

# Energy-Water Nexus



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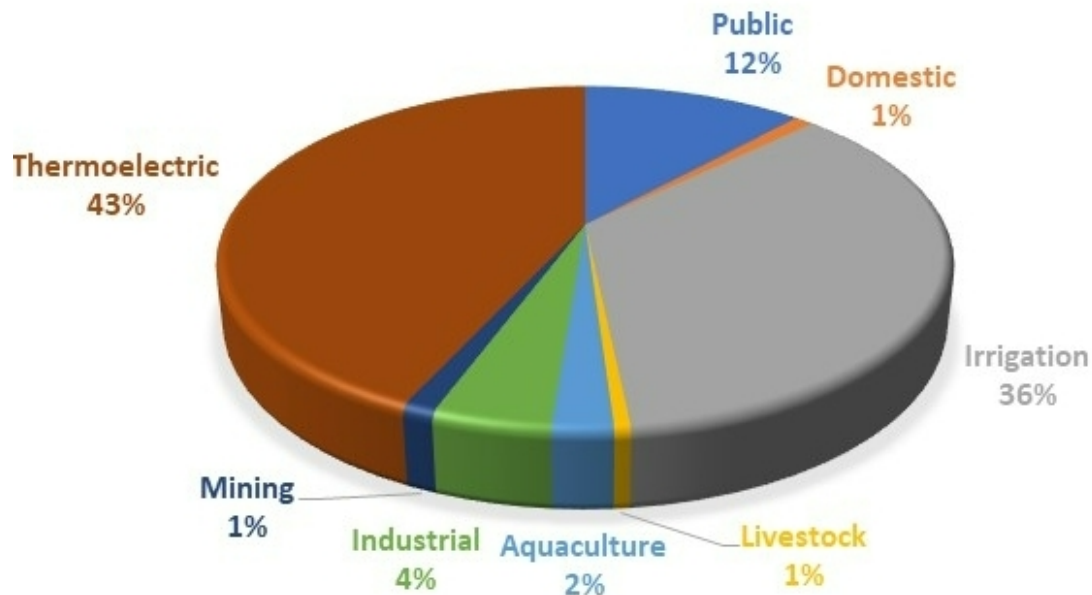
*Vincent Tidwell*  
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Intelligent Water Workshop and Conference  
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# Water Use in the Energy Sector

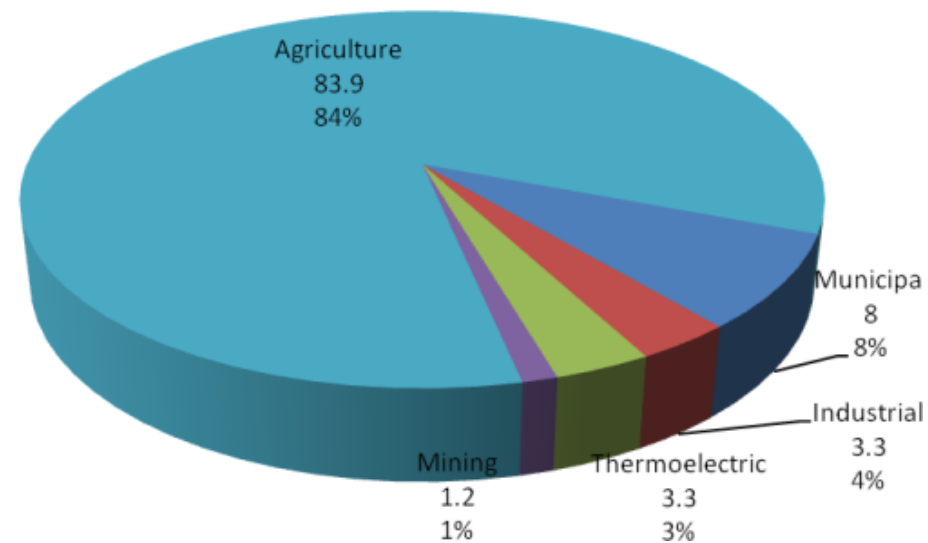
2015 WATER WITHDRAWALS



Source: USGS 2018

322 BGD Total Withdrawals

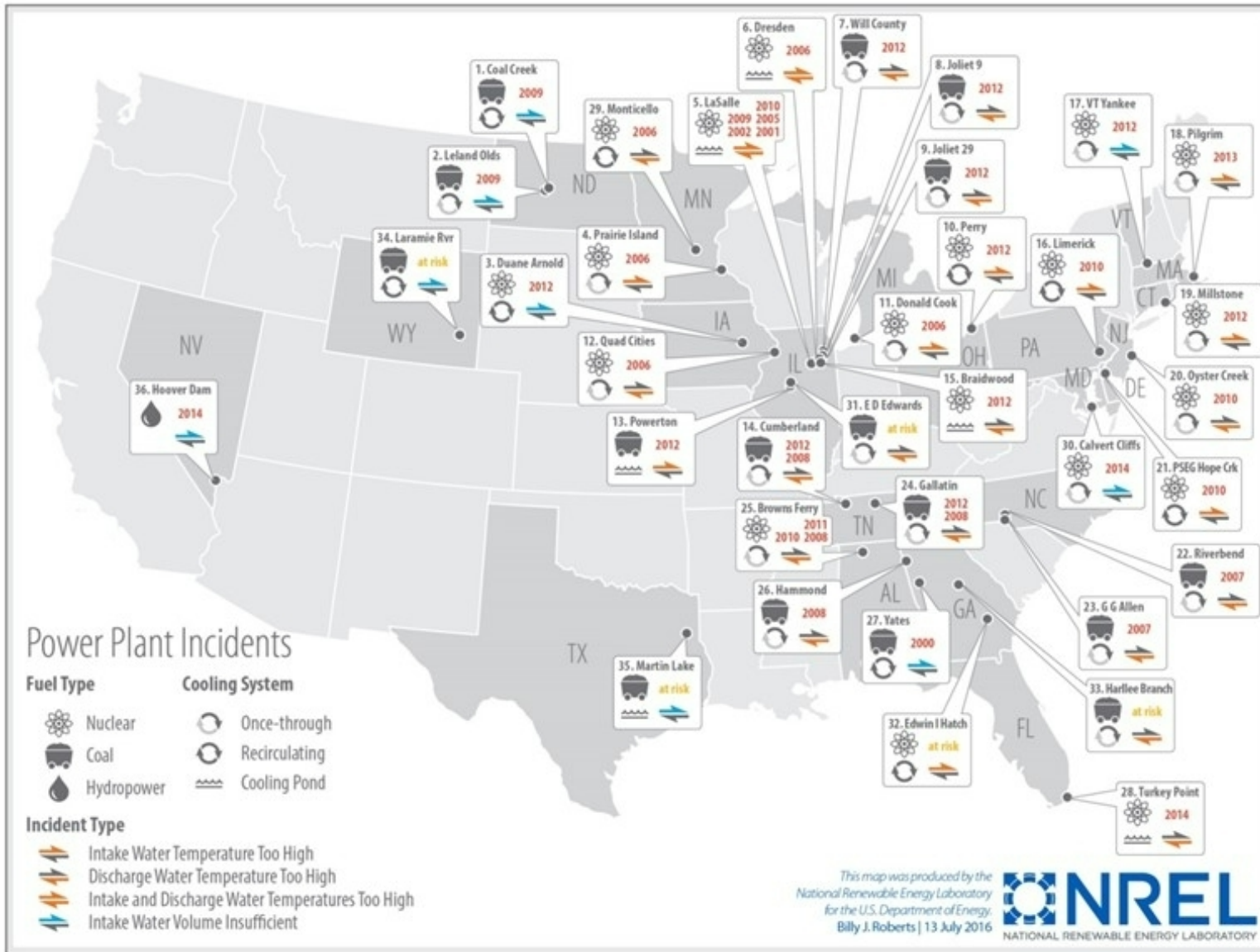
1995 Water Consumption



Source: USGS 1998

4.3 BGD Thermoelectric (USGS 2018)  
2.6 BGD Mining and Fuel Processing (DOE 2014)

# Impacts Today



Water Extremes have impacted:

- Power plant operations (shown here),
- Hydropower operations,
- Impacted energy extraction, and
- Damaged production, transmission and processing facilities



# Impacts Today

The Availability,  
Reliability and Cost  
of Water is  
Impacting the Siting  
of New Power  
Generation



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6/20/2019

## State denies permit to Burrillville power plant

BURRILLVILLE – In a gripping decision that followed several years of debate, the state Energy Facility Siting Board today denied an application by Chicago-based Invenery to build an oil-and-gas-burning power plant off 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 the 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 been fighting the plant's impact on the environment for years. The decision was a victory for conservationists and local residents, many of whom had been fighting the plant's impact on the environment for years.



CENTER for BIOLOGICAL DIVERSITY

Because life is good.

For Immediate Release, February 9, 2009  
Contact: Amy Ahvood, Center for Biological Diversity, (541) 914-6372

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### Statement on NV Energy Inc.'s Abandonment of Plans to Construct Coal-Fired Power Plant in Eastern Nevada

LAS VEGAS, Nev. — The Center for Biological Diversity is celebrating NV Energy Inc.'s announcement today that it will abandon original plans to construct the Ely Energy Center, a coal-fired power plant in eastern Nevada. Citing growing environmental and economic concerns, the company stated that the project has been postponed until greenhouse gas capture and storage capture 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 Ahvood, public lands energy director at the Center for Biological Diversity. "The Obama administration should take swift action to halt regulatory approvals for other 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 global warming."

Ely Energy Center, which would have been located about 20 miles north of Ely in White Pine County, Nevada, would have consisted of two coal-fired 750-megawatt (MW) ultra-supercritical steam turbine units, two 500-MW integrated gasification combined cycle units, and associated facilities. The Center would have had a 2,500-MW generating capacity and an estimated lifespan of 50 years.

Ely Energy Center would consume approximately 8,000 acre-feet of water per year during the first phase alone, compromising the viability of local threatened and endangered species while contributing an estimated 10 million tons of CO<sub>2</sub> to the atmosphere every year. Additional greenhouse gas emissions 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 Ely Energy Center are halted or withdrawn.

The Center for Biological Diversity is dedicated to ensuring that atmospheric CO<sub>2</sub> pollutant levels are reduced to below 350 ppm, which leading climate scientists warn is necessary to prevent devastating climate change. Further development of greenhouse gas-intensive energy sources, including oil shale, tar sands, and coal-fired power plants, is fundamentally incompatible with achieving this goal. If greenhouse gas emissions are not immediately reduced, the current atmospheric CO<sub>2</sub> level of 385 ppm will rise to approximately 500 ppm by mid-century, triggering mass wildlife extinctions, catastrophic global weather and ecosystem changes, and tragic human suffering.

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## Idaho Places Moratorium on Coal-Fired Power Plants

May 24, 2006

Idaho has established a two-year moratorium on the construction of most types of coal-fired power plants. Idaho is the only Western state currently without any coal-fired power plants, but will make such construction unlikely at least for the next two years or until the Idaho legislature, through the [Idaho Interim Committee on Energy, Environment, and Technology](#), develops a comprehensive state energy plan.

The legislation was inspired in part by a controversial plan by California-based [Semptra Generation](#) to build a 600 mega-watt plant in Jerome County, approximately 120 miles southeast of Boise. Following the Senate's passage of [H. 791](#), Semptra announced that it would end efforts to construct the Jerome County project and a similar project in northern Nevada. Craig D. Rose, [Nevada, Idaho Projects Run Into Stiff Opposition](#), San Diego Union Tribune (March 30, 2006). In a letter to Idaho Governor Kempthorne, Semptra stated that it withdrew from the Idaho project because it was focusing on its natural gas related business. *Id.* Semptra plans on seeking buyers for the development work it has already done at the sites. *Id.*

Introduced by House Speaker Bruce Newcomb (R), [H. 791](#) was passed by the Idaho House on a 65-4-1 vote on March 21, 2006, and by the Senate on a 30-5 vote eight days later. Rebecca Mooney, [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 Interim

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## 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 company to use groundwater to cool the nuclear power plant west of Phoenix because the water is being used by nearby residents, officials said.

The state Department of Water Resources denied the request from Arizona Public Service Company to use groundwater in the Buckeye area and study it as an alternative to expensive reclaimed water because it is being used, The Arizona Republic [reported](#) Monday.

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 that this objection provides a valid reason to deny the application," officials said in the rejection letter.

# Water-Energy Nexus

- 2014 report kicked-off coordinated effort to address the Water-Energy Nexus
- Nature of program has evolved over the past three administrations
- Identified need for advanced technology, data, modeling and analysis to address the impacts of changing climate, population, policies and technologies on the Nexus

## The Water-Energy Nexus:

Challenges and Opportunities

June 2014



# Integrated Multi-Sector, Multi-Scale Modeling



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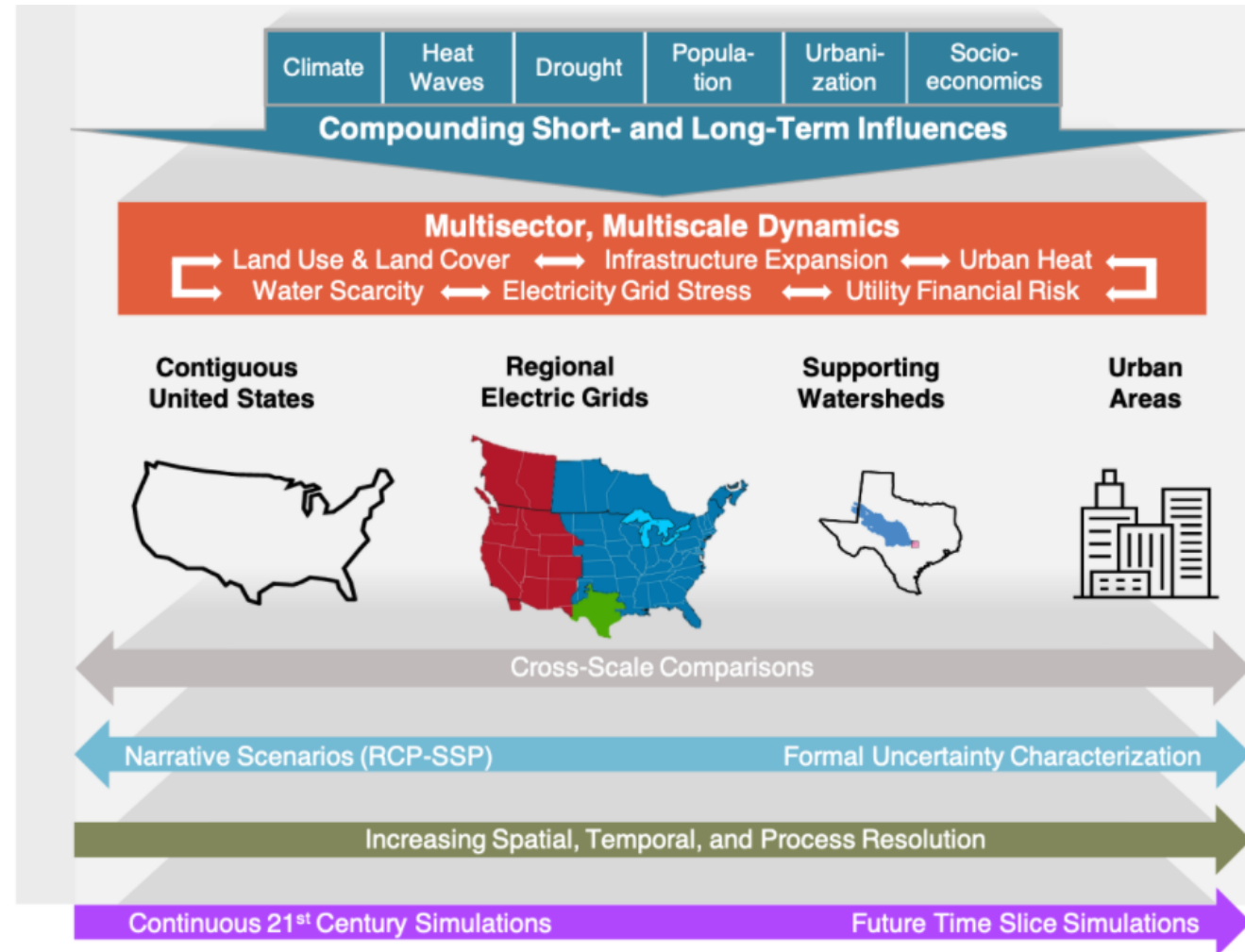
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Cornell University

## Technical Challenge

- How will changes in extreme weather, economic development and other related stresses affect the performance and reliability of coupled energy-water systems? How best do we adapt to these changes?
- How do different model configurations, levels of complexity, multi-model coupling strategies, and spatiotemporal resolutions influence simulation fidelity and the propagation of uncertainties?

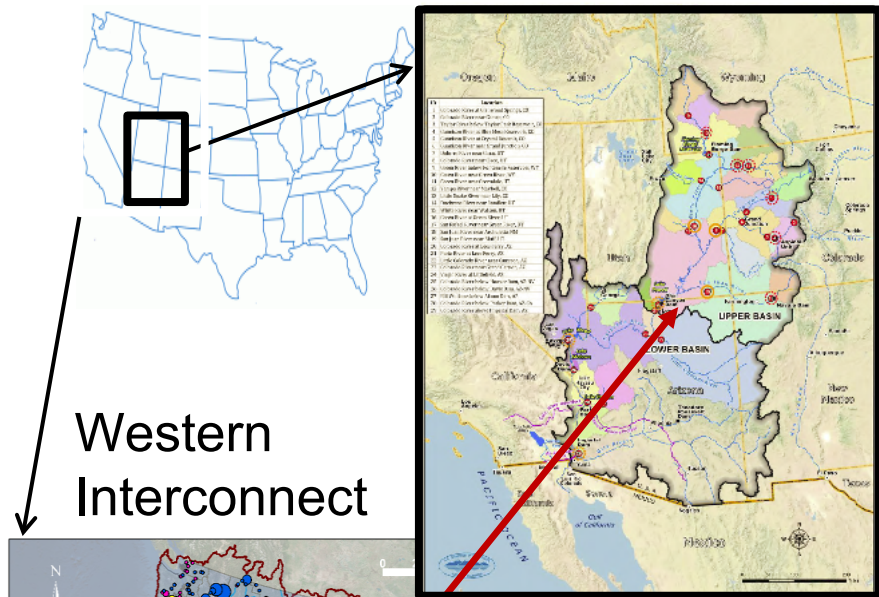




# Water Shortage and Scale

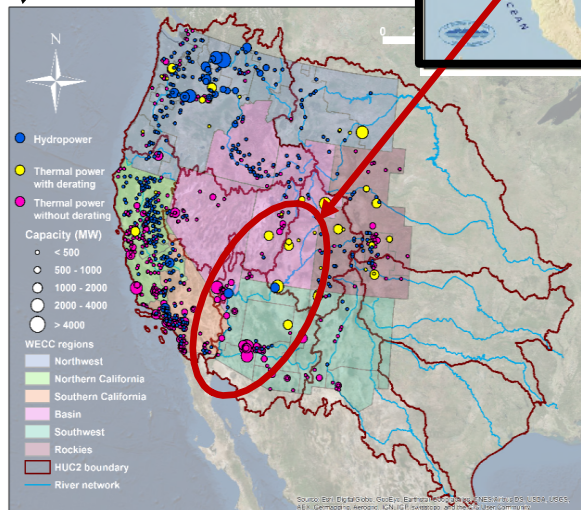
## Colorado River Basin

- How is water shortage impacted by changing climate conditions?
- How sensitive are estimates of water shortage to the scale and purpose of model?



Western Interconnect

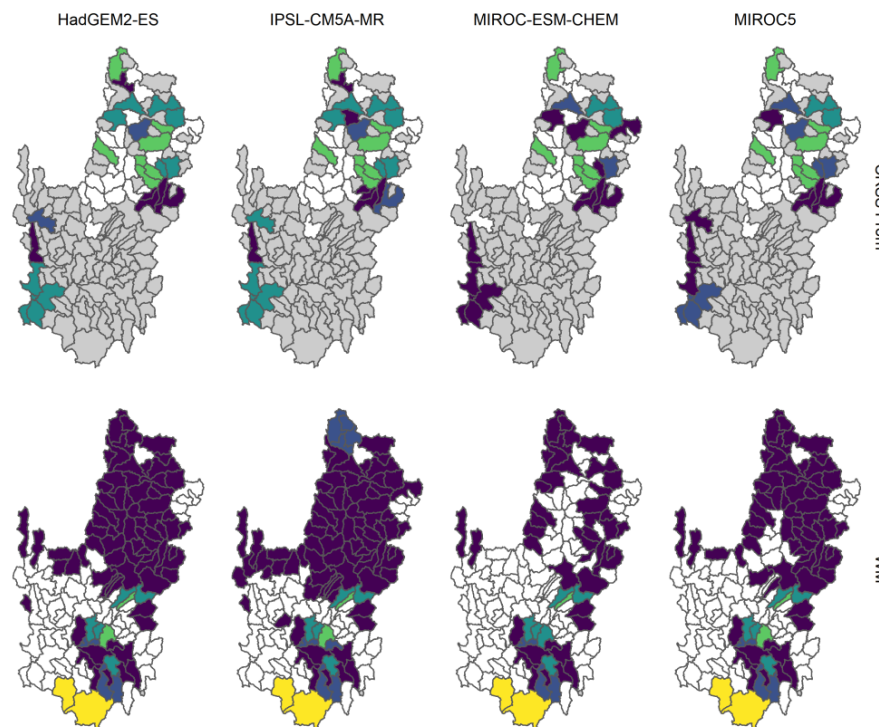
RiverWare



MOSART-WM

shortage ratio

No data	>0 - 0.05	0.1 - 0.25	>0.5
0	0.05 - 0.1	0.25 - 0.5	

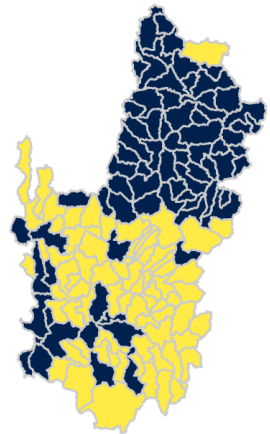


Comparison of average water shortage CRSS (top) WM (below) for four future climate scenarios (2060)

# Water Shortage and Scale

## Models are fundamentally different—and thus yield different results

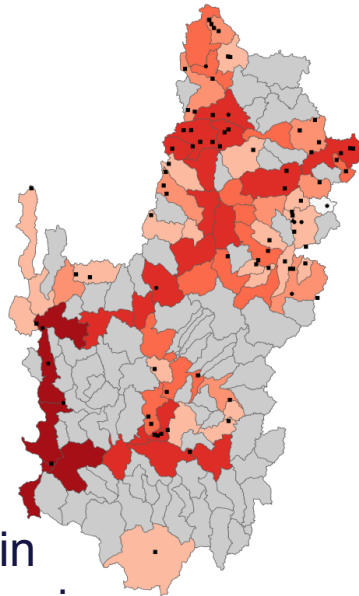
Common WM Only



Difference in basin representation

Cumulative reservoir storage (acre-feet)

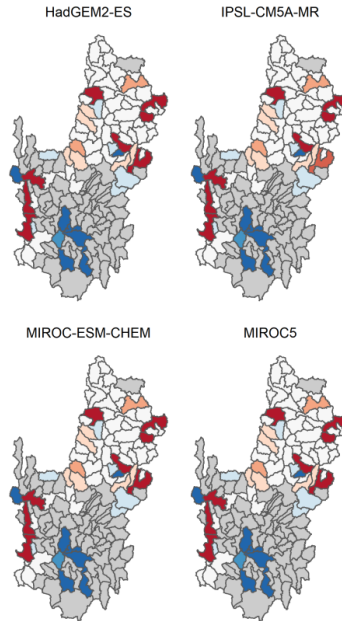
Model: Both CRSS only WM only



Difference in operated reservoirs

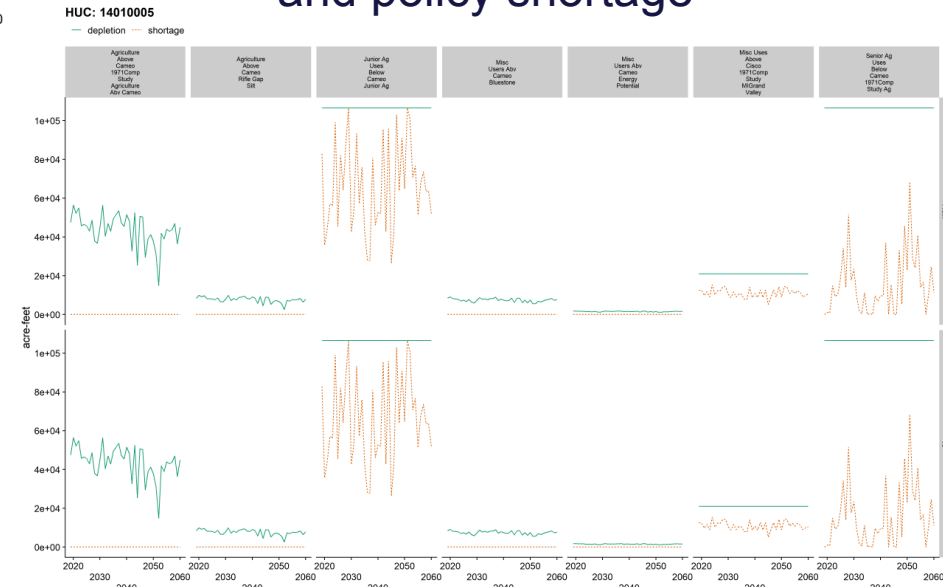
net depletion (acre-feet)

No data <-100,000 -100,000 -50,000 -50,000 -10,000 -10,000 -0 -0 >0 -25,000 25,000 -50,000 50,000 -100,000 >100,000



Difference in treatment of inter- and intra-basin transfers that account for roughly 30% of demand

Difference in evaluation of water scarcity in terms of physical shortage and policy shortage



Both models subject to critical limitations—understanding limitations required to interpret results



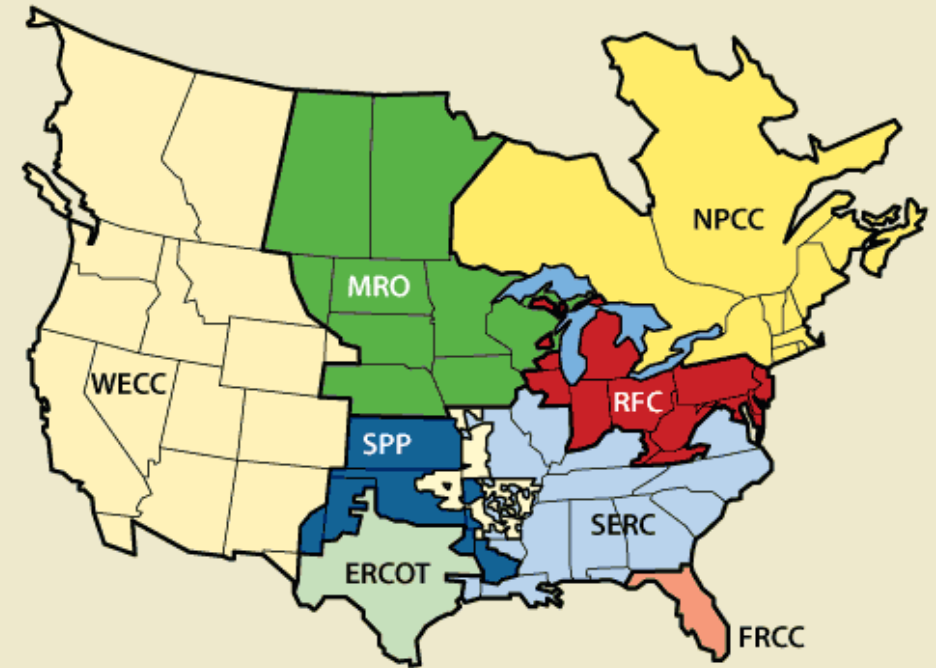
# Water and Electric Sector Planning



## Technical Challenge

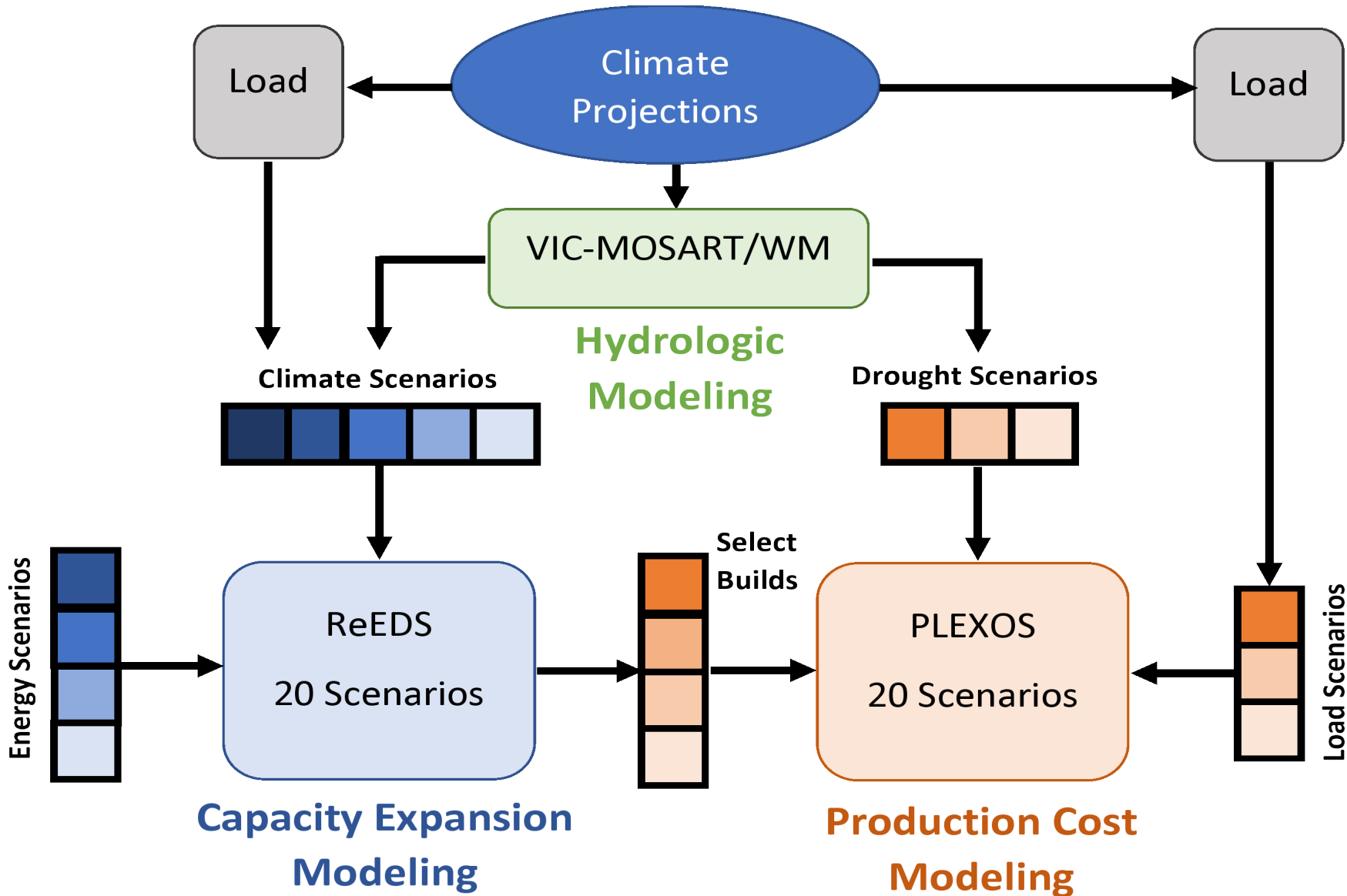
- What potential risks to the reliability of the Bulk Electric System in the Western Interconnection would result through changes to the climate, and how would those changes impact the electrical reliability of the Western Interconnection?

## The North American Electric Reliability Corporation Regions



Source: North American Energy Reliability Corporation.

# Multi-Model Energy-Water Modeling Platform



# Infrastructure and Climate Scenarios

Infrastructure expansion scenarios vary the possible future generation mix

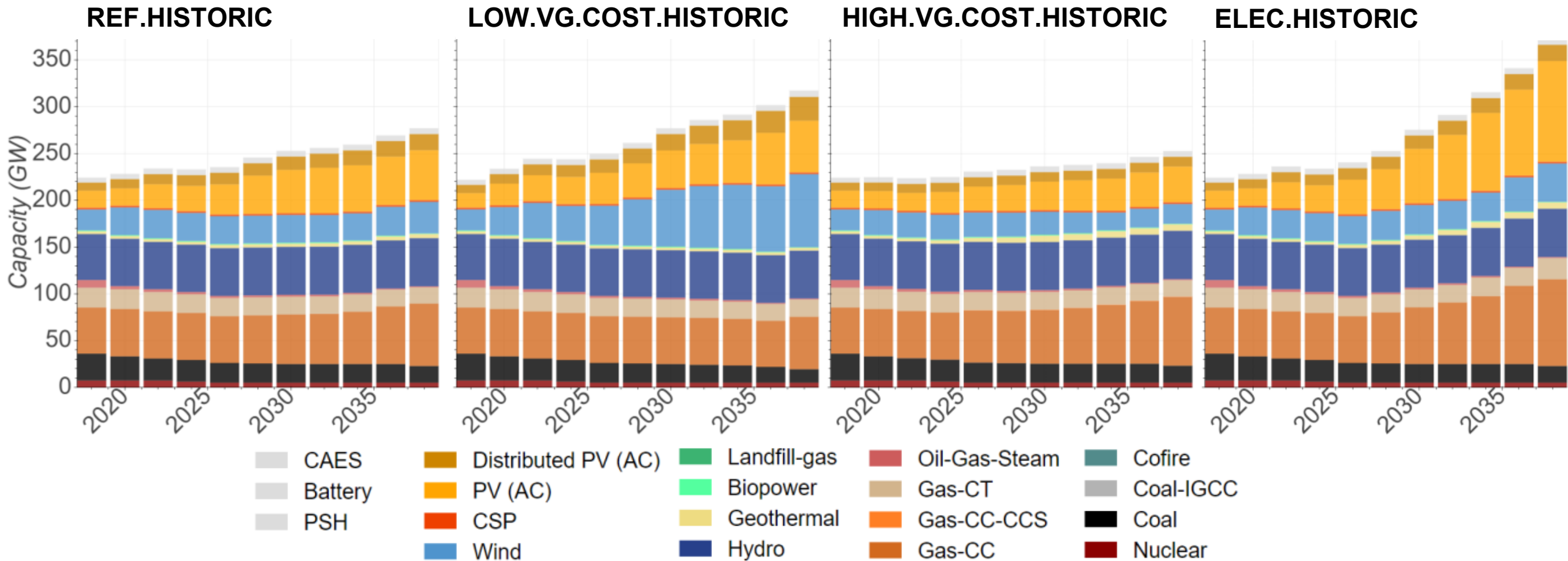
1. **REF**: default ReEDS v2018 assumptions
2. **LOW.VG.COST**: NREL ATB 2018 Low Cost case for wind and solar
3. **HIGH.VG.COST**: NREL ATB 2018 High Cost case for wind and solar
4. **ELEC**: NREL Electrification Futures High Technology Adoption, Moderate Technology Advancement case with moderate demand flexibility (in review)

Climate scenarios bound future temperature and precipitation

1. **HISTORIC**: Static historical climate conditions
2. **IPSL85**: Uses data from the IPSL climate model under RCP8.5 conditions
3. **MIROC85**: Uses data from the Miroc climate model under RCP8.5 conditions
4. **IPSL45**: Uses data from the IPSL climate model under RCP4.5 conditions
5. **GFDL45**: Uses data from the GFDL climate model under RCP4.5 conditions

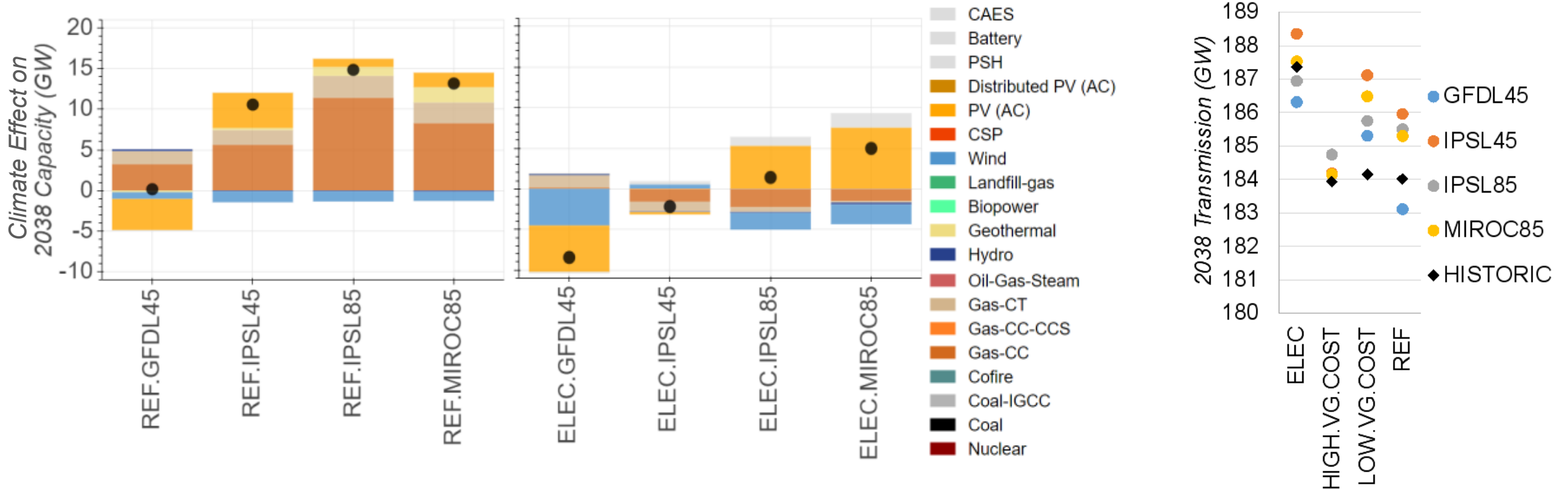


# Future Expansion Trends



- New deployment in these scenarios is primarily a combination of PV, wind, and natural gas
- The relative competitiveness of technologies depends on assumed technology costs and demand

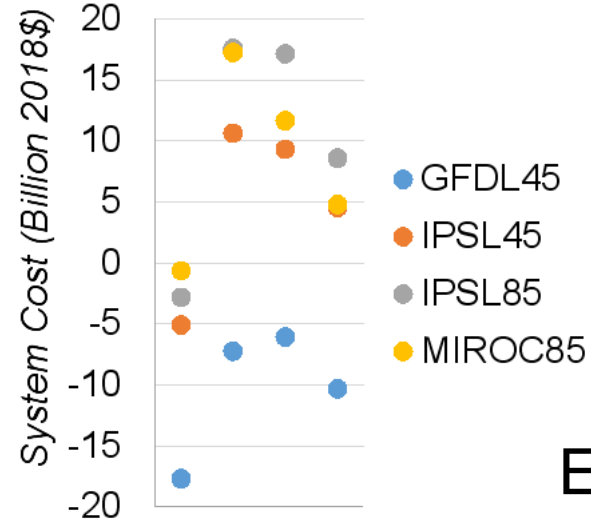
# Changes in Climate Impact Generation and Transmission Investment Decisions



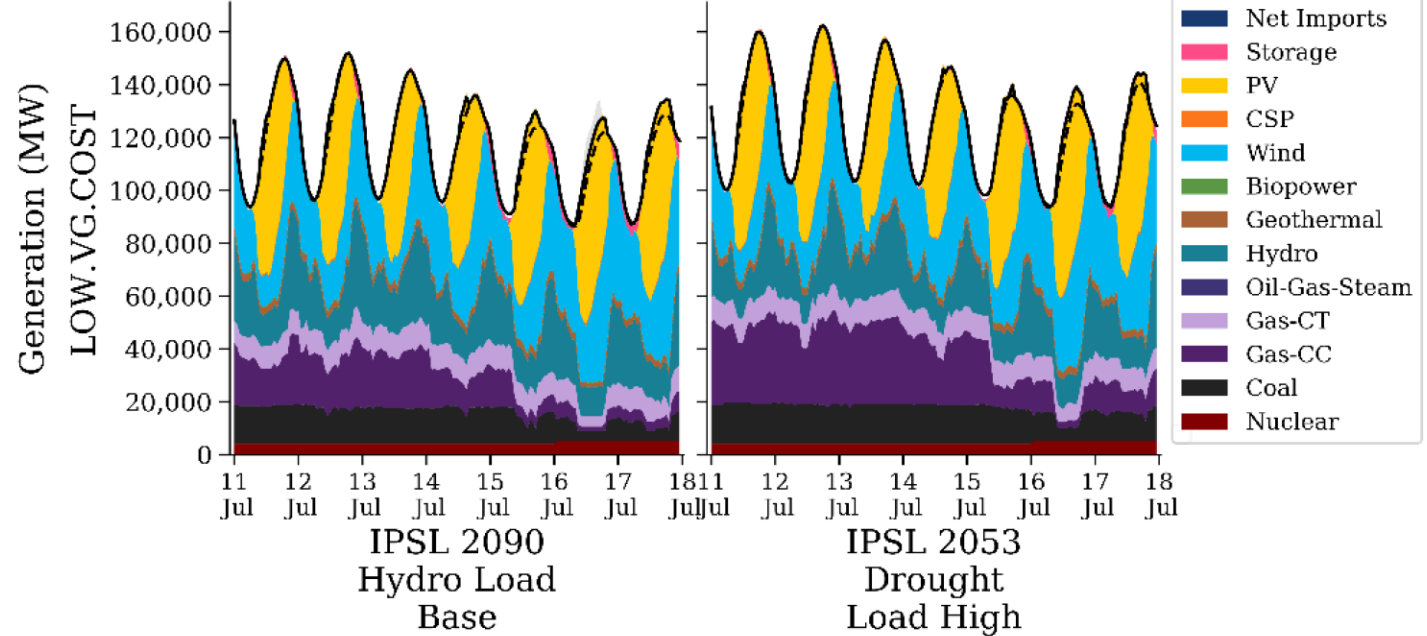
- Climate change primarily affects PV and gas capacity, with up to a 7% increase in total 2038 capacity
- Hotter climate requires more total capacity
- Wetter climate can reduce capacity needs with additional hydropower generation
- Electrification can reduce capacity needs through flexible demand
- Higher generation capacity typically leads to more transmission capacity

# Climate Impacts System Performance

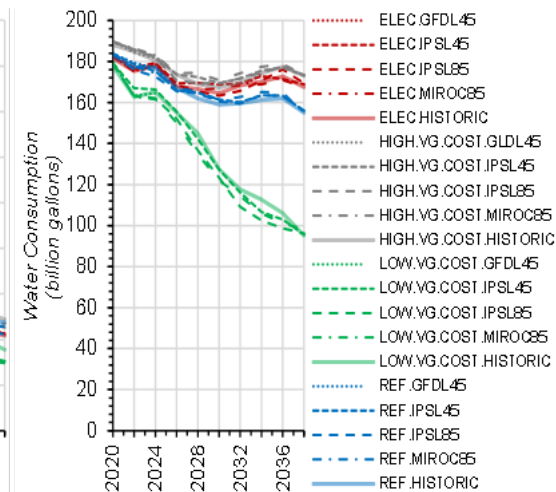
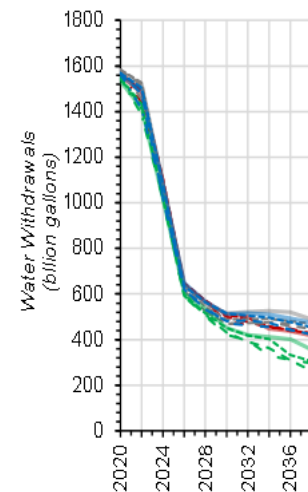
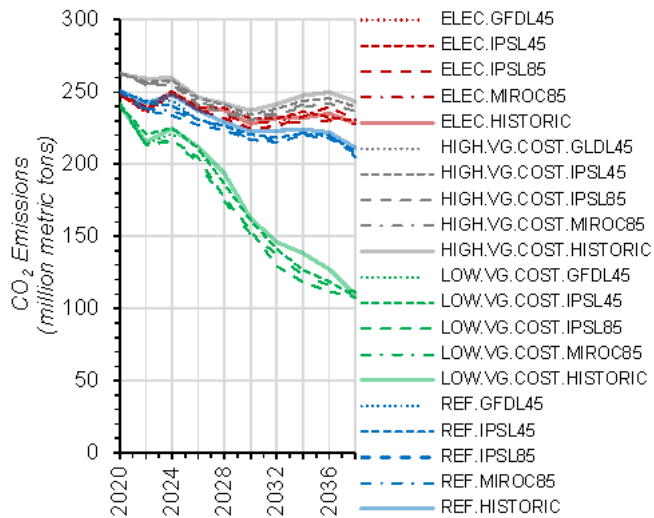
## System Costs



## Unserved Load and Reserve Margins



## Emissions



## Water Withdrawals and Consumption

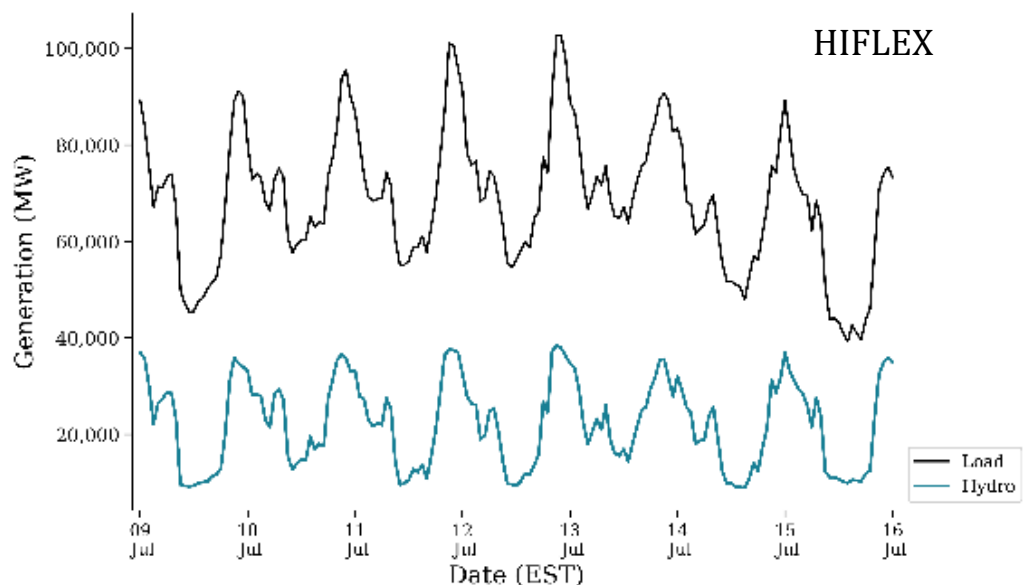
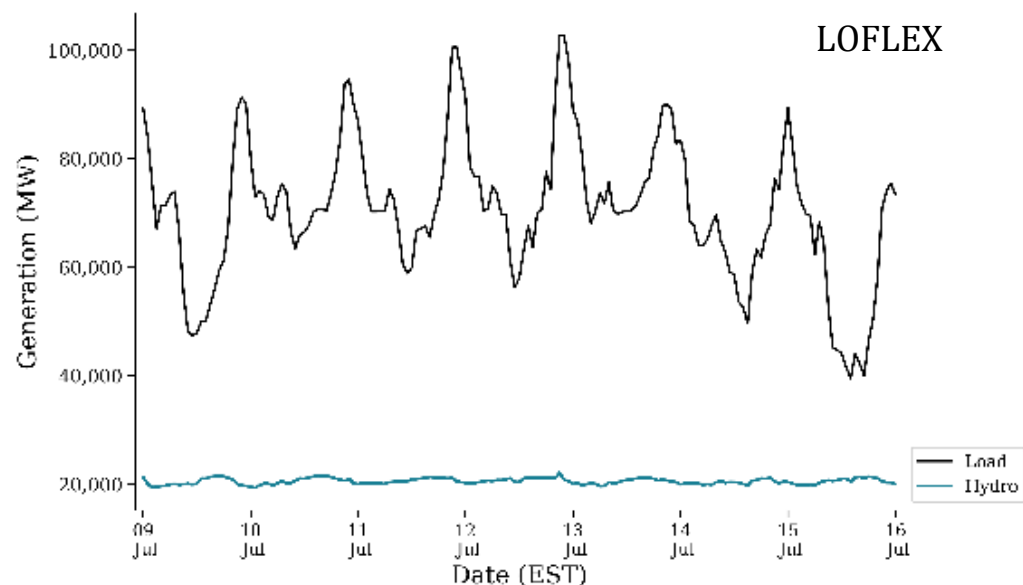


# Climate Impacts on Hydropower Dispatch

Scenarios represent bounding cases of increased (HIFLEX) or decreased (LOFLEX) flexibility of the dispatchable (non-run-of-river) hydropower fleet.

**HIFLEX:** Dispatchable hydropower can vary power output from zero to its maximum rated capacity at any time of the year.

**LOFLEX:** Dispatchable hydropower produces constant output across a representative season (ReEDS) or month (PLEXOS) within energy limits.



Net load and hydro dispatch for LOW.VG.COST in PLEXOS, showing impact of hydropower flexibility on hourly dispatch.

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Sandia National Laboratories

Energy and Climate

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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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Last Updated: August 7, 2014

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- Water, Energy, and Natural Resource Systems
- Energy and Water in the Western and Texas Interconnects
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