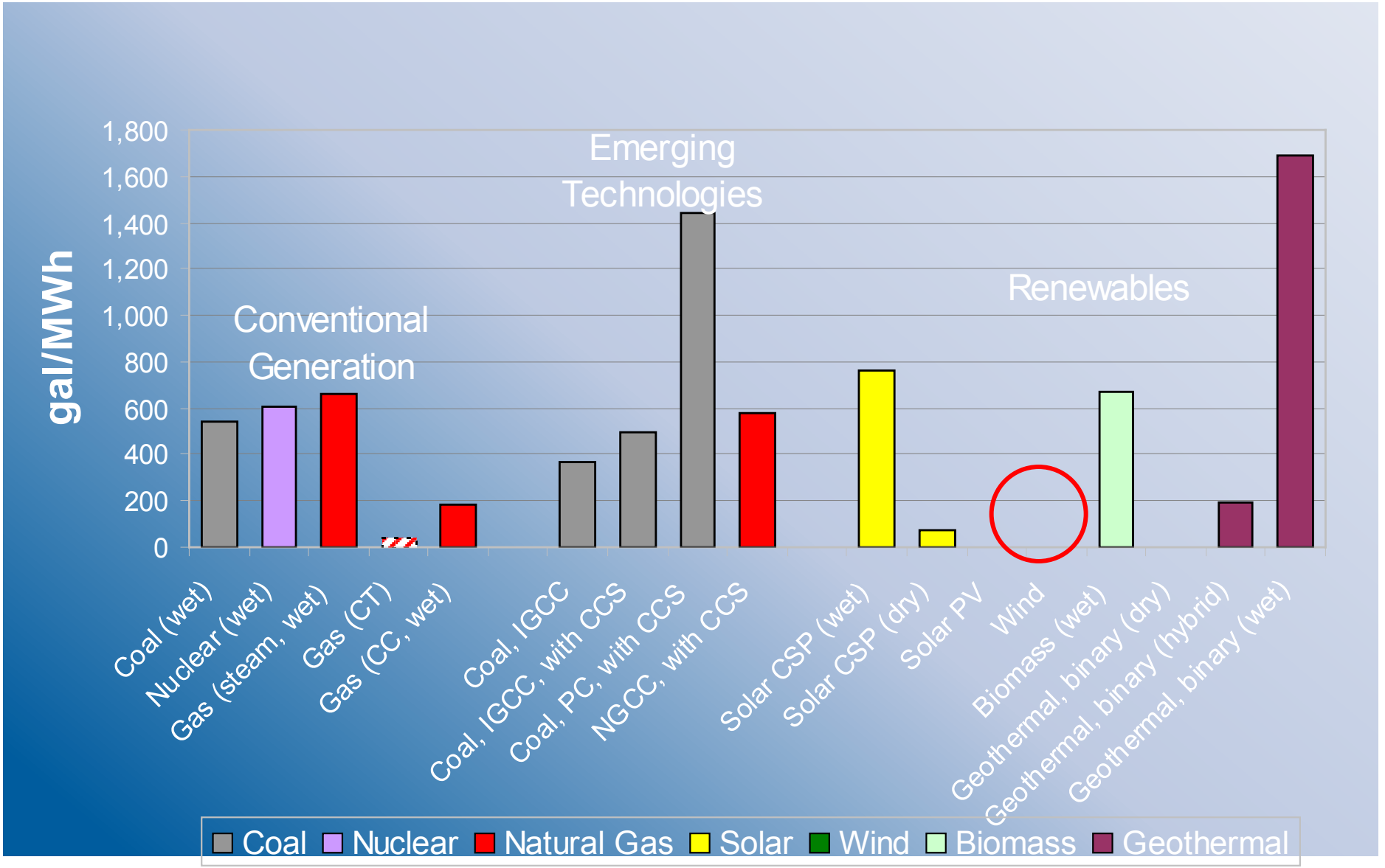
- Load vs. Resource Match
- Energy/Demand Tariff Structure

Water Transfers Out of Agriculture

Potential externalities include:

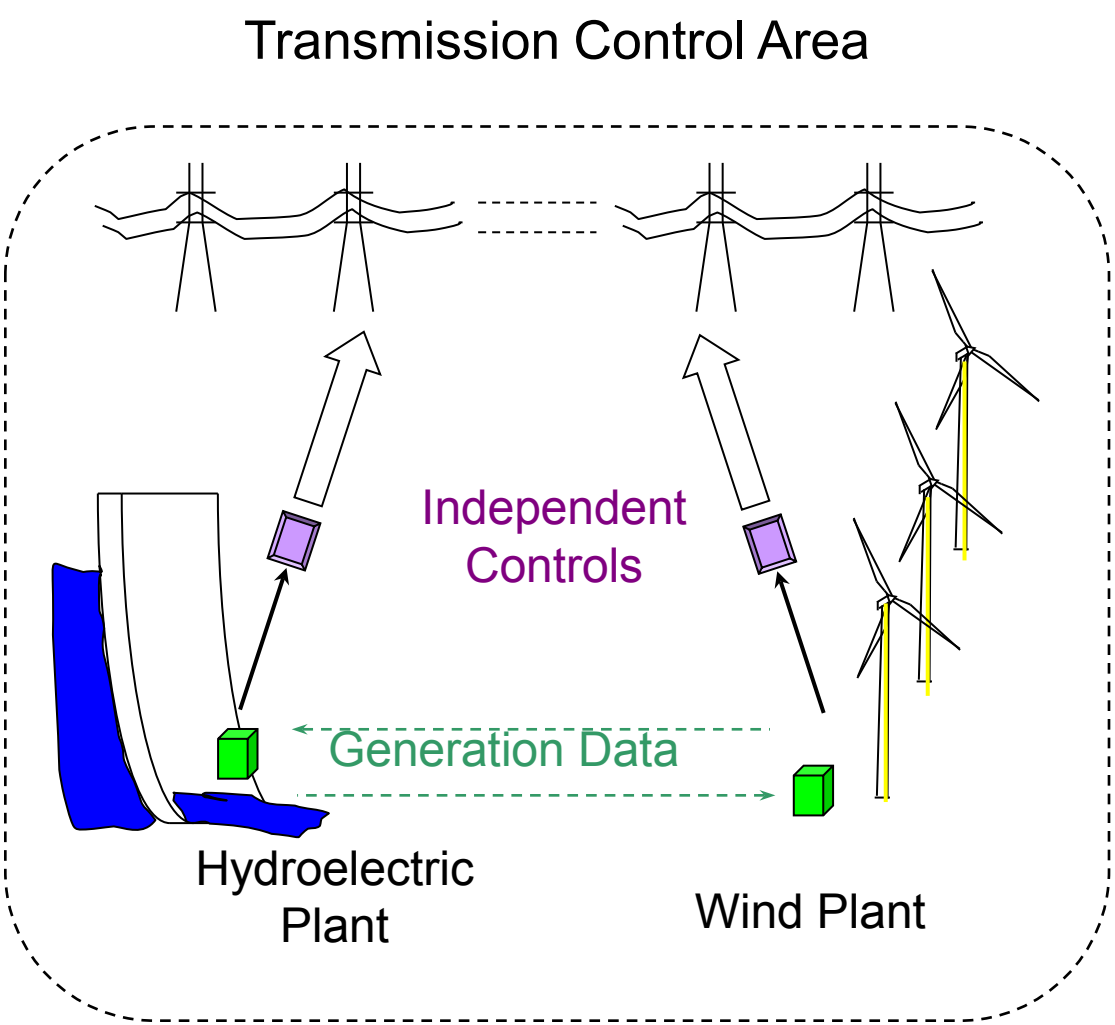
- Decreased food production
- Economic development stagnation
- Loss of agricultural productivity
- Water quality reduction
- Biological and environmental impact
- Outmigration
- Transitory or permanent income losses
- Job losses in sectors with linkages to irrigated agriculture
- Increased cost of goods from importing

Water Intensity of Electricity Generation



Source: Western Resource Advocates "The Energy-Water Nexus: A Case Study of the Arkansas River Basin" (2008)

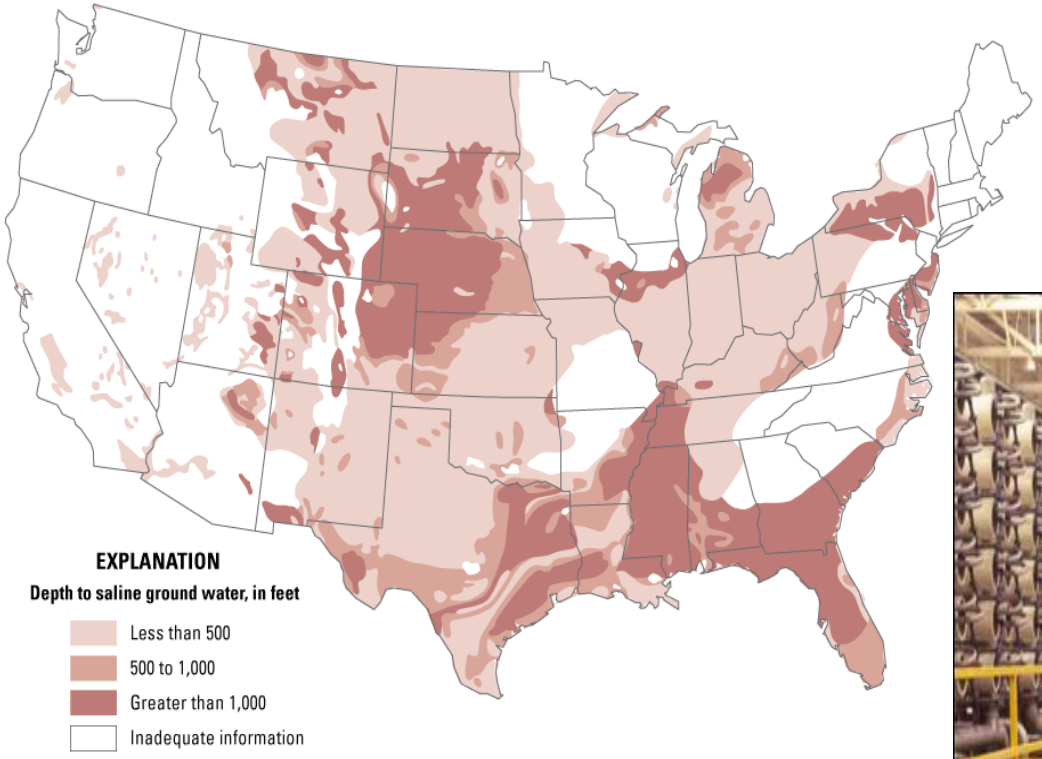
Wind & Hydro on the Grid



Source: T. Acker, NAU

- Plants NOT co-located
- Same transmission control area (non-constrained area)
- Independent but "coordinated"
- "Firming" through grid; ***combined*** variations of load and wind
- Storage of water/energy
- Other potential benefits/detriments

Desalination

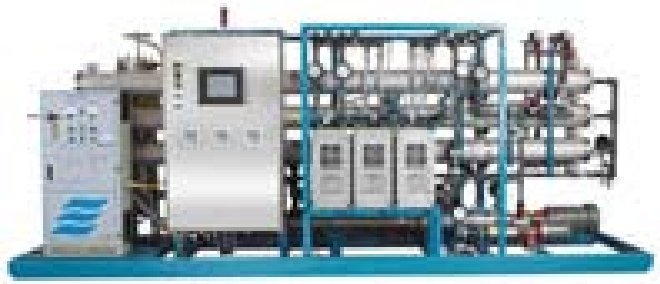


USGS science for a changing world

US BRACKISH AQUIFER SYSTEMS

Wind energy could power desalination systems

Texas Wind - Desalination Pilot Project



Reverse Osmosis Desalination

Seminole, TX Integrated Wind-Water System Addressing Diminishing Potable Groundwater Aquifers

- *Shallow, Potable Ogallala Aquifer Being Consumed*
- *Access Deeper, Brackish Santa Rosa Aquifer*
- *Lift Water and Purify Using Reverse Osmosis*
- *Wind Turbine to Power Lift and RO Pumps*
- *Integrate into Supply of Inland Municipality*
- *Water Storage = Energy Storage and Time-Shifting of the Wind Energy*

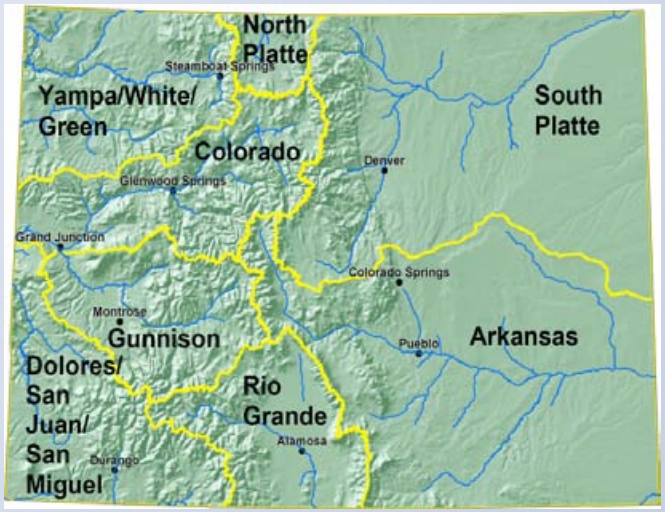
Collaborators/funders

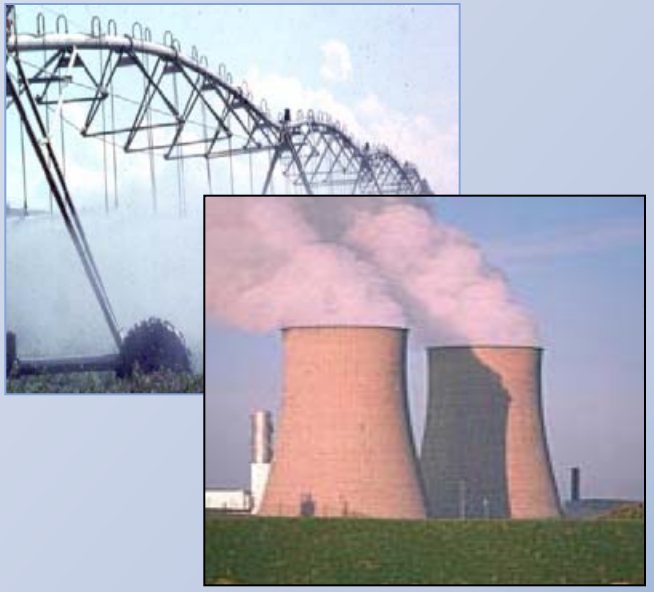
- *Texas Tech University*
- *Texas Water Development Board*
- *Texas Department of Rural Affairs*
- *Texas State Energy Conservation Office*
- *City of Seminole, Texas*
- *US Department of Energy, EERE*

Source: Texas Tech University, Wind Science and Engineering Research Center

PI: Jamie Chapman *jamie.chapman@ttu.edu*

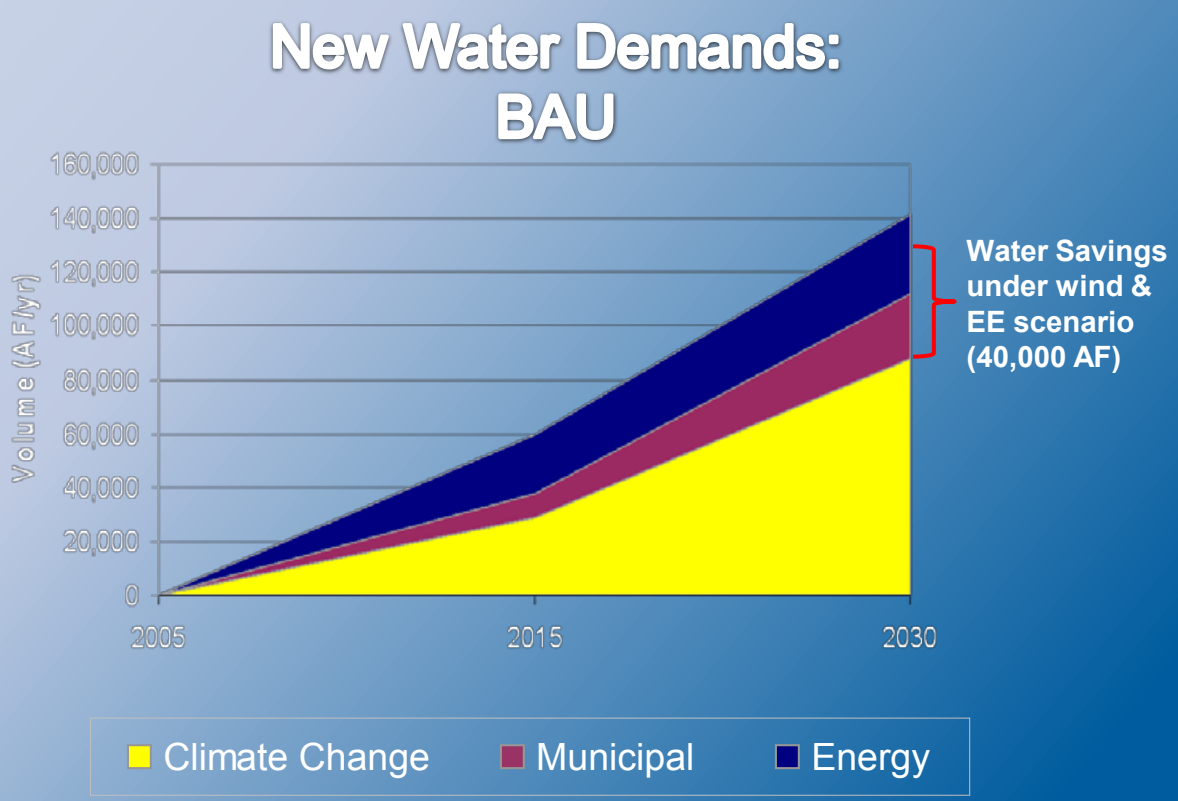
Case Study in the Arkansas River Basin, CO





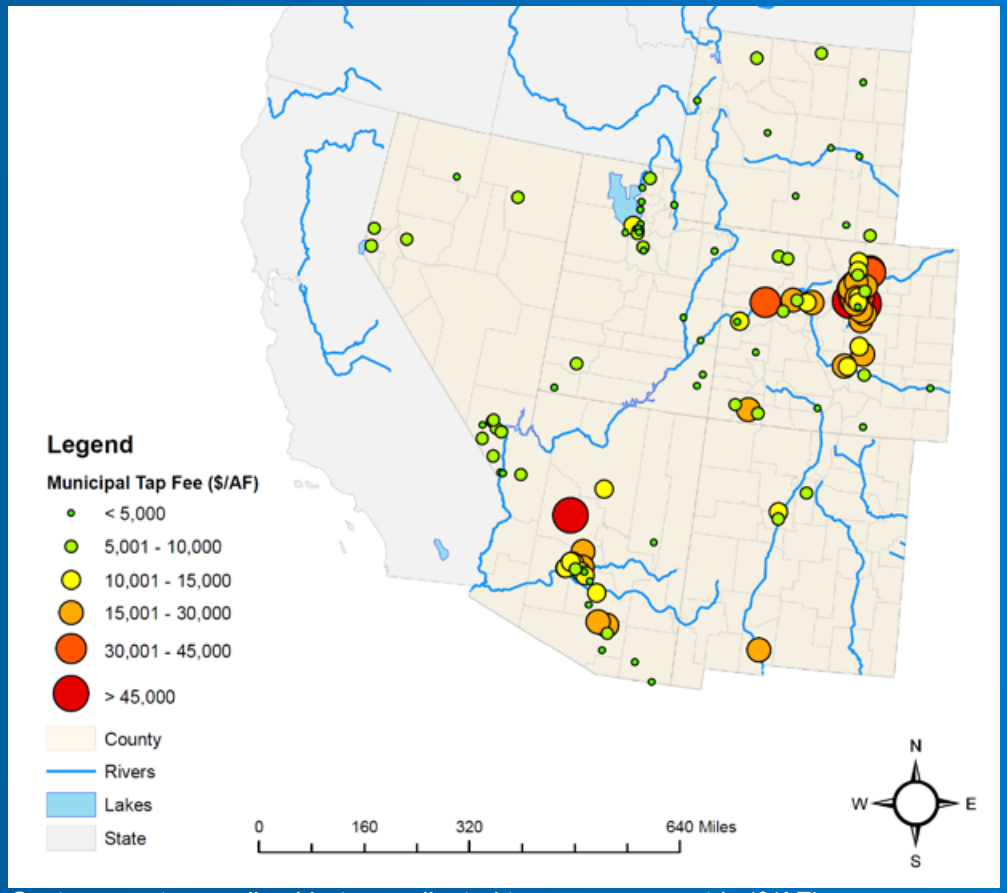
Source: Western Resource Advocates

Wind & energy efficiency could save more than 40,000 acre-feet per year in 2030 (13 billion gallons/yr)



The Value of Water in the West

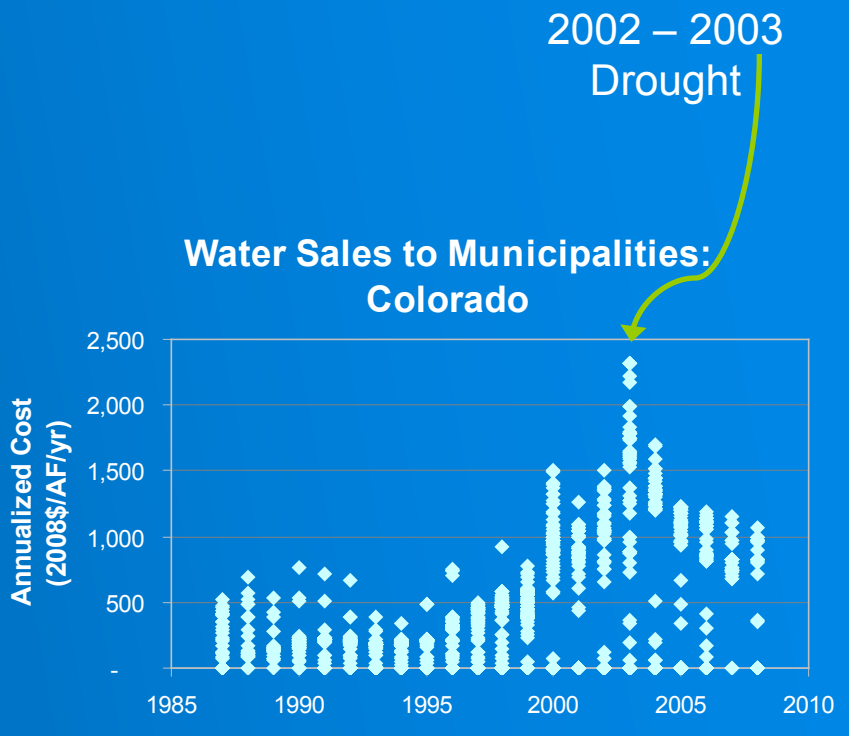
Municipal Water Tap Fees



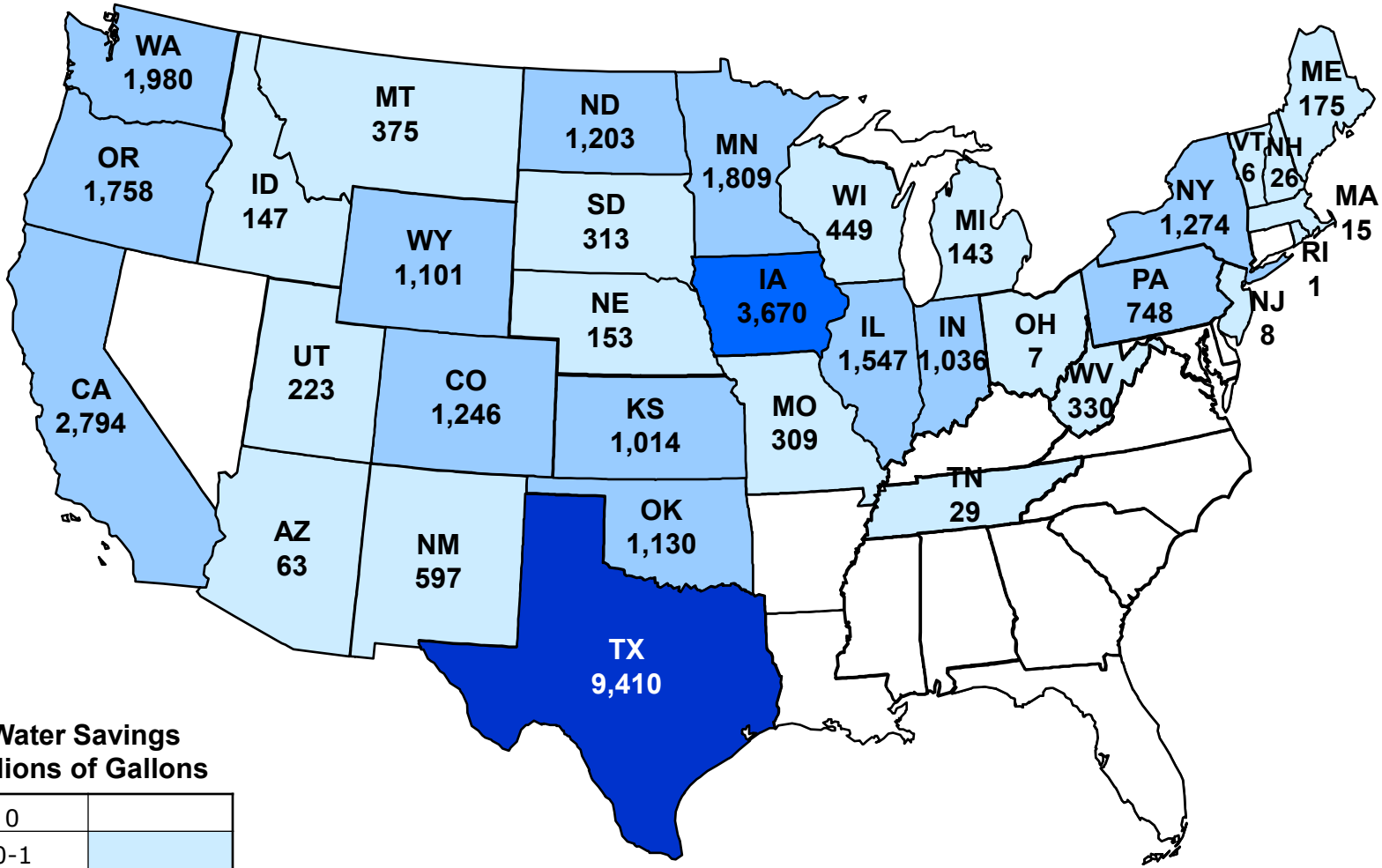
Costs are not annualized but are adjusted to a common metric ($/AF)

Source: Western Resource Advocates

Value is high and rising

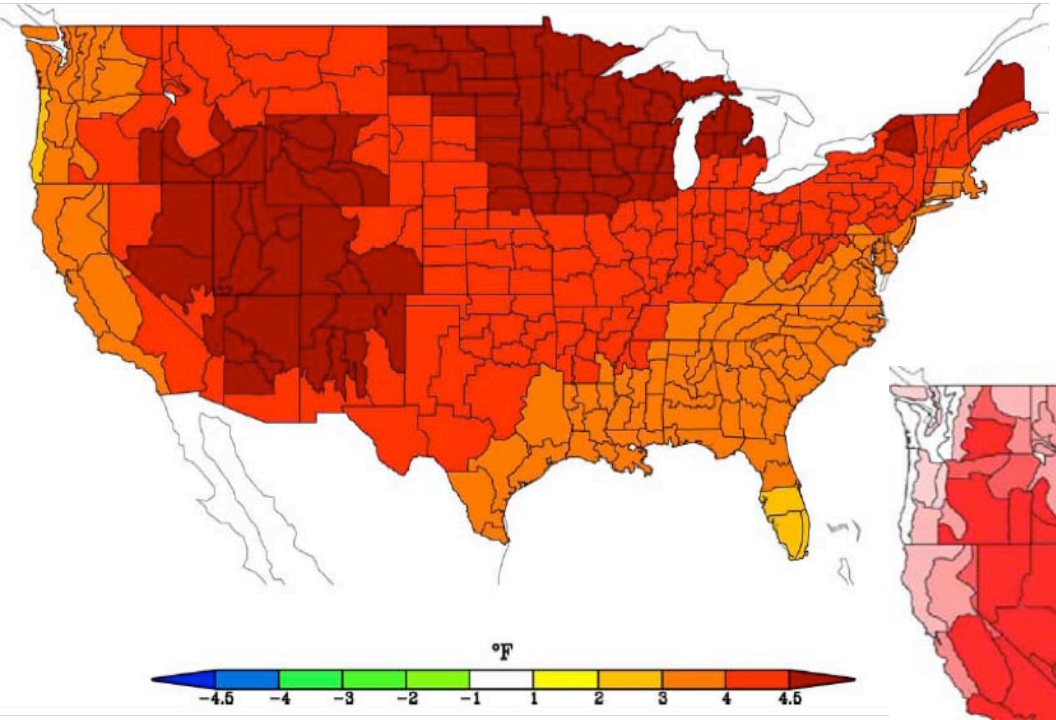


Installed Wind Power Capacity (Dec 2009) and Corresponding Annual Water Savings

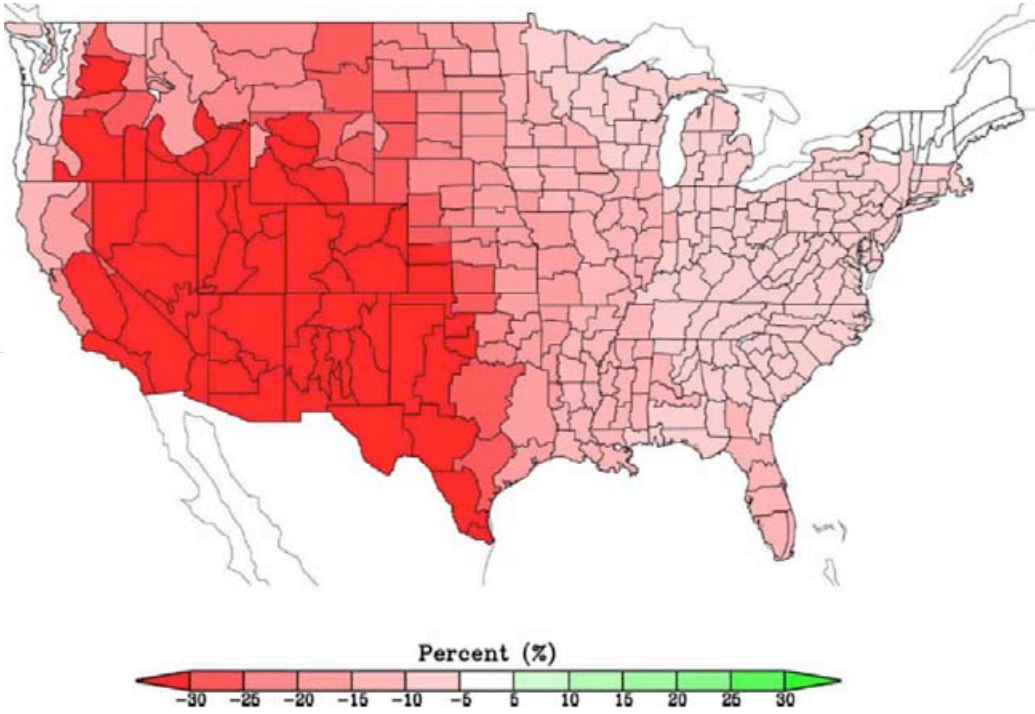


Wind capacity data: AWEA Market Report Jan 2010

Climate Change Impacts



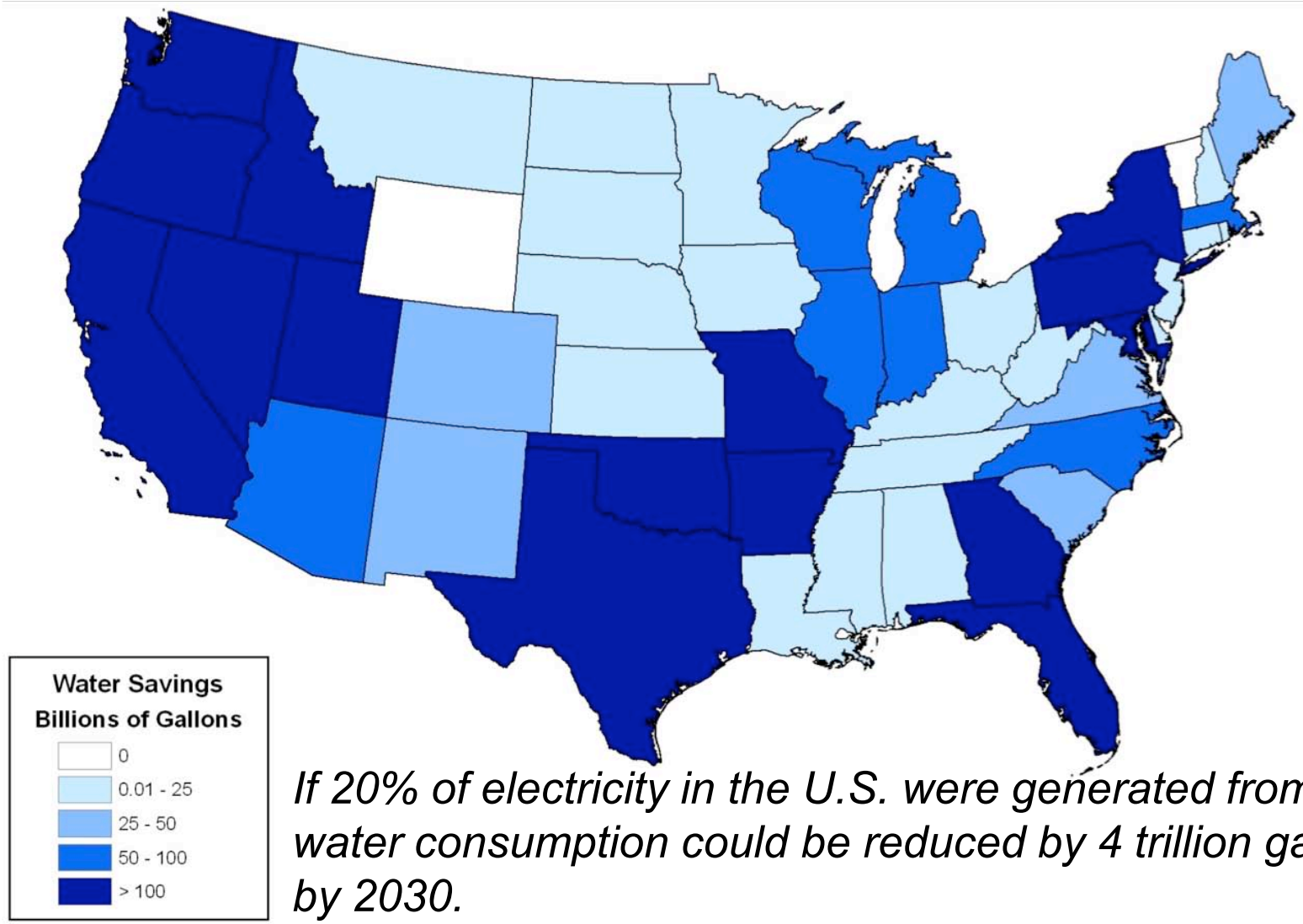
Change in Annual Temperature (2035-2060)



Change in Annual Evapotranspiration (2035-2060)

Source: NOAA

Cumulative Water Savings from 20% Scenario



If 20% of electricity in the U.S. were generated from wind, water consumption could be reduced by 4 trillion gallons by 2030.

Source: 20% Wind Energy by 2030 Report, NREL, May 2008

Conclusions

- Sustained economic development depends on affordable, available water and energy
- Water and energy demand are increasing, but water resources are regionally decreasing and uncertain
- Water resource management is a high priority for all U.S. regions (and the world)
- Appropriate allocation of scarce water resources is paramount to a secure energy and sustainable future
- Wind energy is an important piece of the answer to water scarcity and economics

Energy-Water Nexus

“There’s a two-thirds chance there will be a [water] disaster … and that’s in the best scenario.”

Steven Chu, U.S. Energy Secretary and Nobel Laureate

Carpe Ventem
(Servo Aqua)










www.windpoweringamerica.gov

References:

Slide # 7- USGS
Slide # 8 - NETL
Slide # 9 - Sandia National Laboratory
Slide # 10 - USGS
Slide #12 - USDA (first map only)
Slide #14 - Western Resource Advocates
Slide #15 - NAU
Slide #17 - Texas Tech University
Slide #18 - Western Resource Advocates
Slide #19 - Western Resource Advocates
Slide #21 - NOAA