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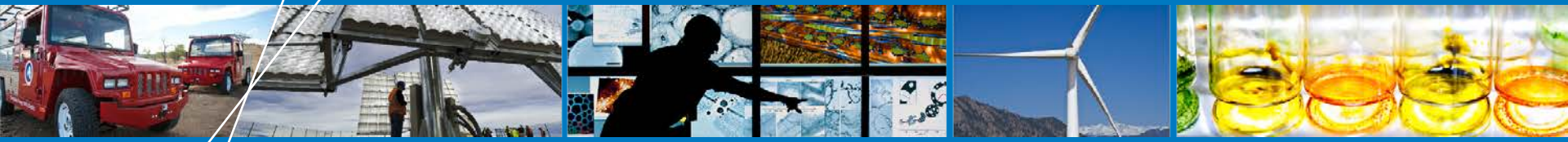
Water Impacts of the Electricity Sector



American Solar Energy Society

World Renewable Energy Forum

Jordan Macknick

May 14, 2012

NREL/PR-6A20-55028

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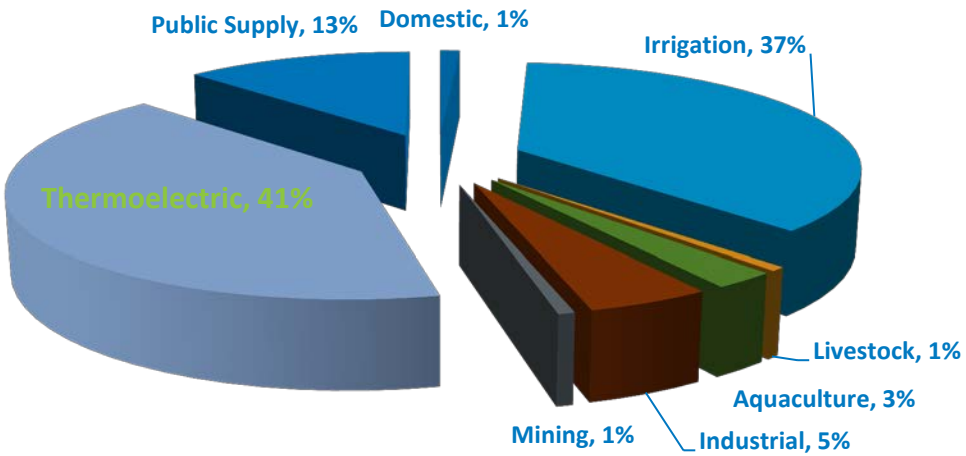
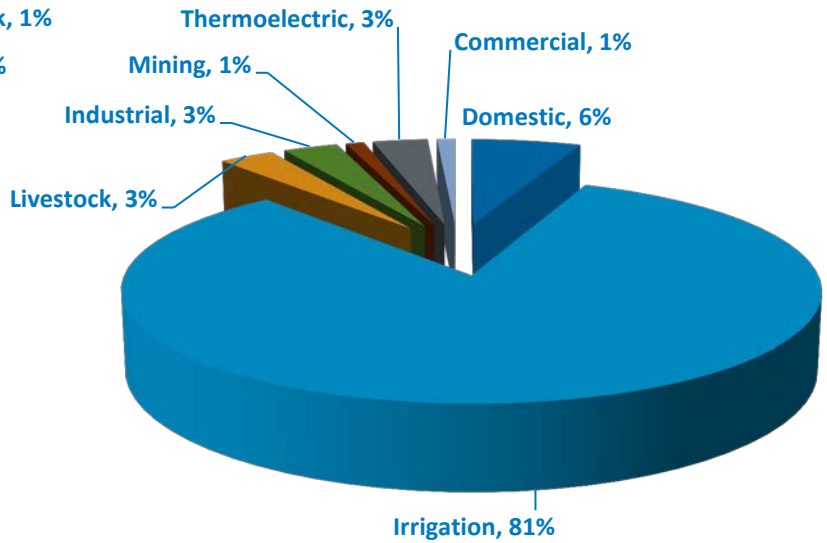
This work was supported by the U.S. Department of Energy under Contract No. DE-AC36-08-GO28308 with the National Renewable Energy Laboratory.

Nationally, the electricity sector is a major end-user of water

U.S. Freshwater Withdrawal[1]



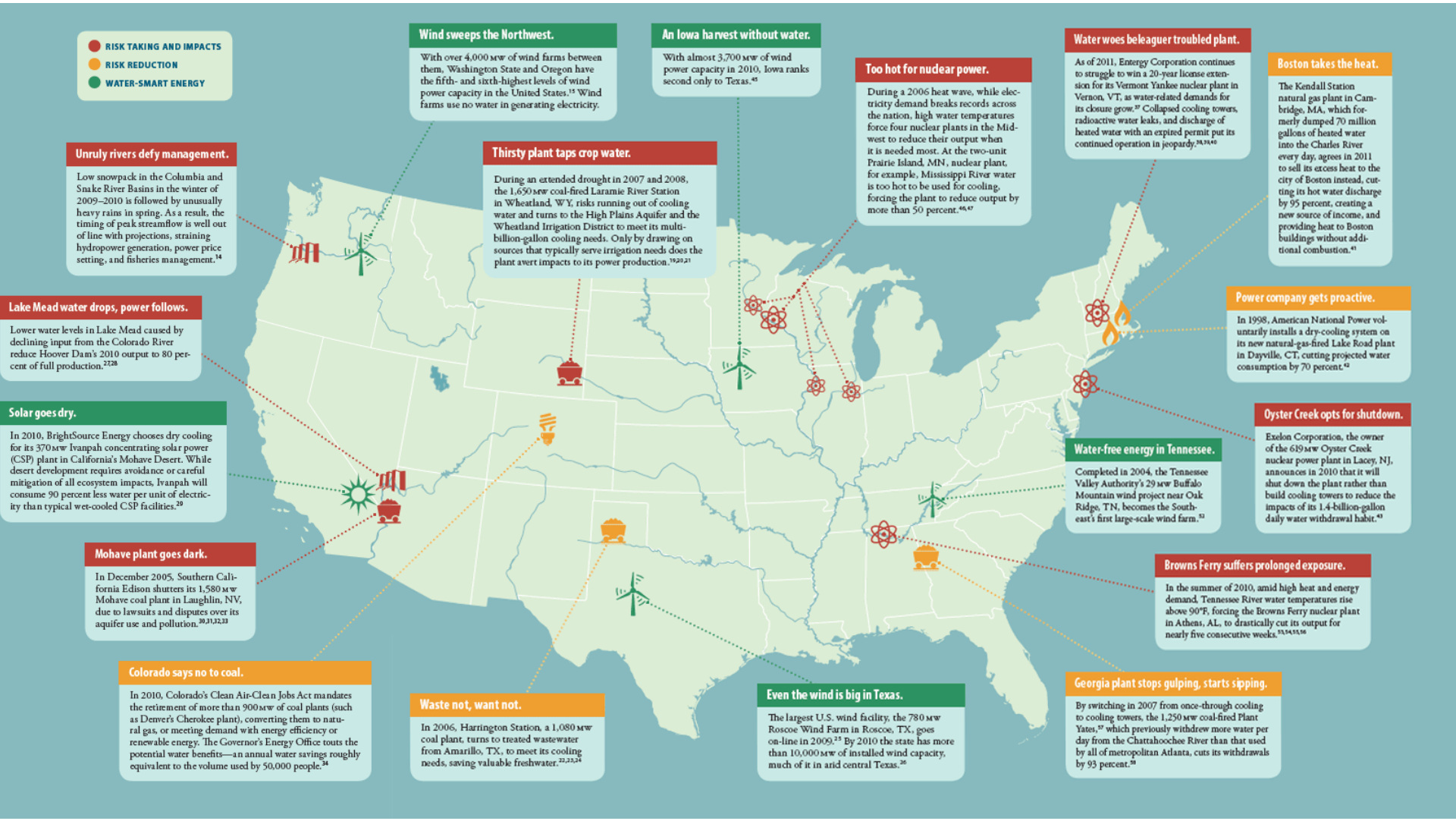
U.S. Freshwater Consumption[2]



- **2005 Thermoelectric water requirements (USGS):**
  - **Withdrawal: ~ 143 BGD (41%)**
  - **Consumption: ~ 4 BGD (3%)**

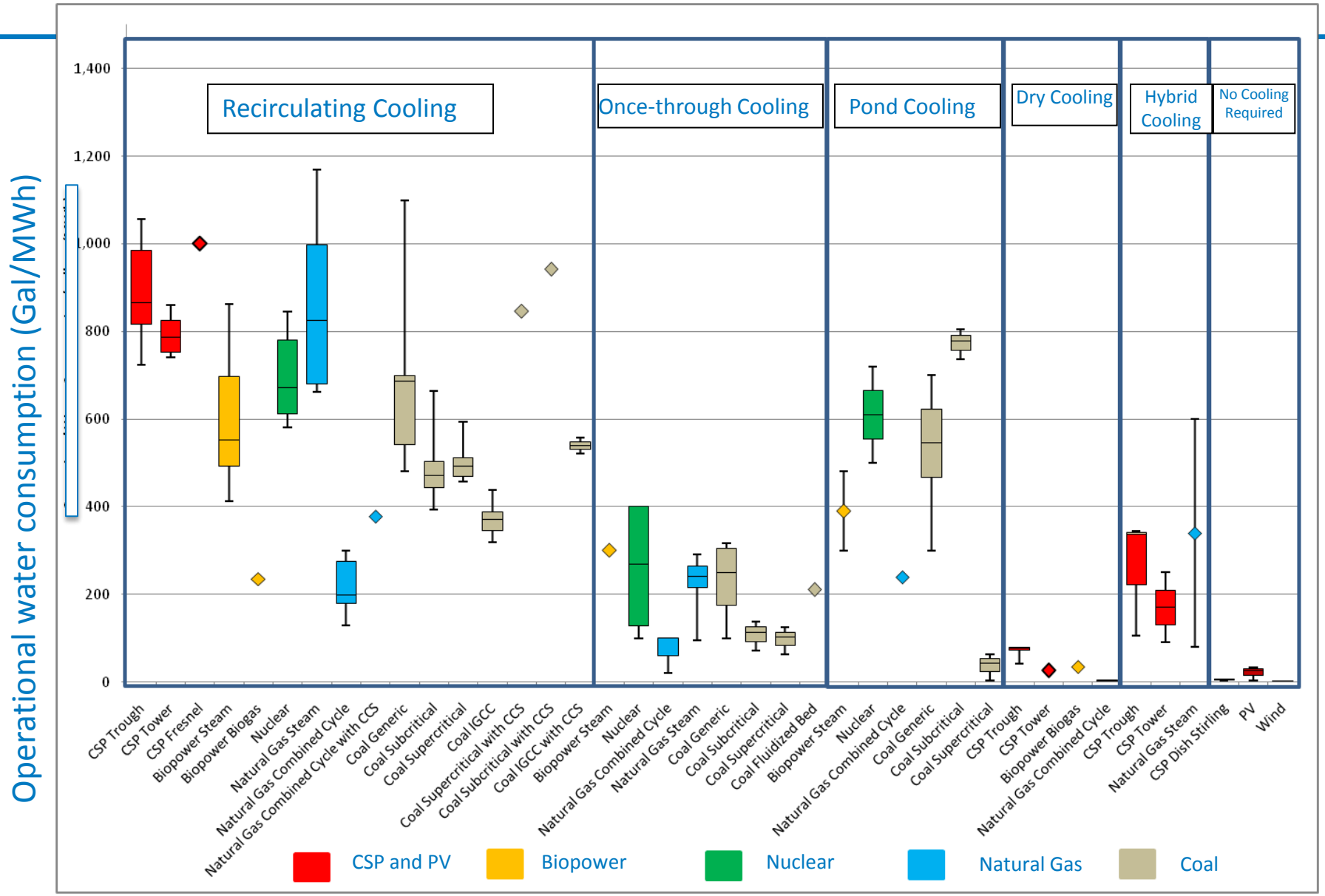
Sources: [1]USGS, Estimated Use of Water in the United States in 2005, USGS Circular 1344, 2009
[2]USGS, Estimated Use of Water in the United States in 1995, USGS Circular 1200, 1998

Water issues affect power plants throughout the nation



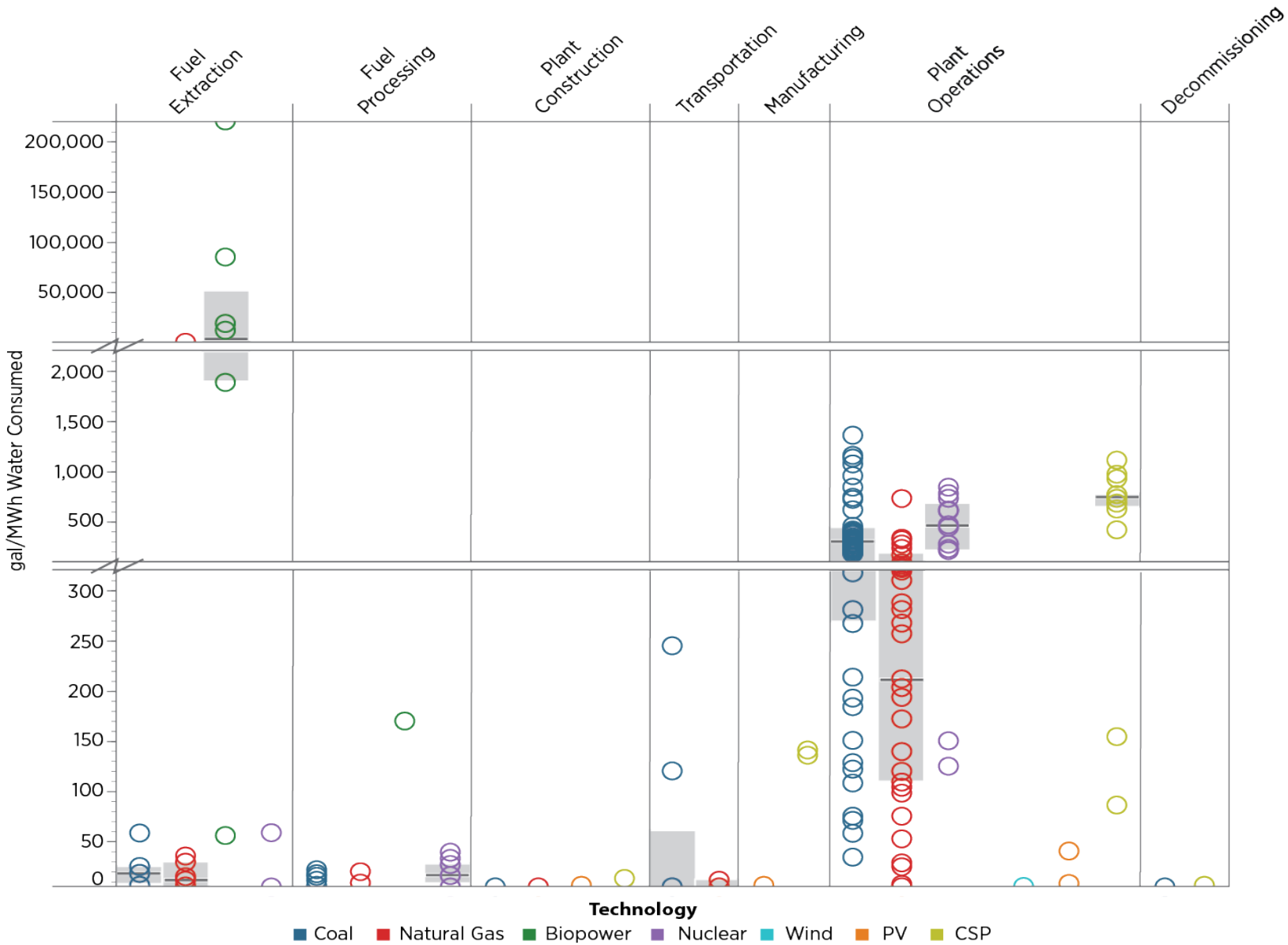
Source: Union of Concerned Scientists. "The Energy-Water Collision: Power and Water at Risk." Fact Sheet. June 2011.
http://www.ucsusa.org/assets/documents/clean_energy/ew3/power-and-water-at-risk-with-endnotes.pdf

Water consumption impacts for electricity generation technologies range widely



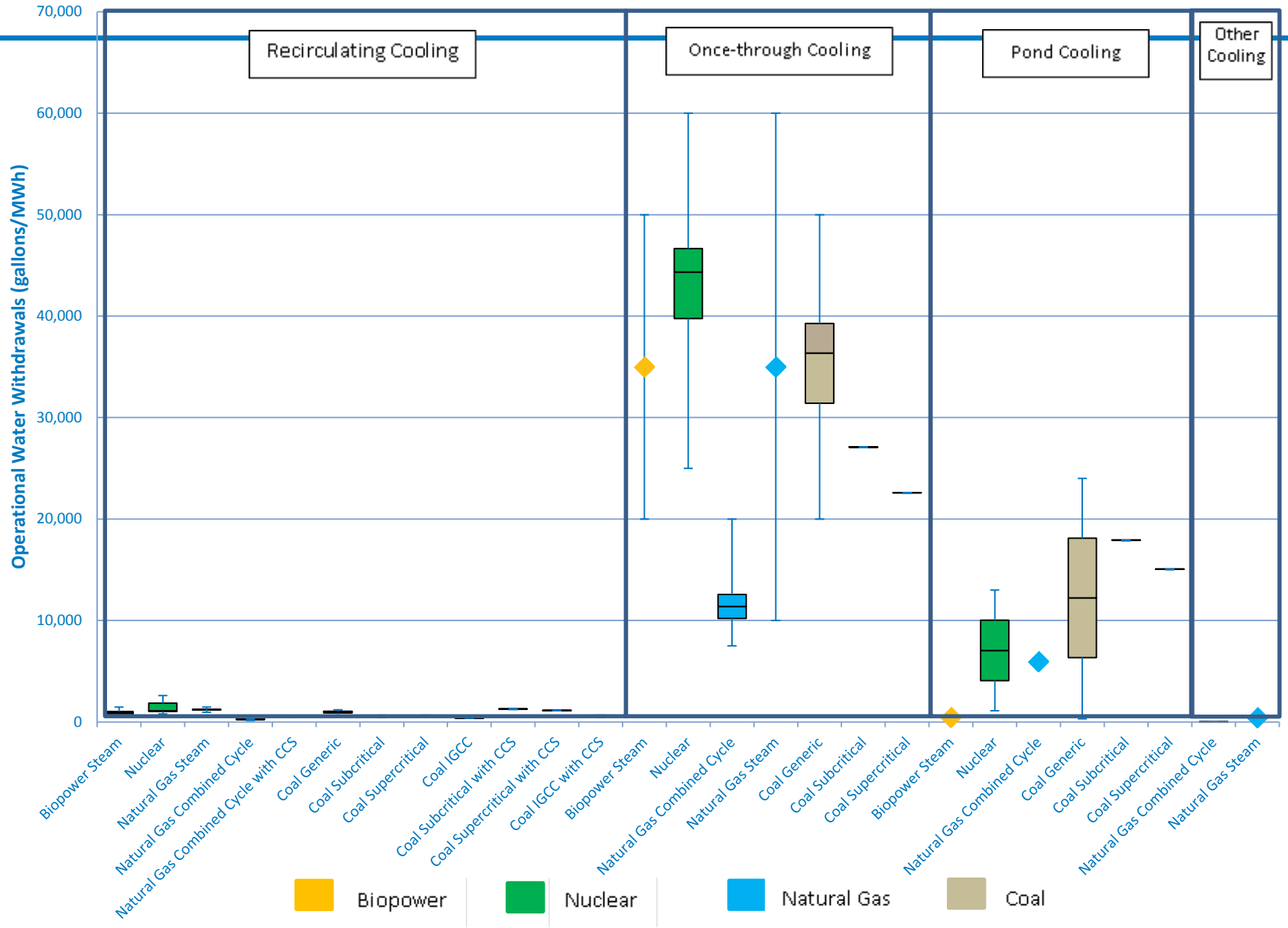
Source: Macknick, J., R. Newmark, G. Heath, and K. Hallett, 2011: A Review of Operational Water Consumption and Withdrawal Factors for Electricity Generating Technologies. *NREL Technical Report*, **NREL/TP-6A20-50900**

Life cycle water uses are dominated by operations



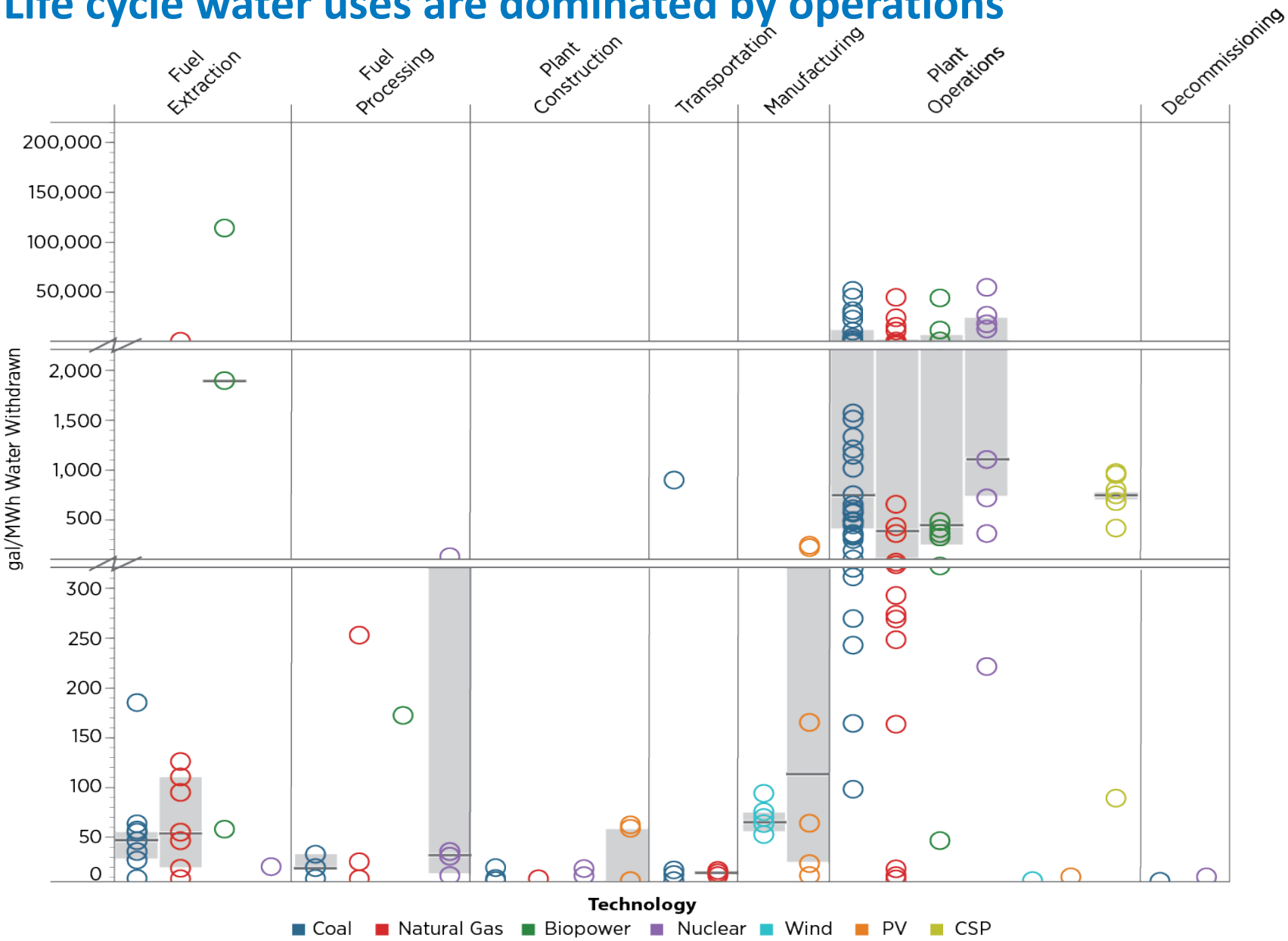
Source: Meldrum, J., Macknick, J., and G. Heath, 2012: Water use in energy technologies – A life cycle perspective. *NREL Technical Report for EPRI*, **NREL/TP-6A20-54044**

Water withdrawal impacts for electricity generation technologies range widely



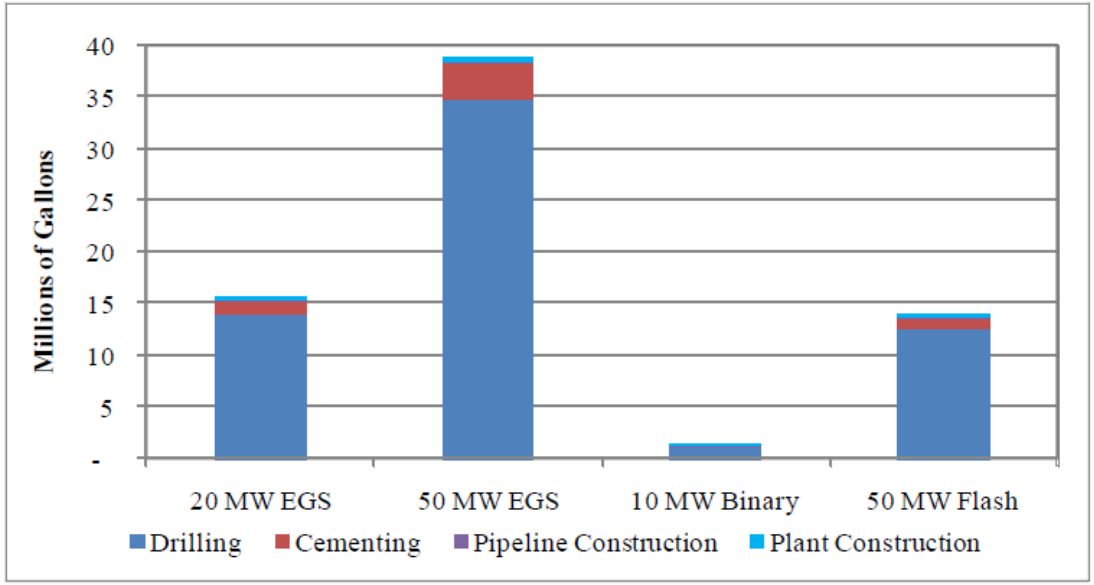
Source: Macknick, J., R. Newmark, G. Heath, and K. Hallett, 2011: A Review of Operational Water Consumption and Withdrawal Factors for Electricity Generating Technologies. *NREL Technical Report*, **NREL/TP-6A20-50900**

Life cycle water uses are dominated by operations



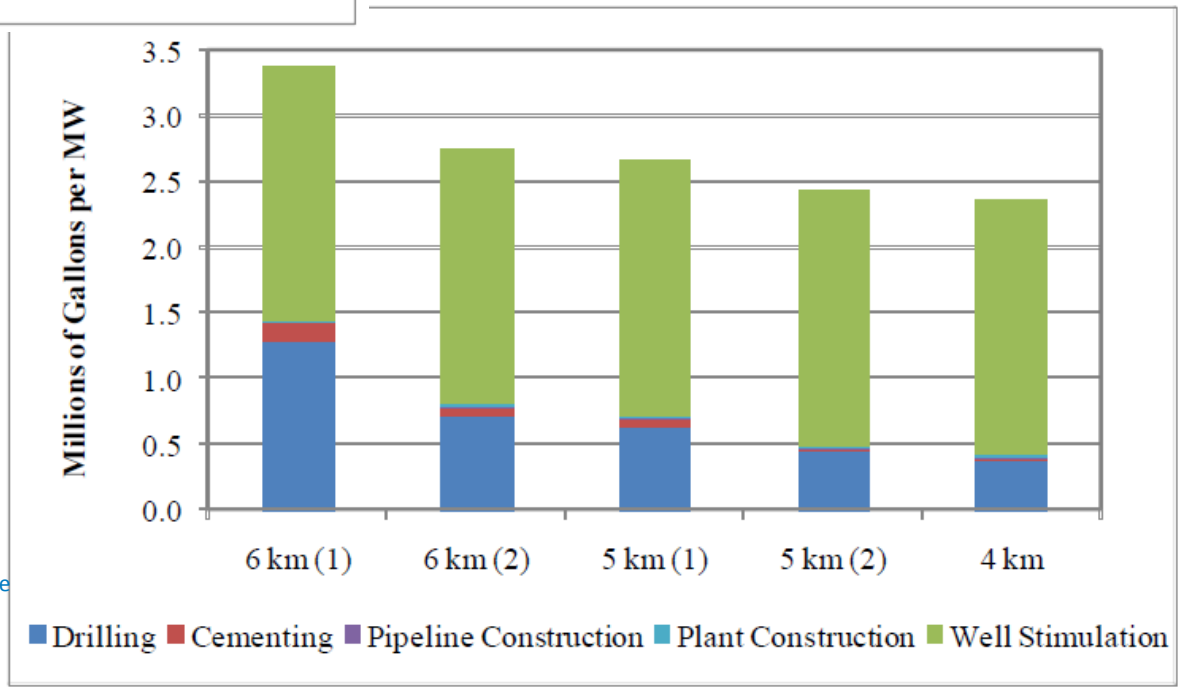
Source: Meldrum, J., Macknick, J., and G. Heath, 2012: Water use in energy technologies – A life cycle perspective. *NREL Technical Report for EPRI*, **NREL/TP-6A20-54044**

Water needed for geothermal fuel development differs by well depth and the number of wells drilled



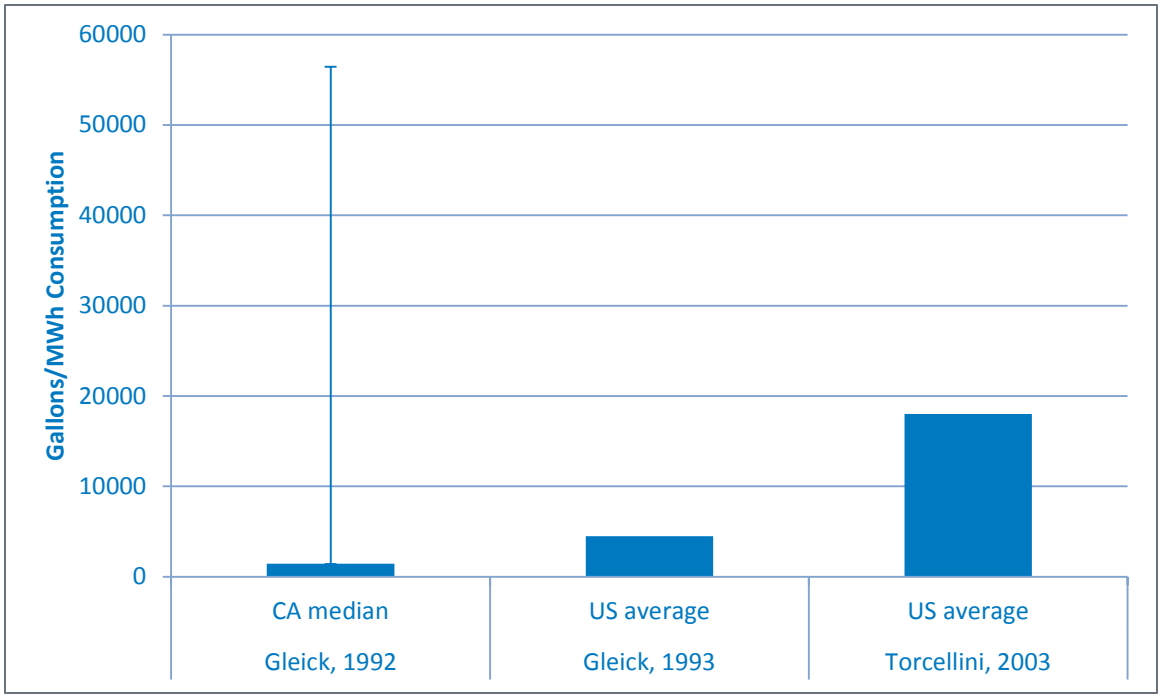
Depth of wells and the total number of wells is determined by resource and by technology used

Hydraulic stimulation water use per well can be greater than natural gas hydro-fracking water use per well



Source: Clark, C., C. Harto, J. Sullivan, and M. Wang, 2011: Water use in the development and operation of geothermal power plants. *Argonne National Laboratory Report* (ANL/EVS/R-10/5)

Hydropower Reservoir Evaporation Rates are Highly Variable and Site-Specific



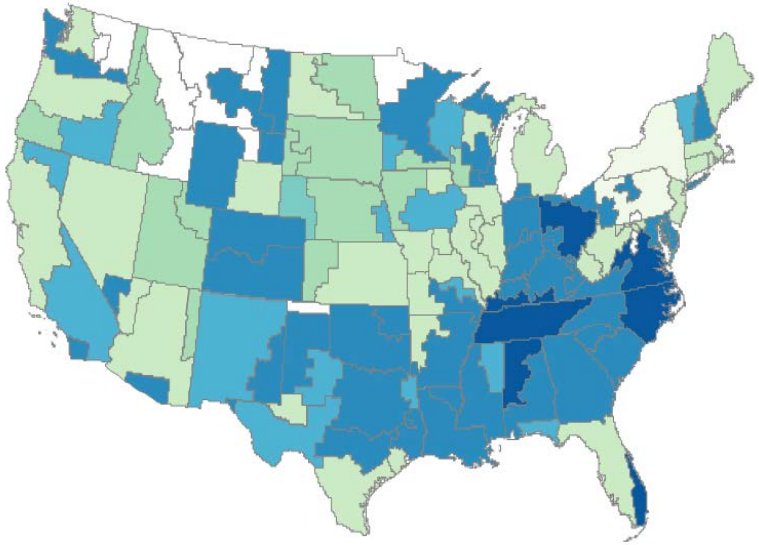
Some factors influencing reservoir evaporation include reservoir depth, temperature, shape, surface area, size of the river, and climatic conditions

Many reservoirs that generate hydropower have multiple uses, such as water supply, flood control, recreation, etc.

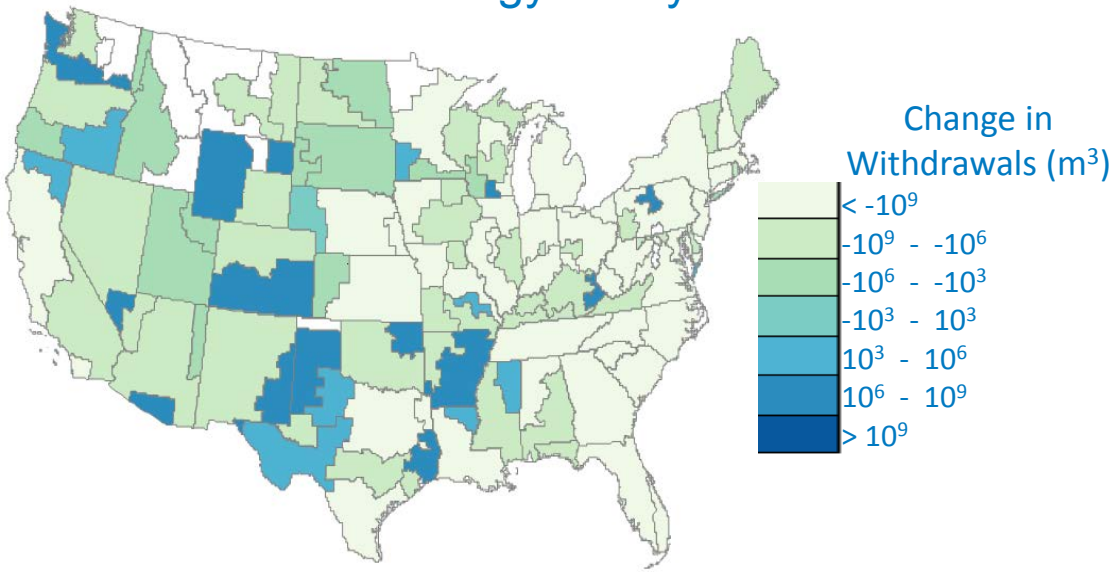
Sources:
Cooley, H., J. Fulton, and P. Gleick, 2011: *Water for Energy: Future Water Needs for Electricity in the Intermountain West.* Pacific Institute.
Torcellini, P., N. Long, and R. Judkoff, 2003: Consumptive Water Use for U.S. Power Production. *NREL Technical Report-TP-550-33905*

Clean energy technology scenarios can lead to reductions in water usage

Base Case - 2030



Clean Energy Policy Scenario - 2030



But results may differ regionally…

Renewables may increase or decrease local water demands, depending on what technology is deployed and what it is replacing

Example results adapted from: Macknick, J., Newmark, R., and K. Hallett. **Future Projections of Water Demands for Energy. Water Environment Federation Conference Proceedings. Energy and Water 2011: Efficiency, Generation, Management and Climate Impacts.** July 31 – August 3, 2011. Chicago, Illinois.

Water quality can also be a concern

- **Manufacturing**
  - Wastewater streams
- **Biopower fuel production**
  - Agricultural practices
- **Geothermal drilling and operations**
  - Accidents/spills
- **Operations for thermoelectric renewables**
  - Once-through cooling systems
    - Marine life intake
    - Water temperature impacts
  - Recirculating cooling systems
    - Air pollution from cooling towers
    - Cooling tower blowdown disposal

Summary

- The electricity sector is the largest withdrawer of freshwater in the nation
- In general, non-thermal renewable technologies have lower operational and life cycle water demands than other technologies
- Some renewable technologies can require more water than conventional technologies
- Energy choices can have a substantial impact on future water withdrawal and consumption demands
- Water demands for the energy sector can vary greatly regionally depending on fuel choice and cooling system decisions
- Renewable technologies can impact water quality at various stages in the life cycle

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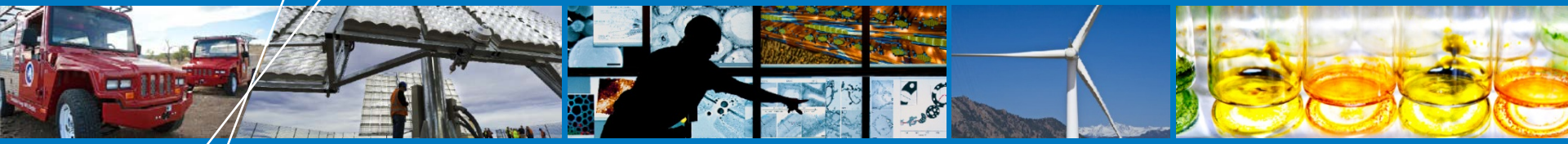
Thank you



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