

# Climate Influences on Capacity Expansion Planning



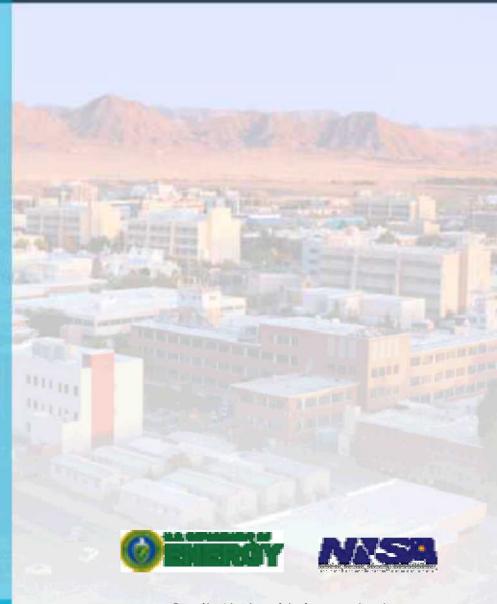
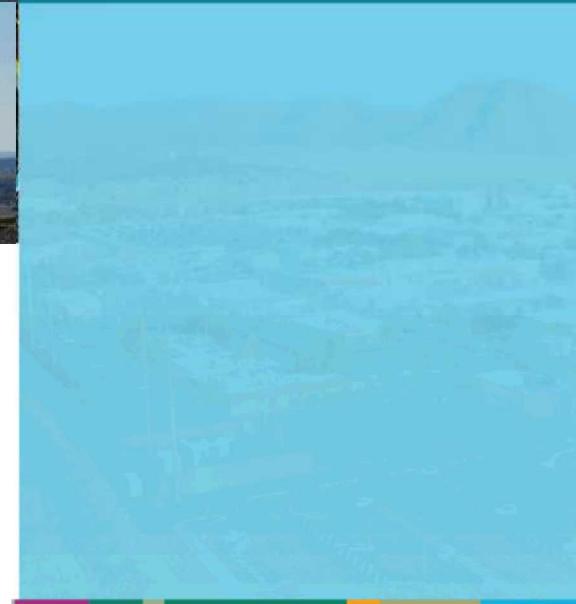
PRESENTED BY

Vincent Tidwell  
Sandia National Laboratories

*Water and Energy: What Connection Can We Draw?*  
IAEE Webinar  
October 12, 2020



SAND2020-11164PE



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# Acknowledgements



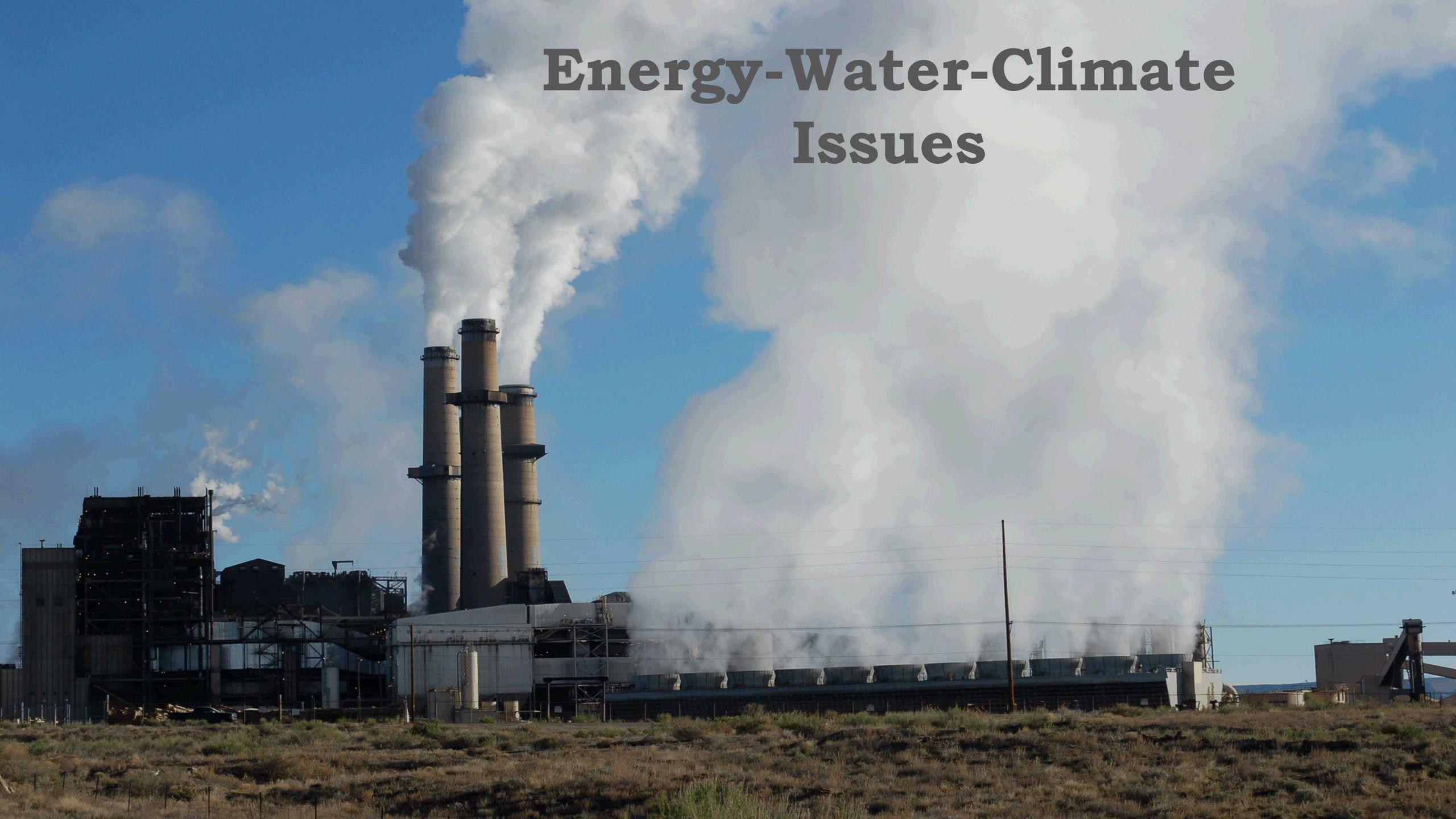
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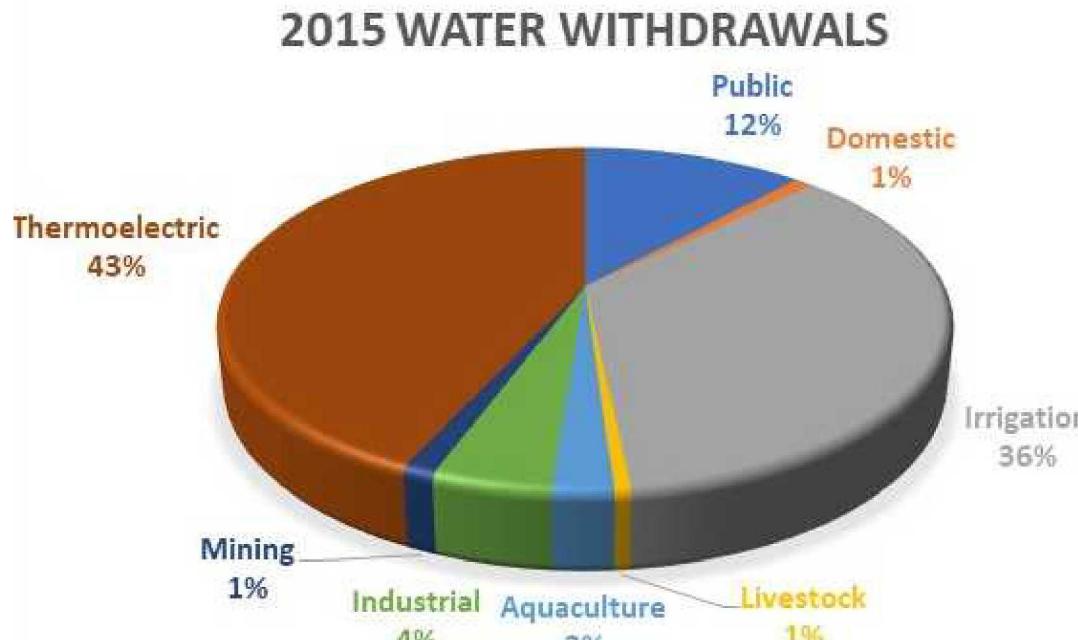
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# Energy-Water-Climate Issues



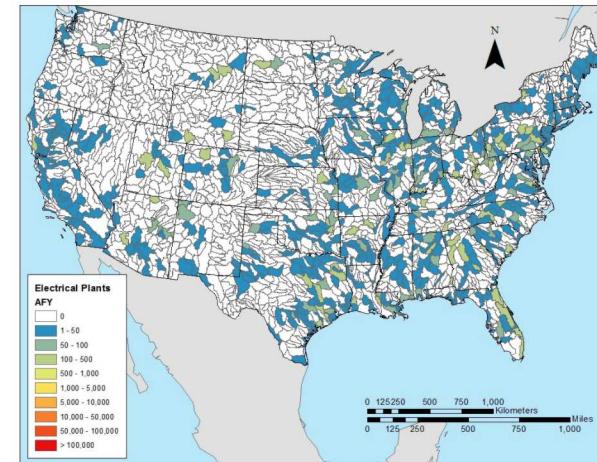
# Water for Energy



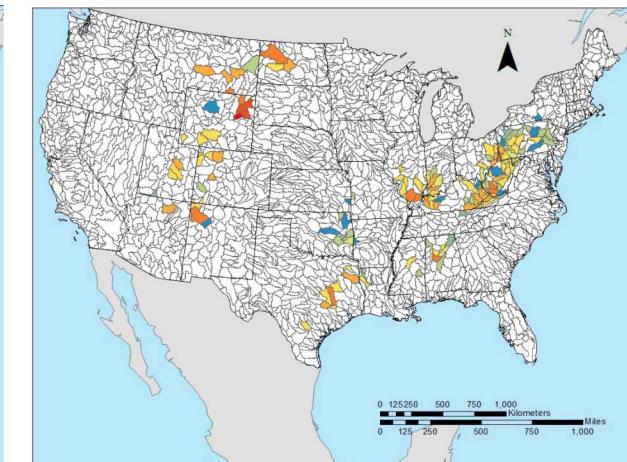
322 BGD Total Withdrawals  
~7-8 BGD Total Consumption

## Water Consumption by County

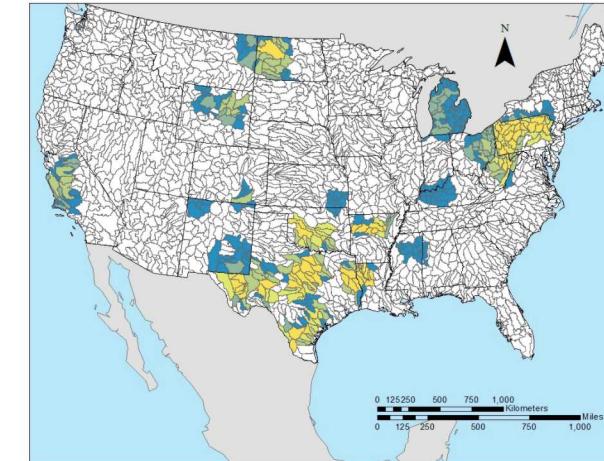
### Thermoelectric



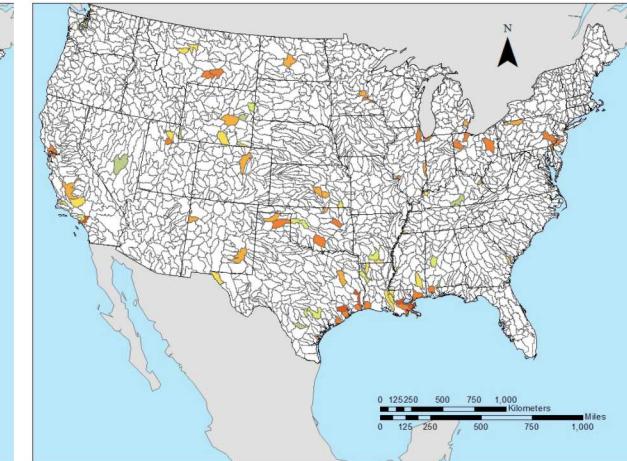
### Coal



### Unconventional Oil and Gas



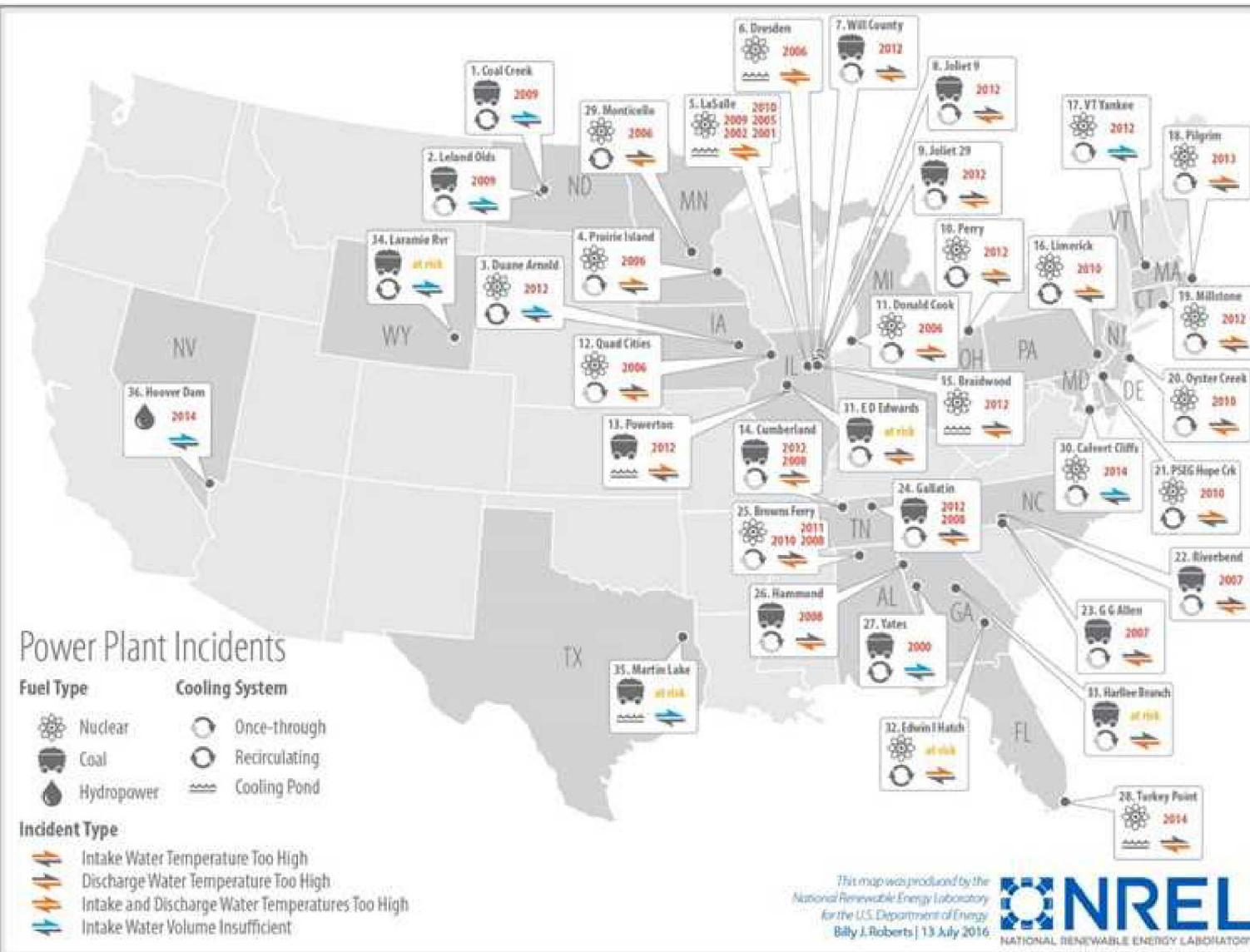
### Refineries



Source: Tidwell et al. 2016

# Current Impacts

## Climate Extremes Impact Power Production



## Water Scarcity Impacts Plant Siting

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**Idaho Places Moratorium on Coal-Fired Power Plants**  
May 24, 2006

The legislation was inspired in part by a controversial plan by California-based Sempra Energy to build a 600-megawatt plant in Jerome County, approximately 100 miles southeast of Boise. Following the Senate's passage of H. 791, Sempra announced that it would and efforts to construct the Jerome County project and a similar project in northern Nevada. Craig D. Rose, *Nevada, Idaho Projects Ran Into Stiff Opposition*, San Diego Union Tribune (March 30, 2006). In a letter to Idaho Governor Kempthorne, Sempra stated that it withdrew from the Idaho project because it was focusing on its natural gas related business. *Id.* Sempra plans on seeking buyers for the development it has already done at the site. *Id.*

Introduced by House Speaker Bruce Newcomb (R), H. 791 was passed by the Idaho House on a 65-1-1 vote on March 21, 2006, and by the Senate on a 30-5 vote eight days later. Rebecca Meany, *Power Plant Moratorium Bill on Governor's Desk*, Idaho Mountain Express (March 31, 2006). The Idaho Legislature found that it was "in the public interest to adopt an integrated energy plan... that provides for the state's power generation needs and protects the health and safety of the citizens of Idaho." *H. 791*. The Legislature also found that "certain coal-fired power plants may have a significant negative impact upon the health, safety and welfare of the population, the quality and financial security of existing agricultural business... and the environmental quality and natural resources of [the] state." *Id.*

**H. 791 amends the Idaho Environmental Protection and Health Act, Idaho Code Ann. § 39-101, et seq. Under the act, as amended, municipalities, counties, and the Idaho Department of Environmental Quality are prohibited**

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**6/20/2019**

**State denies permit to Burrillville power plant**

**BURRILLVILLE** — In a gripping decision that followed several days of debate, the state Energy Facility Siting Board today denied an application by a Chicago-based Invenergy to build an oil-and-gas-burning power plant on Wallum Lake Road.

The decision came after just a few hours of public debate during which members of the state board expressed doubt about the state's need for energy produced by the plant, a key argument made by representatives of the company.

The decision was a victory for conservationists and local residents, many of whom had opposed the plant.

**AP NEWS**

**Company's bid to use groundwater for nuclear plant denied**

**November 12, 2019**

**PHOENIX (AP)** — Arizona water regulators have rejected an application by an electric utility to build a nuclear power plant west of Phoenix because the water is being used by nearby residents.

The state Department of Water Resources denied the request from Arizona Public Service to build the plant in the Buckeye area and study it as an alternative to expensive reclaimed water because it is needed.

The permit requires water has no other beneficial use, state department officials said. "The Department finds that this groundwater is currently being used beneficially and deny the application," officials said in the rejection letter.

**CENTER for BIOLOGICAL DIVERSITY**

For Immediate Release, February 9, 2009  
Contact: Amy Ahood, Center for Biological Diversity, (414) 914-3372  
**Statement on Abandonment of Plans to Construct Coal-Fired Power Plant in Eastern Nevada**

**LAS VEGAS**, Nev. — The Center for Biological Diversity's announcement today that it will abandon original plans to construct the El Nino Energy Center, a coal-fired power plant in eastern Nevada, citing growing environmental and economic concerns, the company's decision to abandon the plant is a welcome one. The plant would have used coal to generate electricity and capture and store carbon dioxide technology becomes commercially viable, which is not likely before the end of the next decade.

"Today's announcement reflects the fact that power companies are starting to recognize coal's bleak future," said Amy Ahood, public lands director at the Center for Biological Diversity. "The El Nino Energy Center would have been the first coal-fired power plant to use carbon capture and storage technology in the West, and it would have been the first new coal-fired power plants that are still proposed for the region. Not another acre of public lands should be destroyed for coal combustion in an age of climate change."

El Nino Energy Center, which would have been located about 20 miles south of Elko in White Pine County, Nevada, would have consisted of ten coal-fired 750-megawatt (MW) ultra-supercritical steam turbine units, two 500-MW integrated gasification combined cycle units, and associated coal handling, ash removal, and waste management facilities.

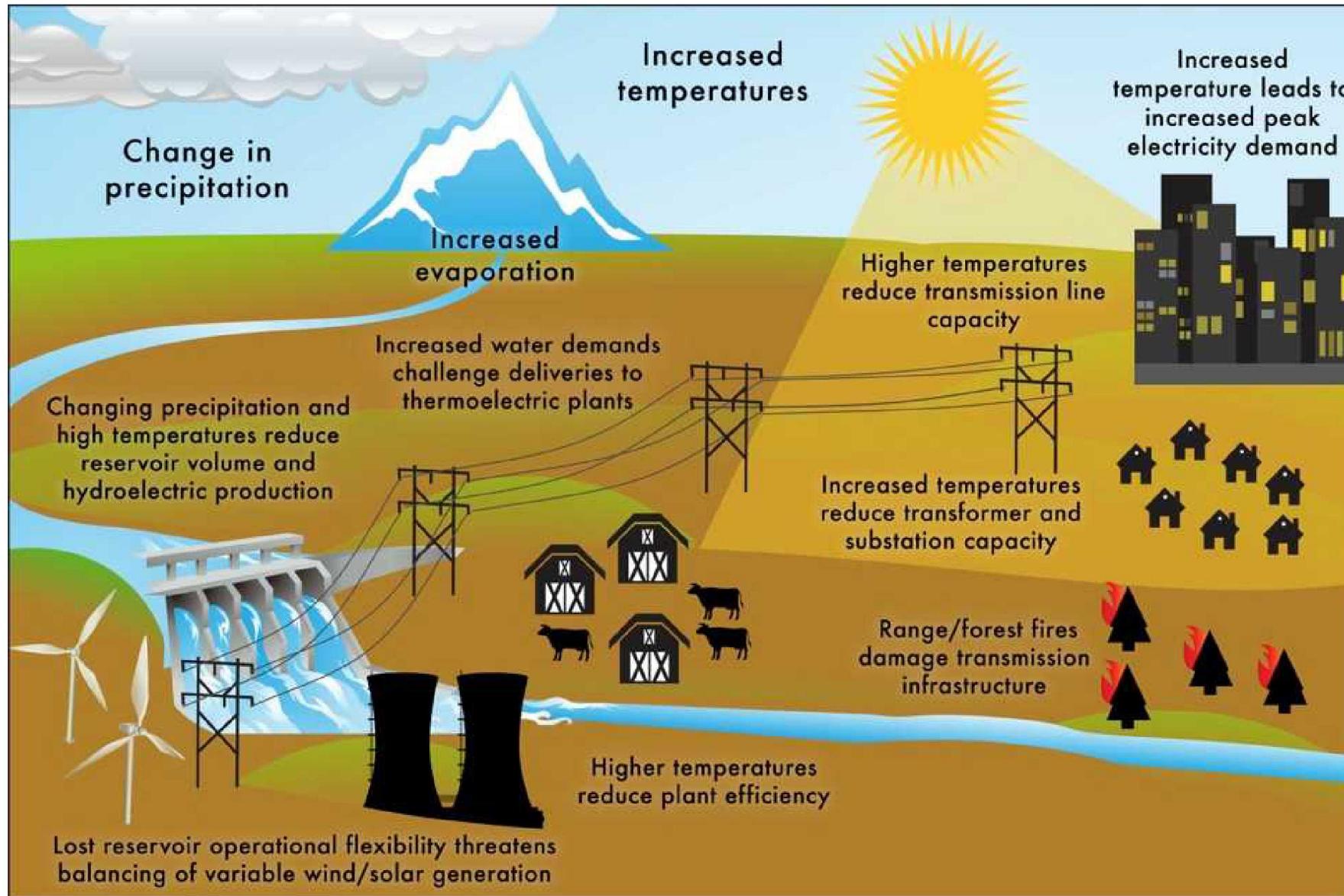
El Nino Energy Center would have consumed approximately 2,000 acre-feet of water per year during the first phase alone, comprising the viability of local threatened and endangered species while contributing an estimated 10.5 million tons of CO<sub>2</sub> to the atmosphere every year. Additional groundwater withdrawals would have resulted from the mining and transportation of coal between eastern Nevada and the Powder River Basin in Wyoming.

The Center will continue to monitor developments to see that regulatory permitting processes for the El Nino Energy Center are halted or withdrawn. The Center for Biological Diversity is committed to ensuring that atmospheric CO<sub>2</sub> pollution levels are reduced to below 400 ppm, and learning choices that will allow us to move away from fossil fuels. Future development of coal-fired power plants must be fundamentally incompatible with achieving that goal. If greenhouse gas emissions are not reduced, we will face catastrophic global warming, ecosystem changes, and tragic human suffering.

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[BiologicalDiversity.org](#)

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# Cascading Impacts on Electric Power



# Reduced Water Use

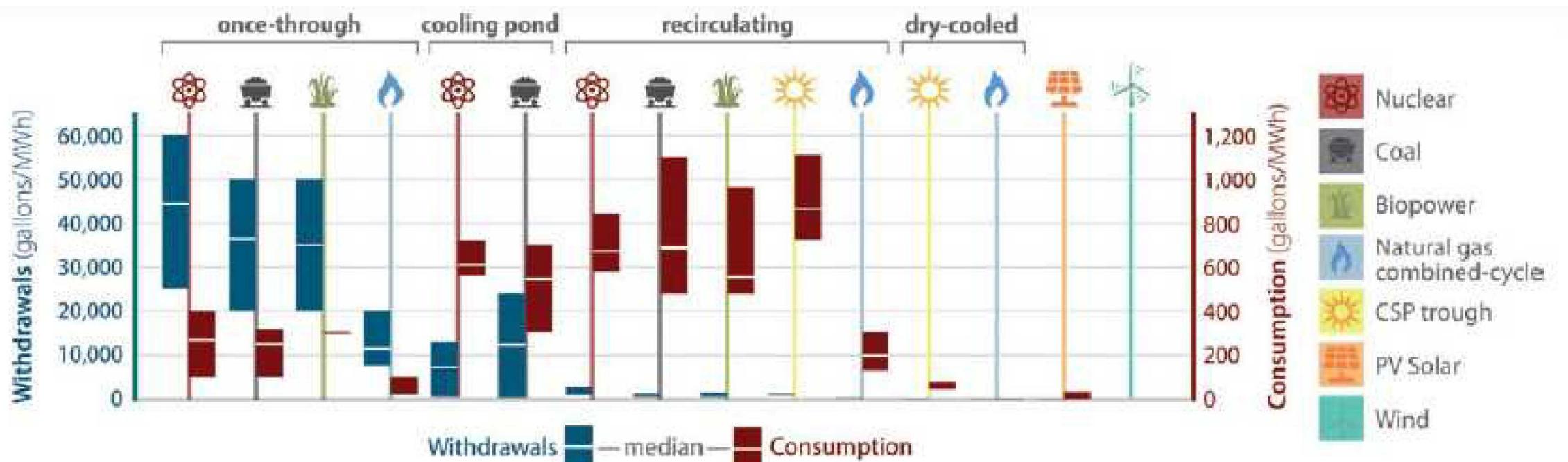
*Systems are Moving to Less Water Intensive Forms of Generation*

Current generation relies on high-water use technology:

- Coal
- Gas-Steam
- Nuclear

New capacity favors low-water use technology:

- Natural gas combined cycle
- Wind
- Solar PV



Ranges reflect minimum and maximum water-use values.

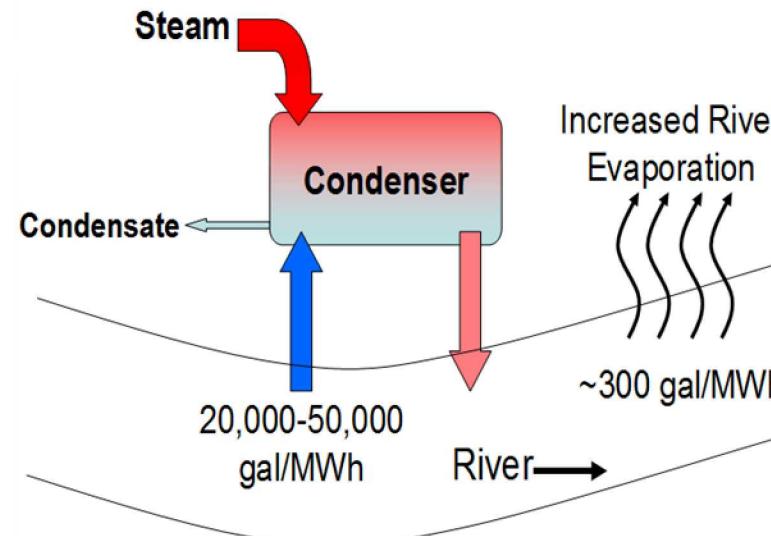
Source: UCS 2011

# Reduced Withdrawals

## Systems are Moving to Less Water Intensive Forms of Cooling

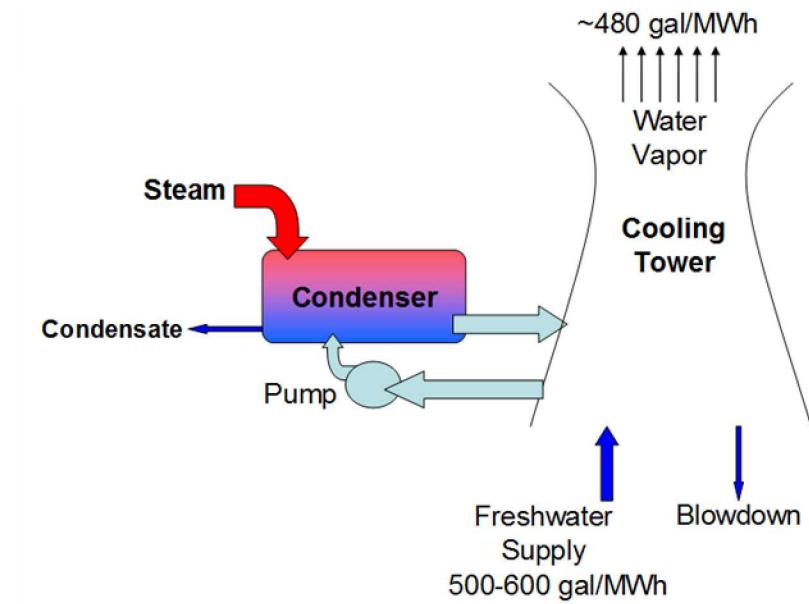
The screenshot shows a news article from the POWER website. The header includes 'POWER' in red, 'Business & Technology for the Global Generation Industry Since 1882', and a 'Check out the new myPOWER section of our website. It's for content you control.' button. The main content is titled 'EPA Issues Final Cooling Water Intake 316(b) Rule' with a sub-headline '316(b) Rule' and a date '05/19/2014 | Sonal Patel'. The article discusses a final rule by the Environmental Protection Agency (EPA) that will affect cooling water intake structures at 544 U.S. power plants. It mentions lower-cost compliance options and the implementation of National Pollutant Discharge Elimination System (NPDES) permits. The website has a navigation bar with 'Home', 'Coal', 'Gas', 'Nuclear', 'Renewable', 'International', and 'More'.

### High Water Withdrawal Low Water Consumption



Open-loop "once-through" cooling cycle

### Low Water Withdrawal High Water Consumption



Closed-loop cooling cycle

Source: EPRI 2002

A photograph of an industrial facility under a blue sky with white clouds. The facility features several large, white, cylindrical pipes arranged in a stepped, descending pattern from left to right. To the right of the pipes is a large, light-colored industrial building with a glass-enclosed entrance. The building has a metal frame and a glass roof. In the foreground, there are some green bushes and a white fence. The overall scene suggests a modern industrial or manufacturing plant.

# Climate Adaptation Opportunities

# Alternative Water Source

## *Retrofit existing plants to eliminate freshwater use*

- Retrofit options:

- Dry cooling
- Municipal waste water
- Brackish groundwater



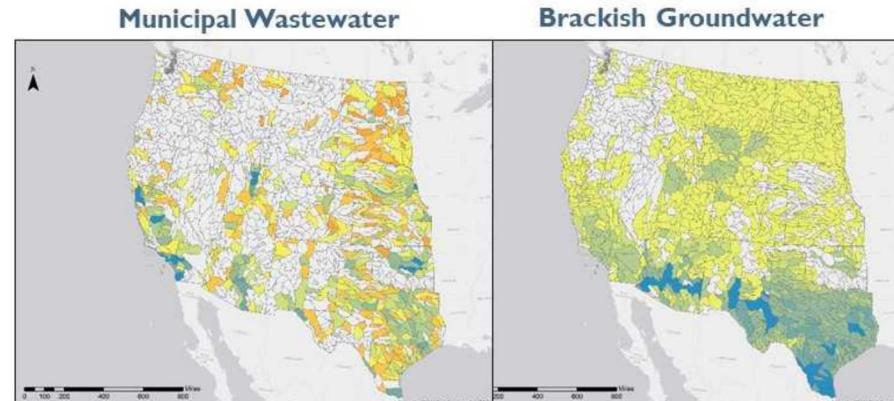
1,178 Freshwater Using  
Thermoelectric Power Plants

- Costs:

- Capital
- Operating and Maintenance
- Capture
- Treatment
- Parasitic energy losses



Water Availability

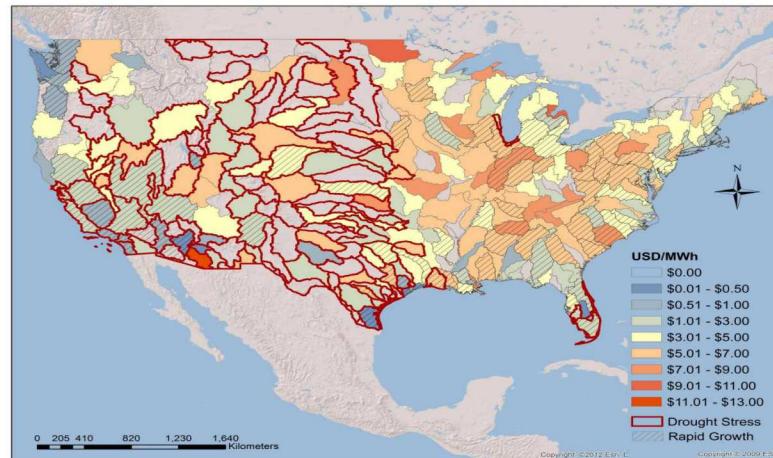


# Alternative Water Source

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

1,178 Freshwater  
Using Thermoelectric  
Power Plants

Note:  $\Delta$ LCOEs 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.*

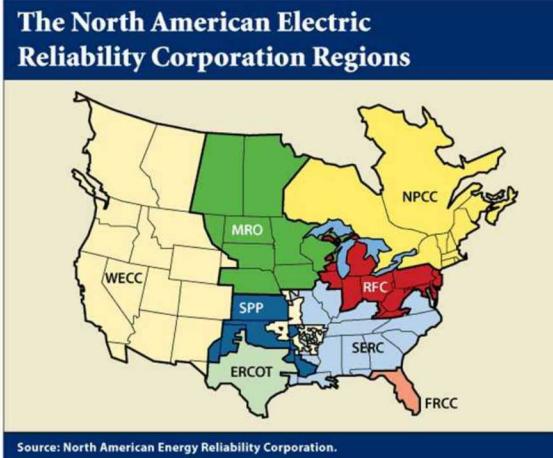
Source: Tidwell et al. 2014



Least cost alternative values mapped on watersheds vulnerable to drought (outlined in red)

\*average 2012 wholesale cost over 3 US trading hub regions

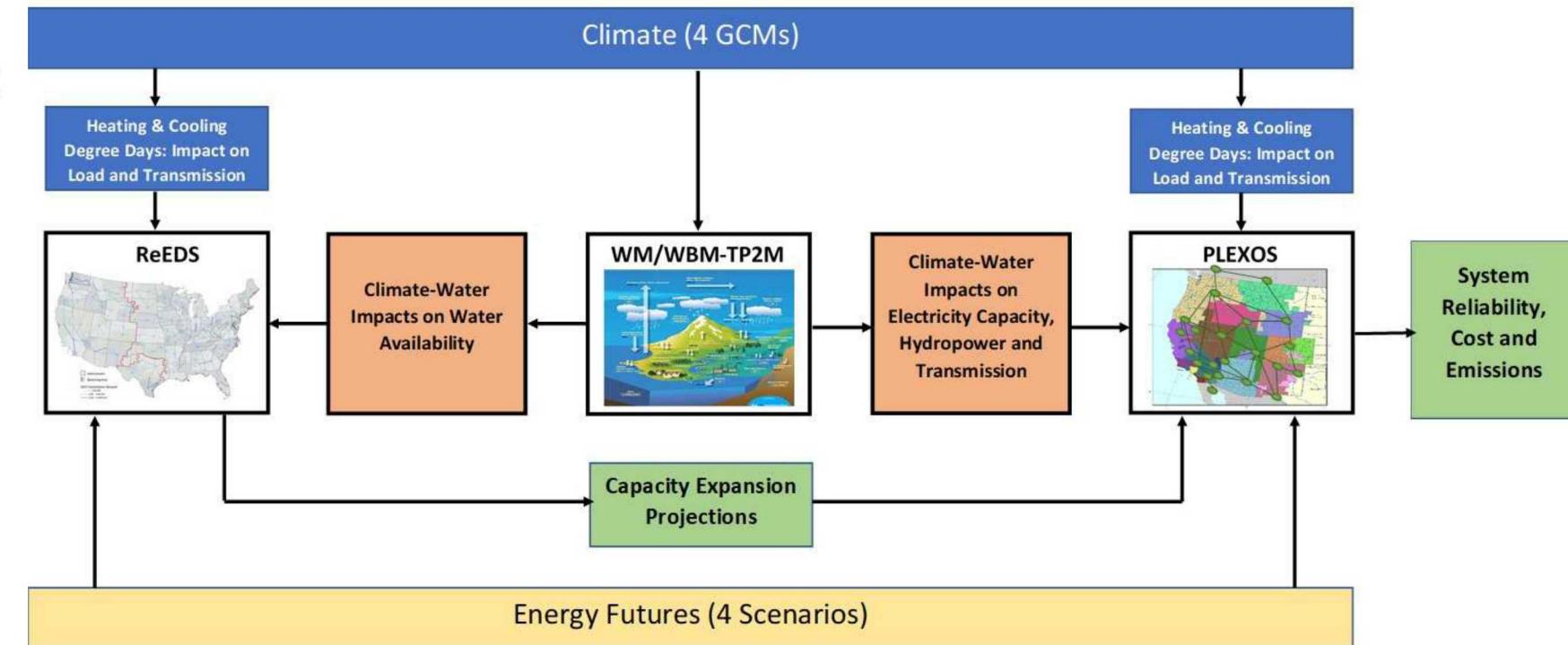
# Integrated Planning



## Analysis platform included:

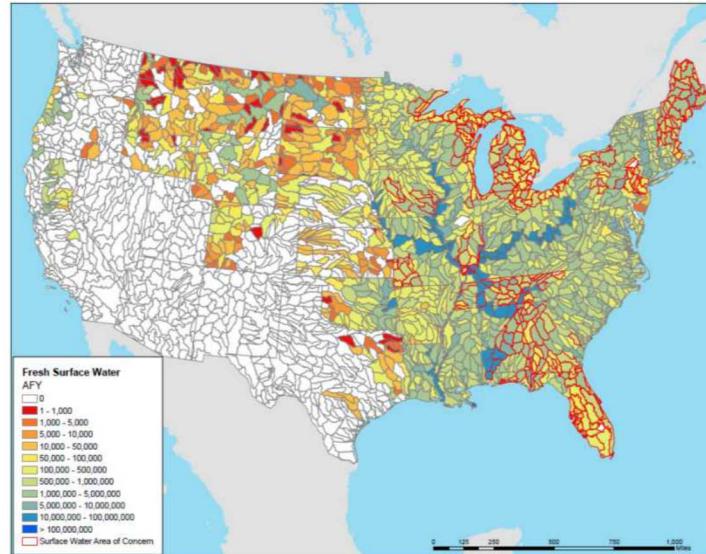
- Hydrologic modeling,
- Capacity expansion modeling, and
- Production Cost Modeling

- Integrated climate into WECC's capacity expansion planning exercise
- Explored how water extremes influence planning decisions

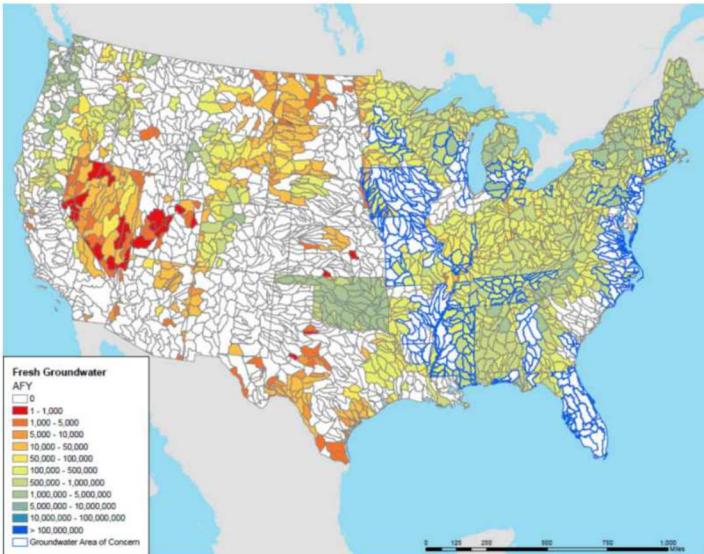


# Limited Supply for Development

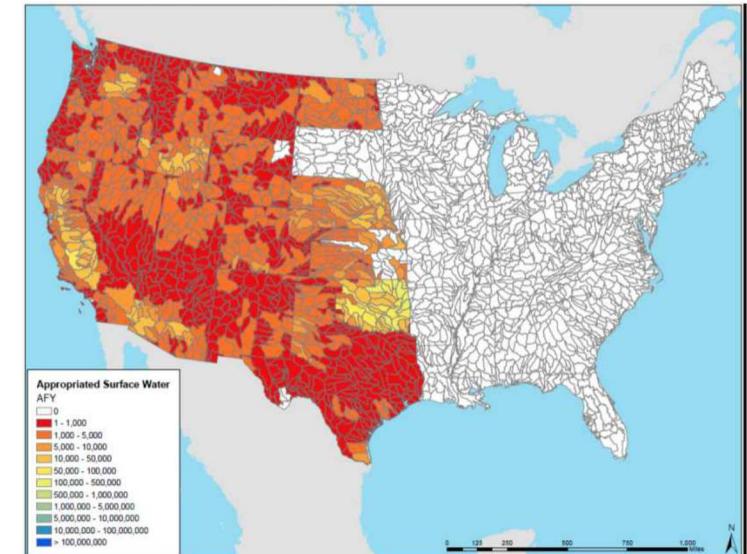
Fresh Surface Water



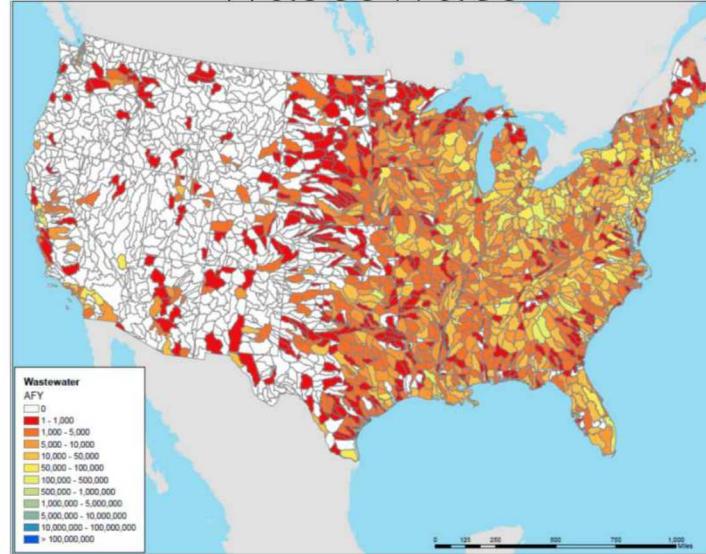
Fresh Groundwater



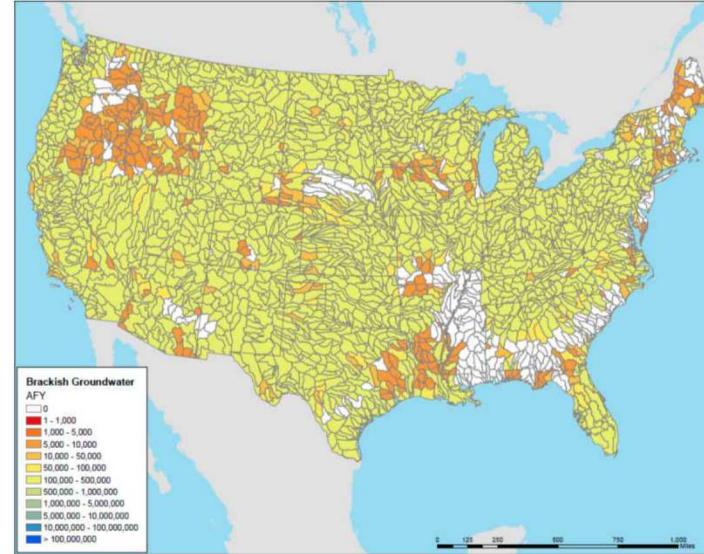
Appropriated Water



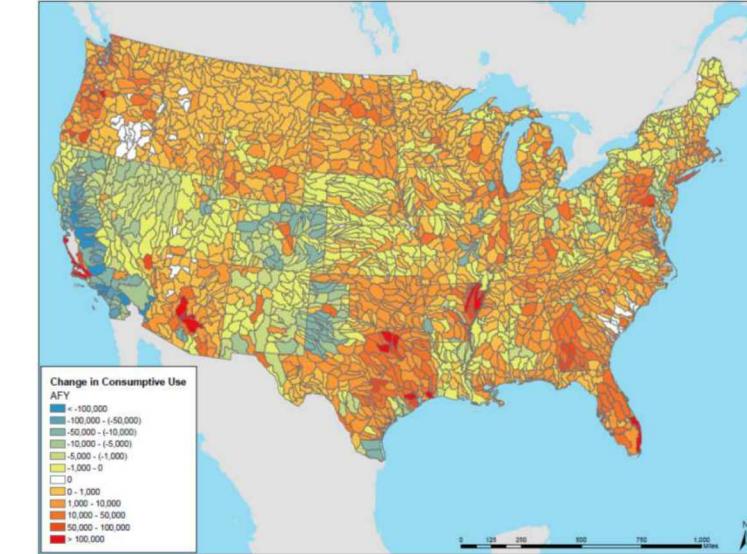
Wastewater



Brackish Water



Growth in Demand 2015-2035



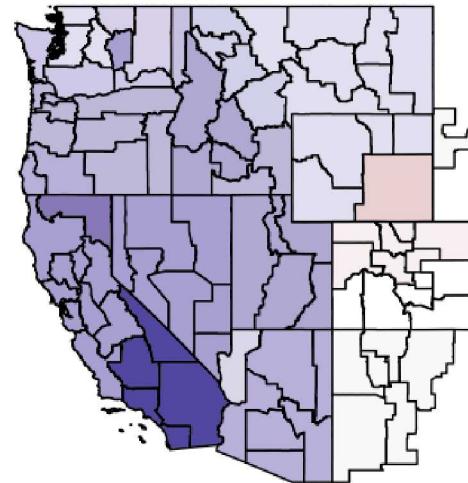
Source: Tidwell et al. 2018

# Limited Water for Hydropower

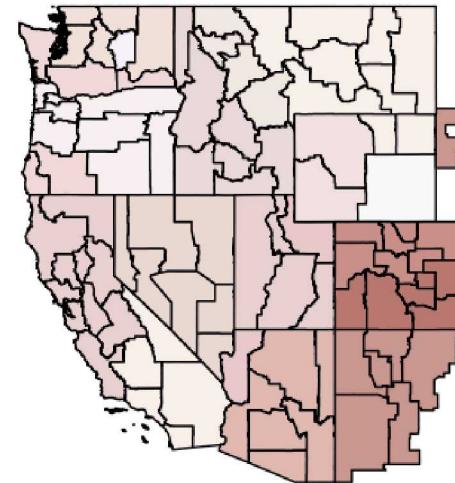
Moderate emissions pathway

Relative trends in available hydropower

GFDL-ESM2M RCP4.5



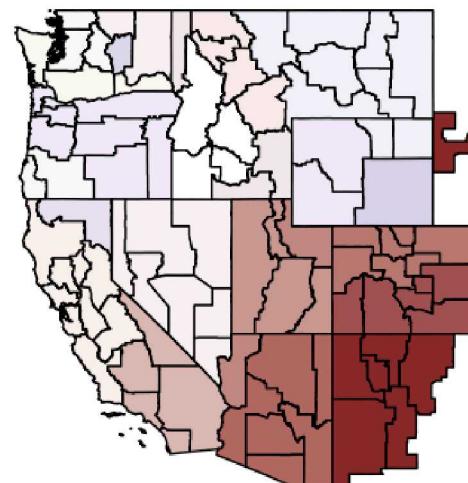
IPSL-CM5A-LR RCP4.5



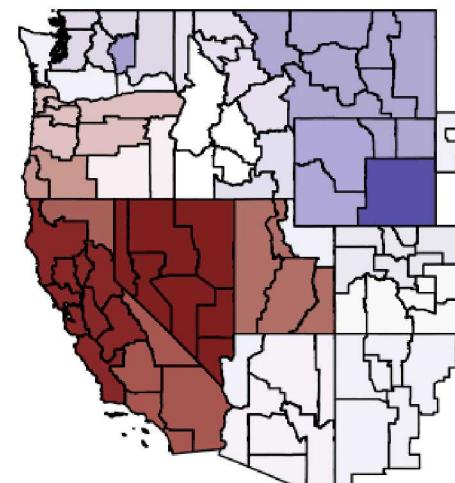
Impact (%)  
2038 vs 2018



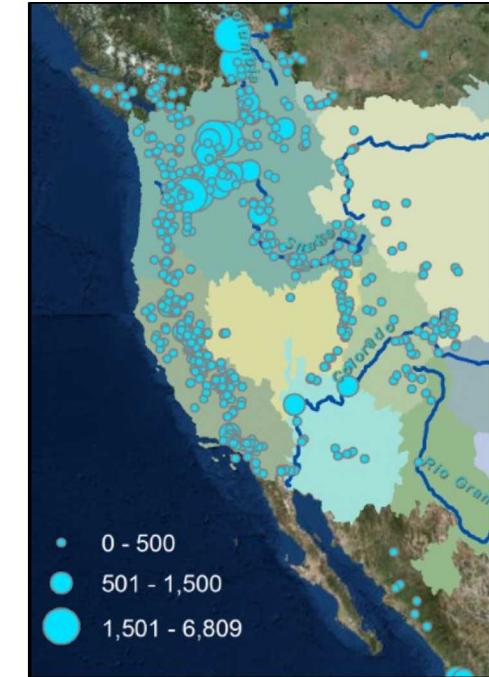
IPSL-CM5A-LR RCP8.5



MIROC-ESM-CHEM RCP8.5



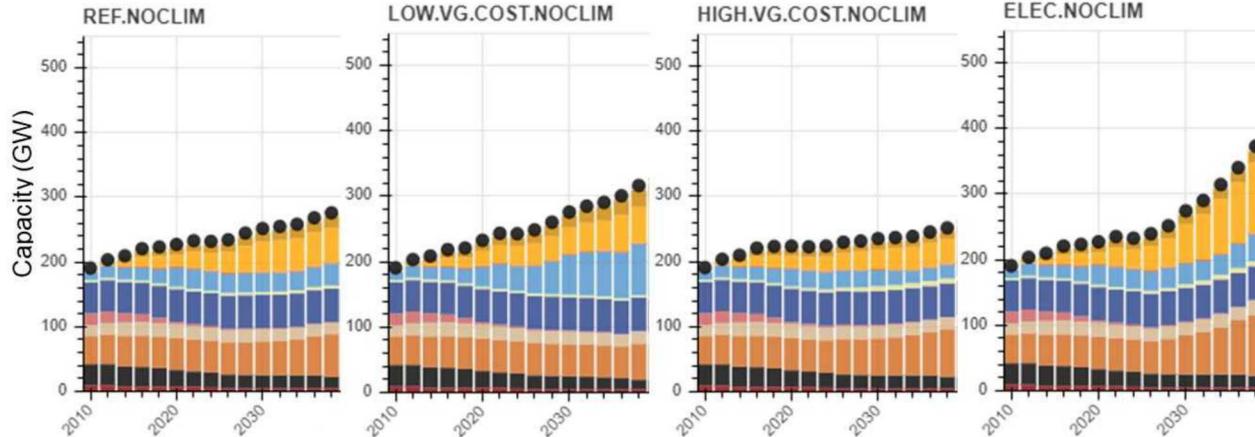
Extreme emissions pathway



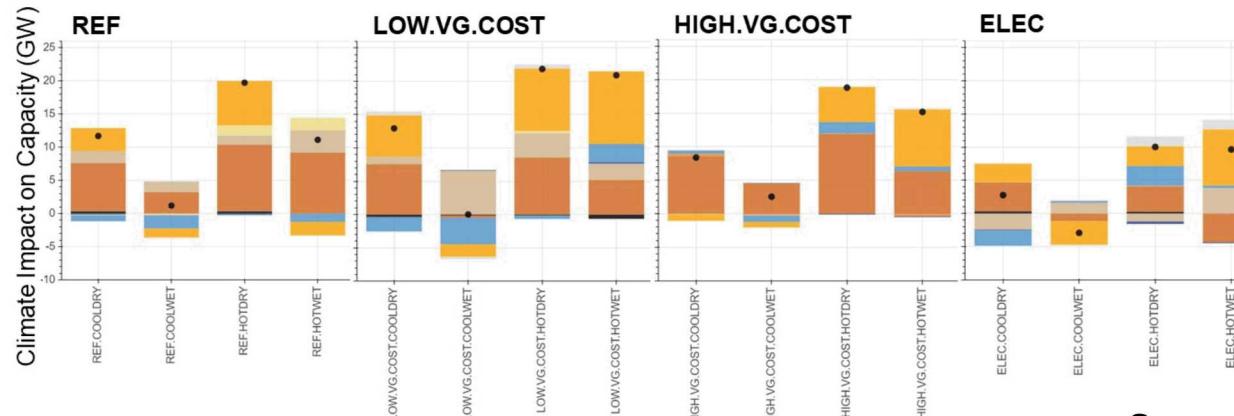
# Climate Impacts on Capacity Expansion



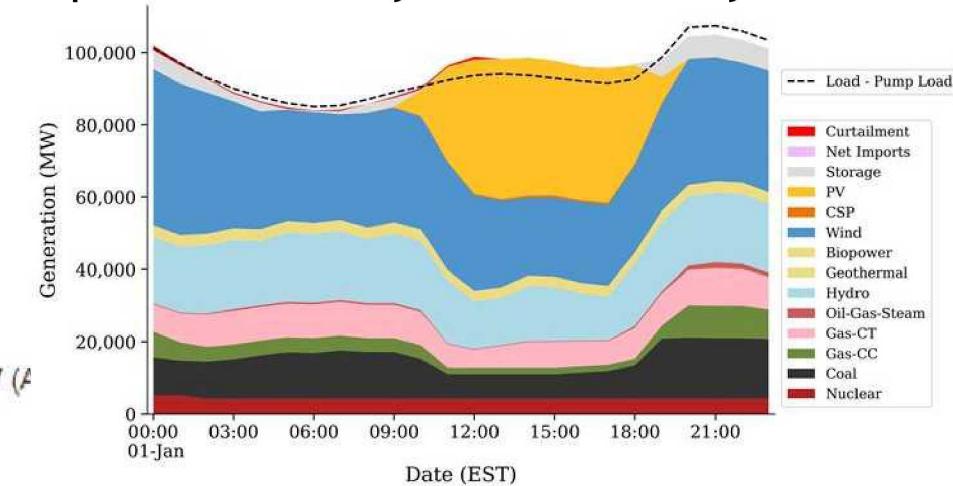
## Generation Expansion Profiles



## Difference with and without Water Constraint



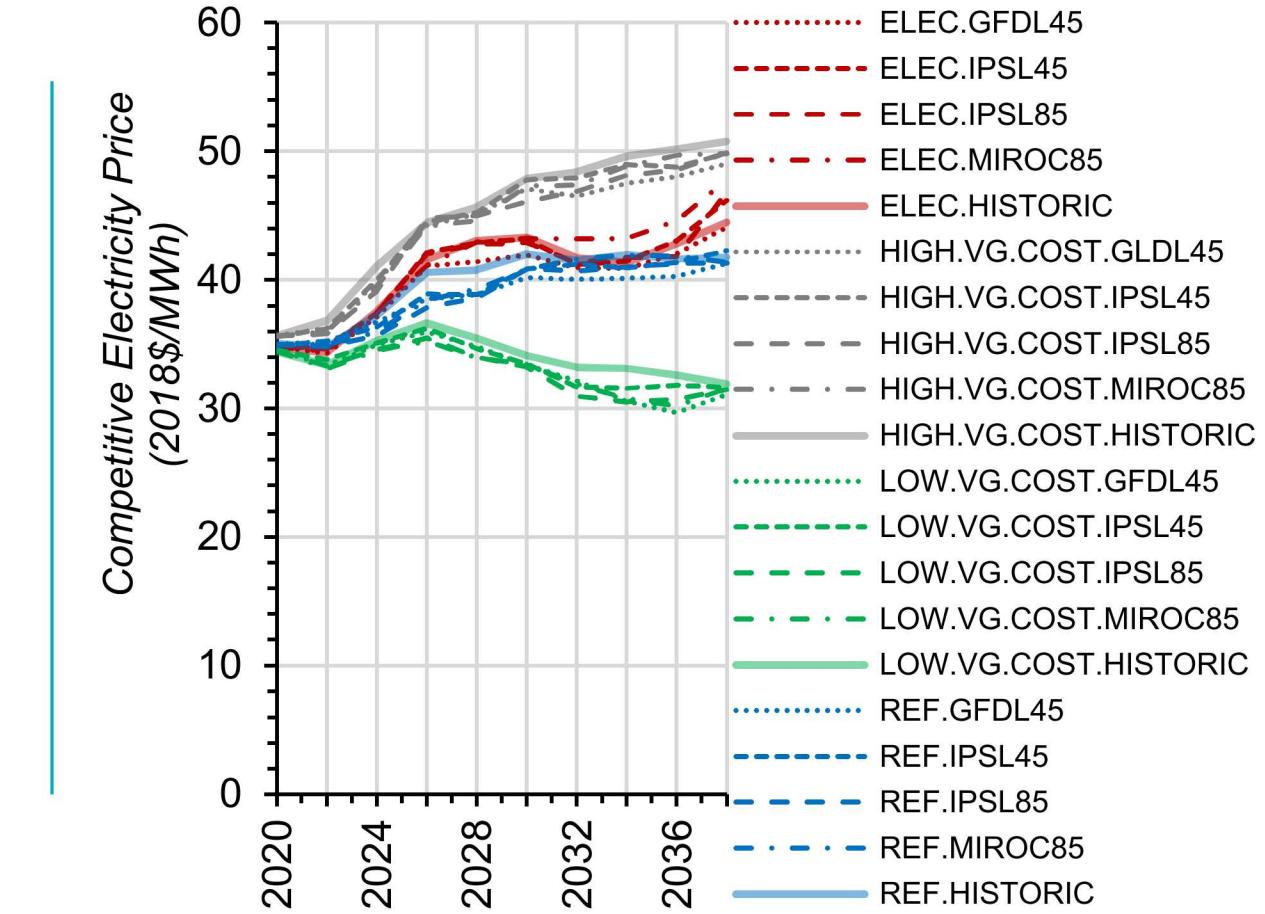
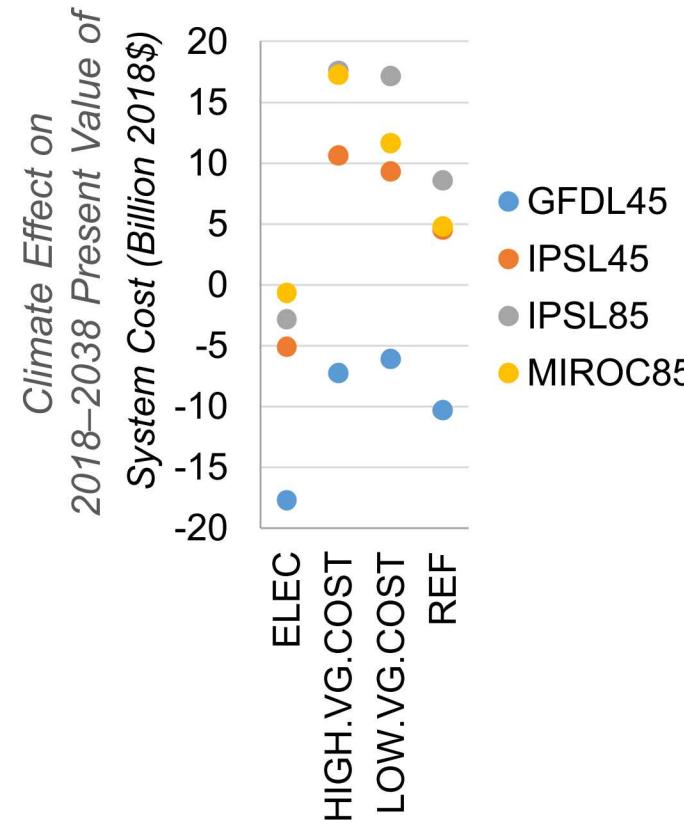
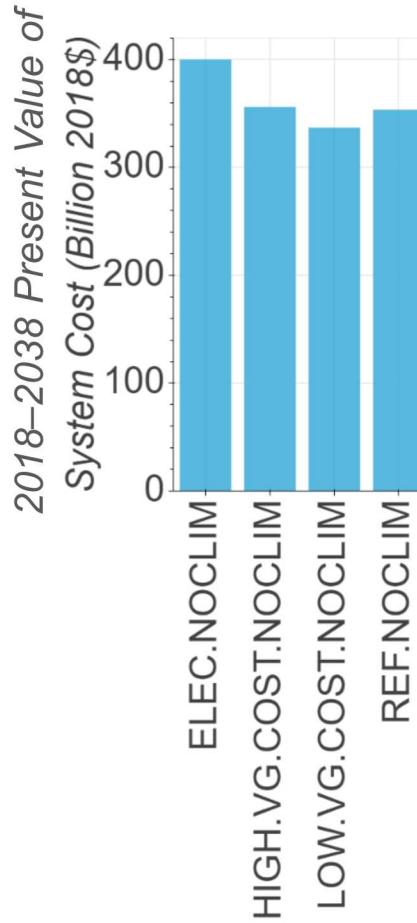
## Implications for System Reliability and Cost



- Additional capacity needed to meet peak load.
- Hydropower production is key uncertainty.
- Considerable adaptive capacity available in the grid.

Source: Tidwell et al 2020

# Climate Impacts on Economics



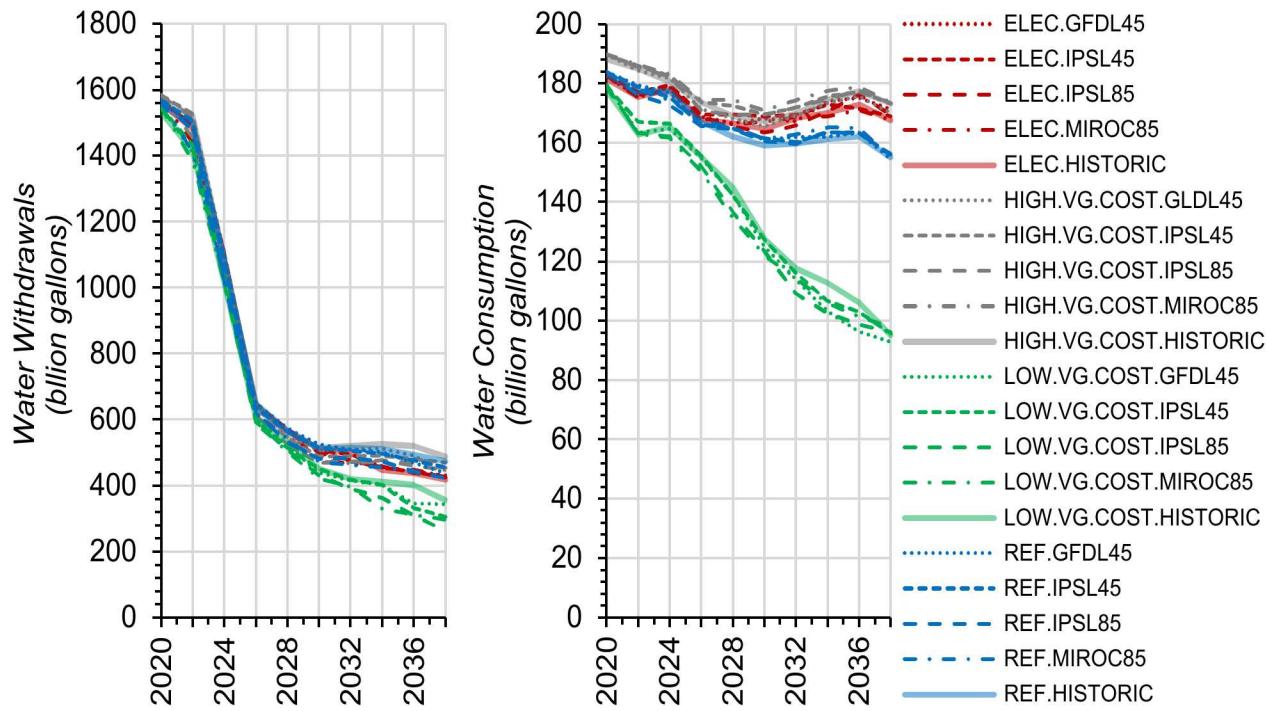
Heat-driven demand can increase costs, but increased hydropower can reduce costs

Cumulative climate impacts on cost range from -17.7–17.6 billion \$

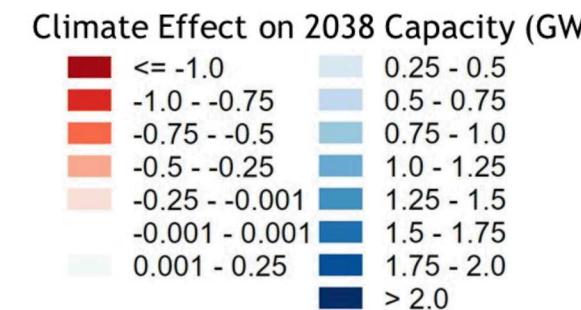
Climate impacts on electricity prices are small compared to technology and electrification

# Climate Impacts on Environment

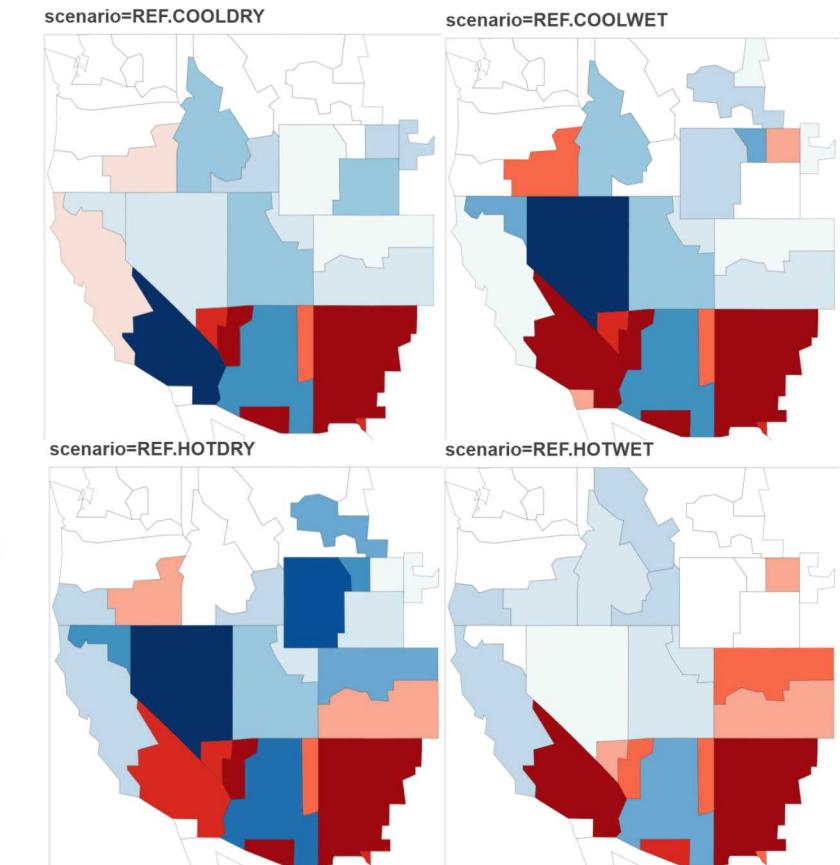
## Implications for Future Water Use



Source: Tidwell et al 2020



Combined influence of climate and water availability influence siting decisions



1. Energy-Water-Climate issues are affecting energy production today.
2. Without attention these issues will intensify.
3. Changes in the energy and water sectors are mitigating some climate vulnerabilities.
4. Options are available to adapt to a changing and uncertain future.

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Sandia National Laboratories

## Energy and Climate

RENEWABLE SYSTEMS CLIMATE/ENVIRONMENT ENERGY INFRASTRUCTURE ENERGY RESEARCH ABOUT EC

Energy and Climate • Climate/Environment • Water Security Program • Energy and Water in the Western and Texas Interconnects

# Energy and Water in the Western and Texas Interconnects

Background Objectives Tasks Benefits/Outcomes Collaborators Links Documents Data Portal

### Water Scarcity Impacts Energy Production

In the United States the energy sector accounts for approximately 41% of daily fresh water withdrawals and 49% of total overall daily water withdrawals for the following energy-related uses:

- Hydroelectric power generation
- Thermoelectric power plant cooling and air emissions control
- Energy-resource extraction, refining, and processing



The Energy Information Administration projects the U.S. population will grow by **70 million people** between 2005 and 2030, increasing electric power demand by **50 percent** and transportation fuel demand by **30 percent**. This will require more water. Unfortunately, this growth in water demand is occurring at a time when the nation's fresh water supplies are seeing increasing stress from:

- Limitations of surface-water storage capacity
- Increasing depletion and degradation of ground water supplies
- Increasing demands for the use of surface water for in-stream ecological and environmental uses
- Uncertainty about the impact of climate variability on future water fresh surface and ground water resources

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### WATER SECURITY PROGRAM

- Water Infrastructure Security
- Water, Energy, and Natural Resources
- Energy and Water in the Western and Texas Interconnects**
  - Energy and Water Data Portal
  - Electric Power Generation and Water Use Data
  - Water Availability, Cost, and Use

### ENERGY-WATER DATA PORTAL



Last Updated: August 7, 2014

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