

Exceptional service in the national interest



Energy-Water Nexus in the U.S.

Vincent Tidwell

Sandia National Laboratories

*Ten year Framework for Energy and the Environment Cooperation
Washington, DC, March 2014*

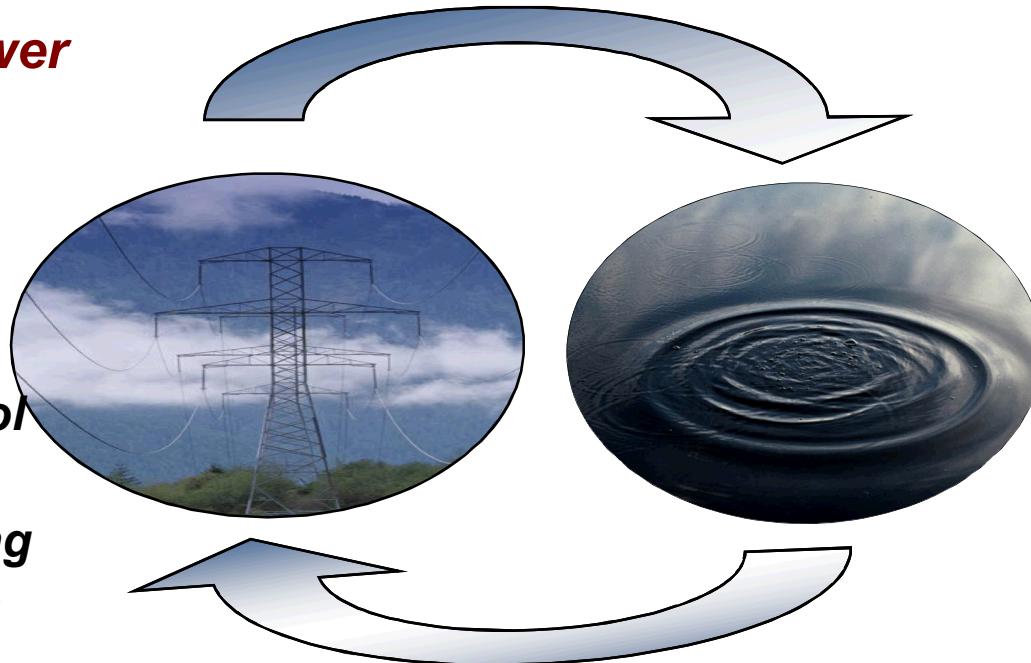


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Energy-Water Nexus

Energy and power production requires water

- Thermoelectric Cooling
- Emission Control
- Energy Minerals Extraction/Mining
- Fuel Processing (fossil fuels, H_2 , biofuels)



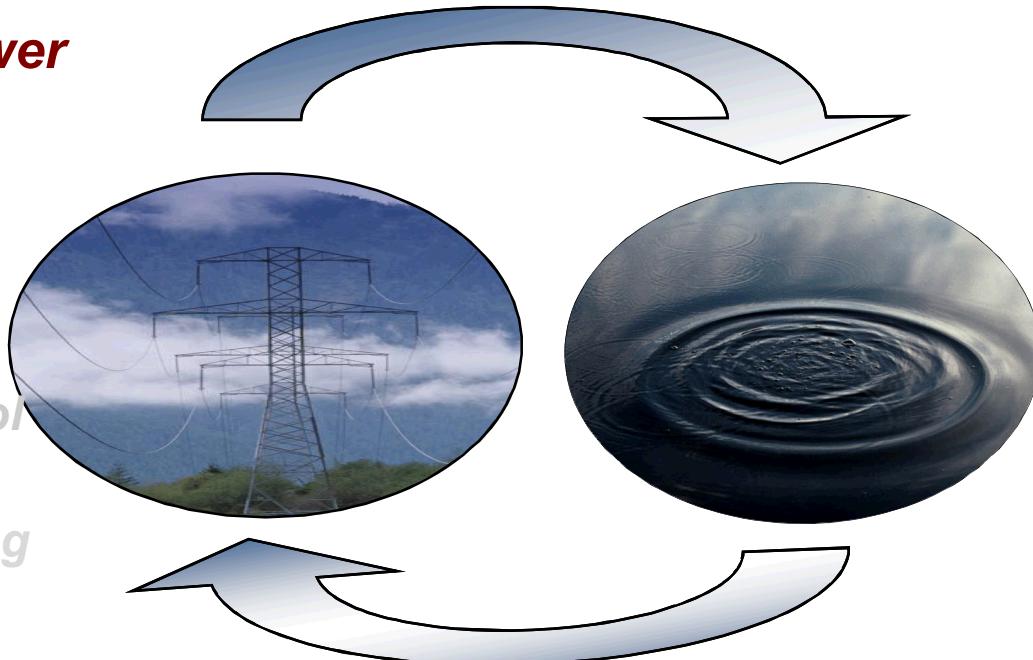
Water production, processing, distribution, and end-use requires energy

- Pumping
- Conveyance
- Treatment
- Distribution
- Use Conditioning

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Water Utility Energy Use

- Drinking water accounts 1% of total electricity use in the U.S.
- Wastewater use 0.8%

(EPRI 2013)



- Water and wastewater account for 35 percent of typical U.S. municipal energy budgets,
- 25–40 percent of the operating budgets for wastewater utilities
- 80 percent of drinking water processing and distribution costs

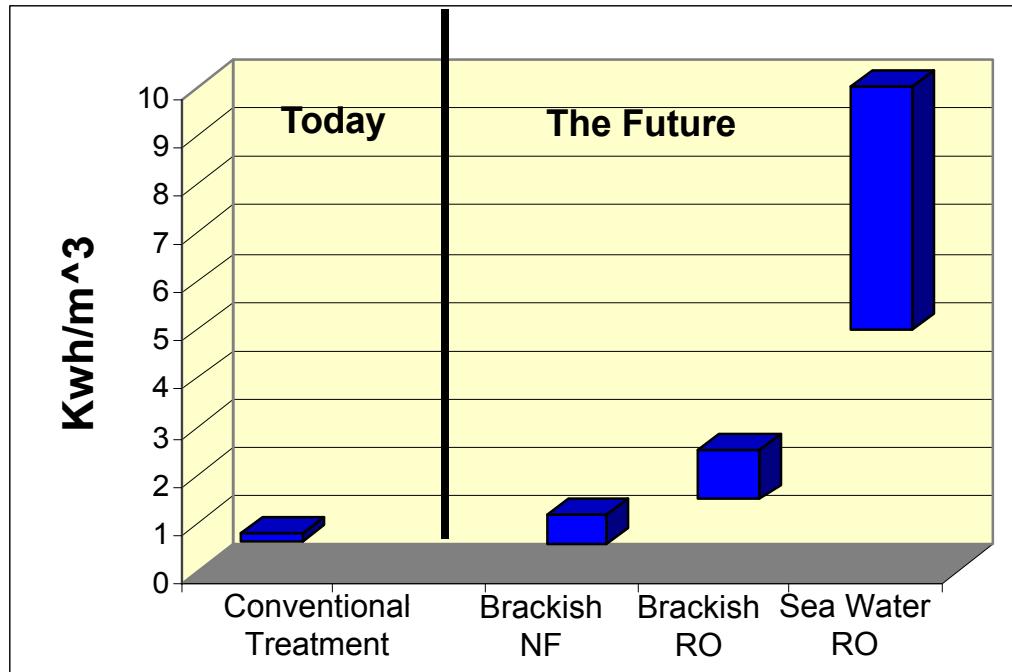
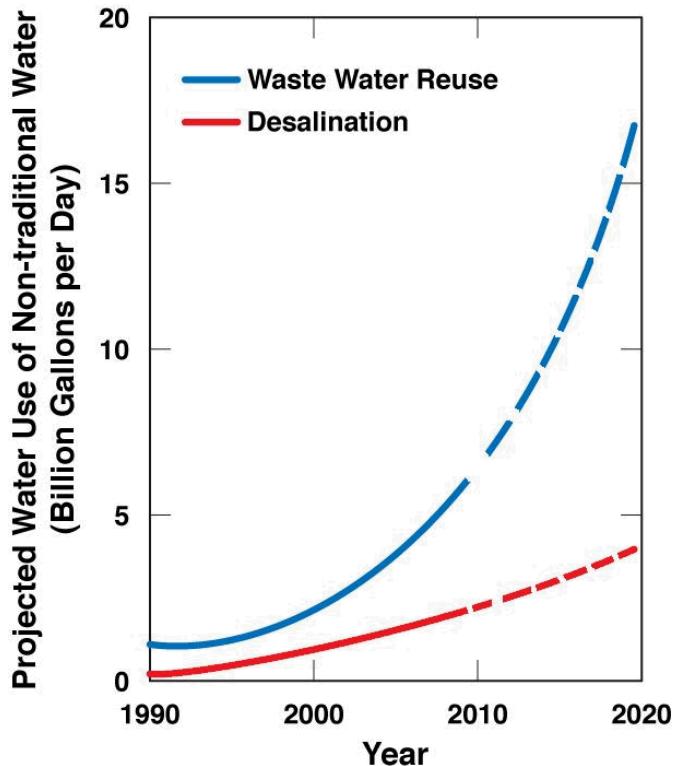
(NYSERDA, 2008)

Energy Management Opportunities

Energy Efficiency, Load Management, and Demand Response	Emerging Technologies and Processes	Energy Recovery and Generation
<ul style="list-style-type: none">• Strategic Energy Management Practices• Data Monitoring and Process Control• Water Conservation• High-Efficiency Pumps and Motors• Adjustable Speed Drives• Pipeline Optimization• Advanced Aeration• Demand Response	<ul style="list-style-type: none">• Odor Control• Membrane Bioreactors• Deammonification Sidestream Process• Water Reuse• Residuals Processing• Microbial Fuel Cells• LED UV Lamps	<ul style="list-style-type: none">• Cogeneration Using Digester Biogas• Use of Renewable Energy to Pump Water• Recovery of Excess Line Pressure to Produce Electricity

Energy for Water

Power Requirements For Treatment



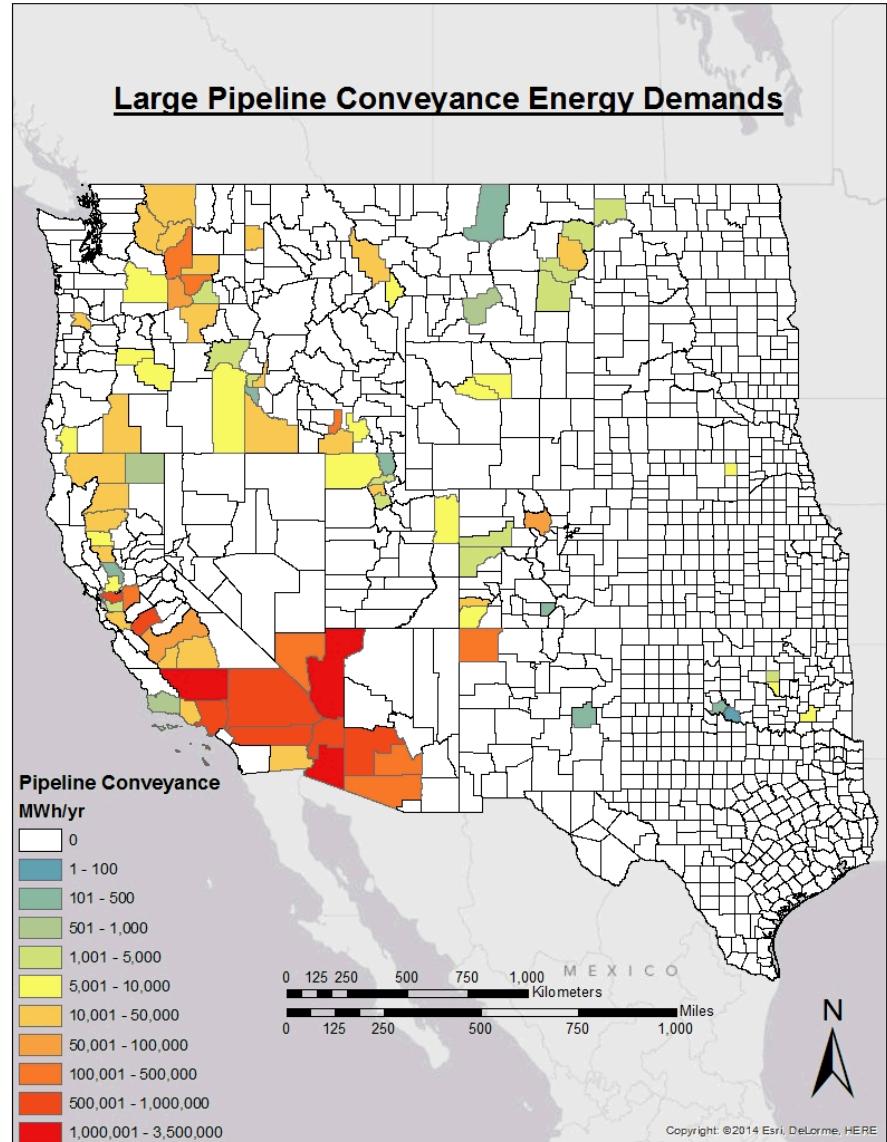
(Modified from Water Reuse 2007, EPA 2004, Mickley 2003)

(Einfeld 2007)

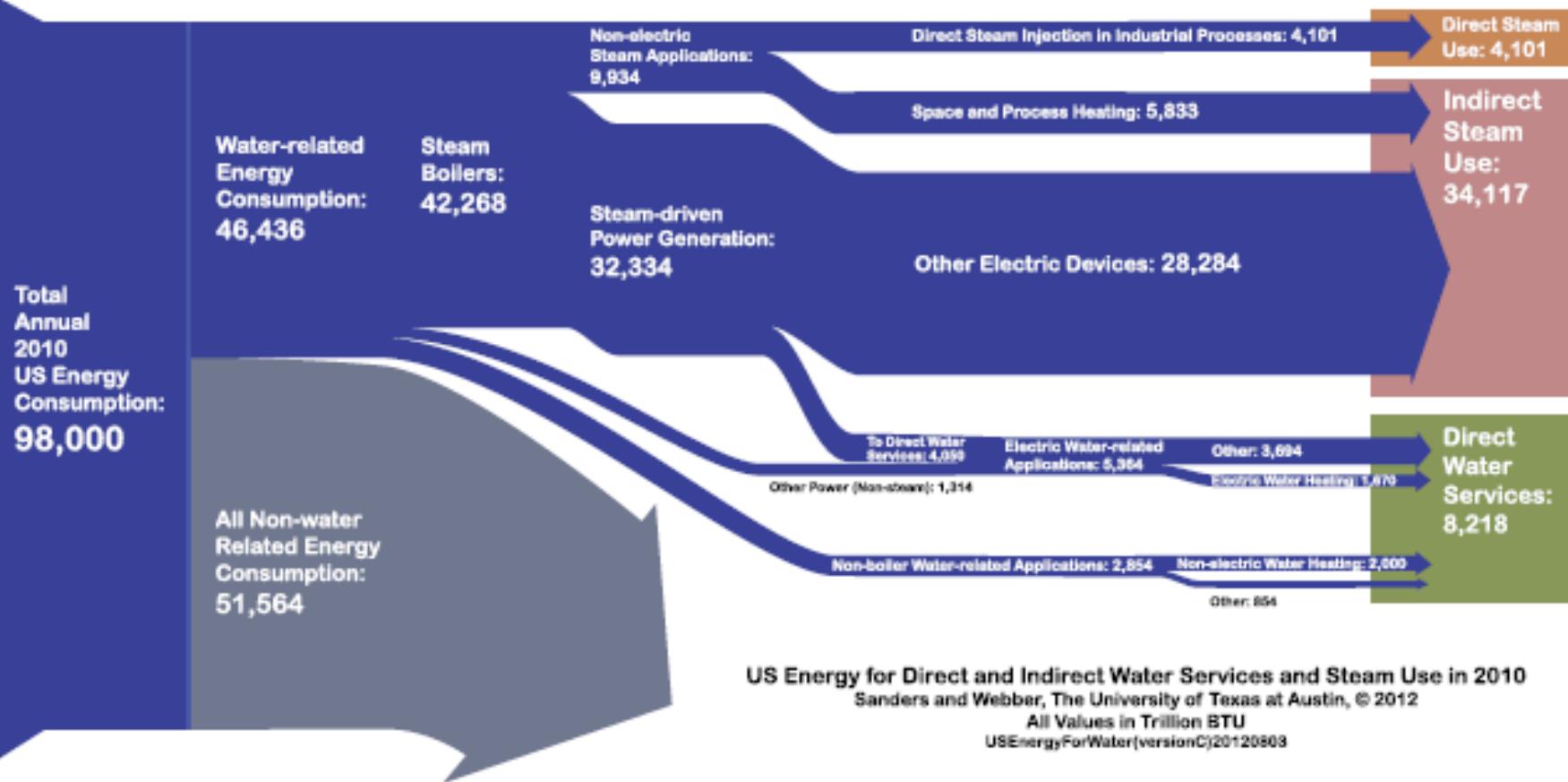
- Desal growing at 10% per year, waste water reuse at 15% per year
- Non-traditional water use is energy intensive

Large-Scale Conveyance

- Inter-basin transfers account for 1.2% of West-wide electricity use.
 - 6% of Arizona electricity use, and
 - 3% of California electricity use.

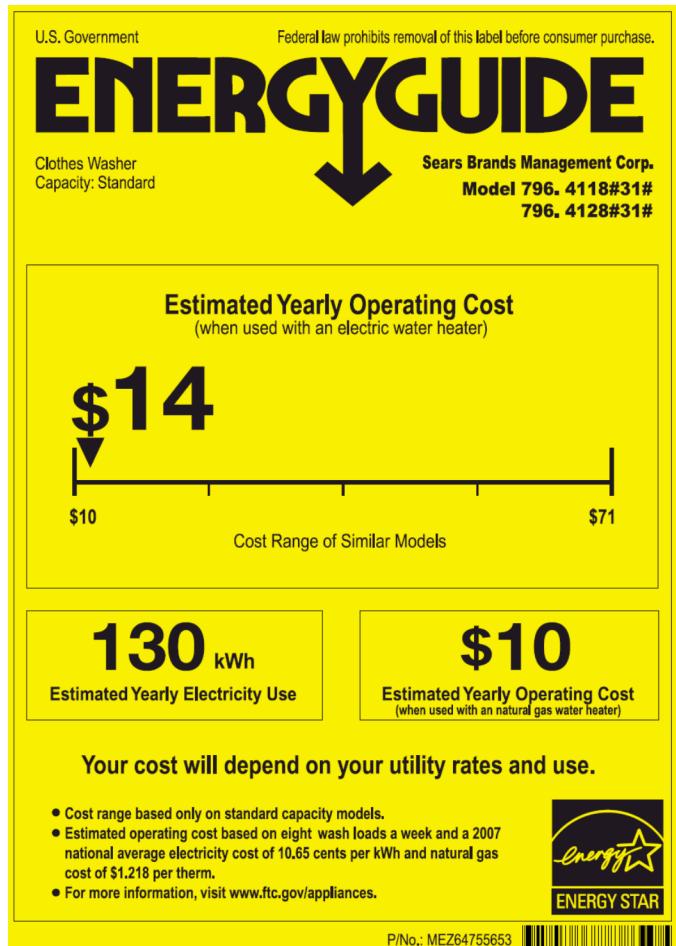


Energy for Water



- Water services account for 12.6% of energy consumption in U.S.
 - 8.2% for heating, chilling, treating, etc. water
 - 4.4% for direct steam applications

Water and Energy Conservation



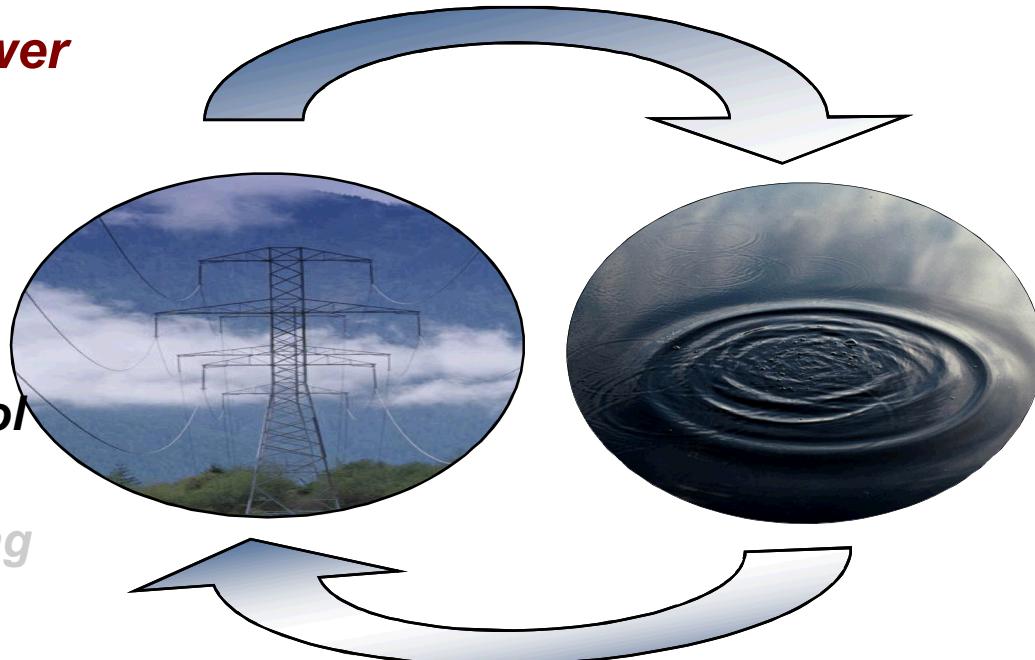
City of Denver Water Conservation Campaign

Appliance Standards

Energy-Water Nexus

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- ***Thermoelectric Cooling***
- ***Emission Control***
- ***Energy Minerals Extraction/Mining***
- ***Fuel Processing (fossil fuels, H₂, biofuels)***

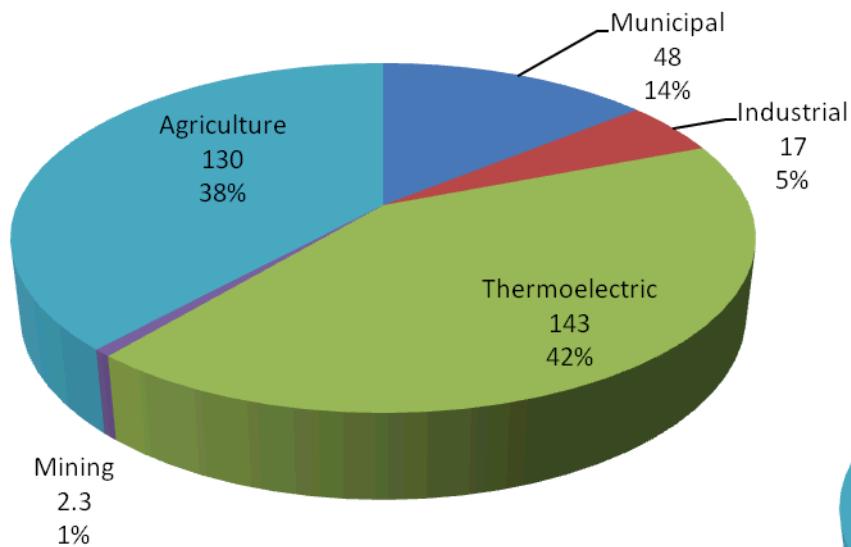


Water production, processing, distribution, and end-use requires energy

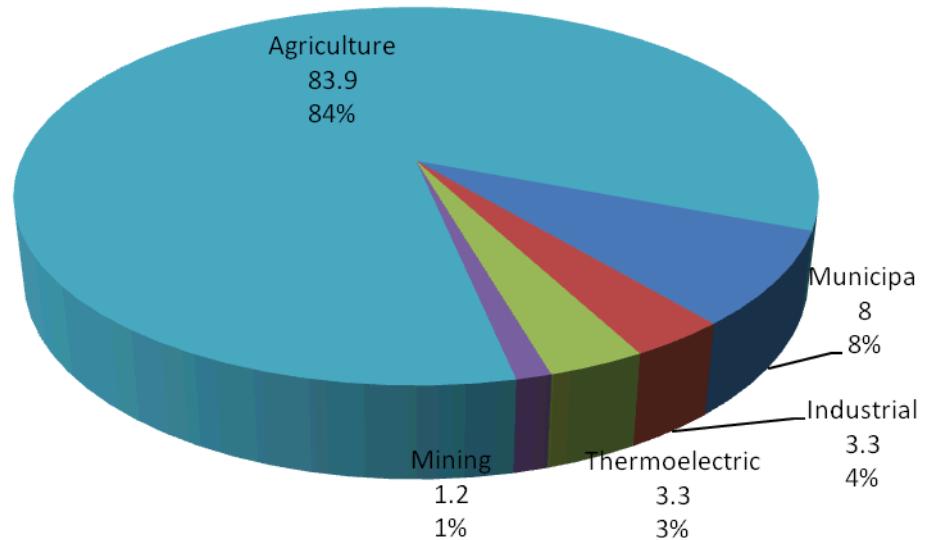
- ***Pumping***
- ***Conveyance***
- ***Treatment***
- ***Distribution***
- ***Use Conditioning***

Water for Thermoelectric Power Generation

Water Withdrawal (BGD) 2005

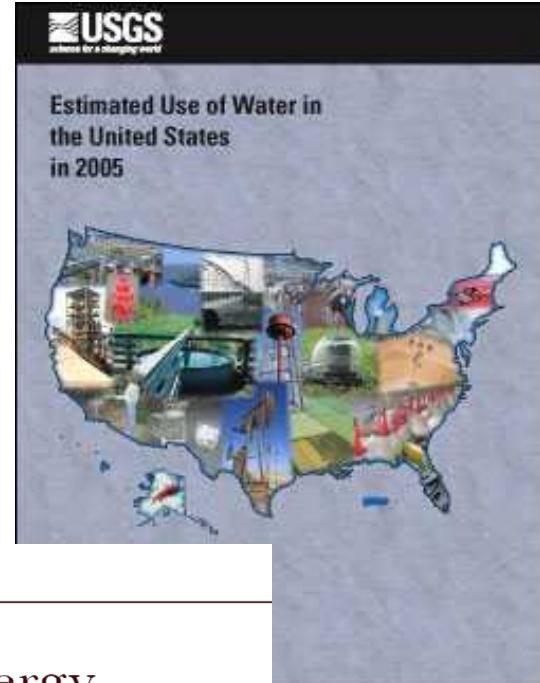


Water Consumption (BGD) 1995



Energy-Water Data

- Collaboration between:
 - U.S. Geological Survey
 - U.S. Energy Information Administration
- Expanded data collection
- Standardized procedures and definitions



DOE/EIA-0383(2013) | April 2013

Annual Energy Outlook 2013

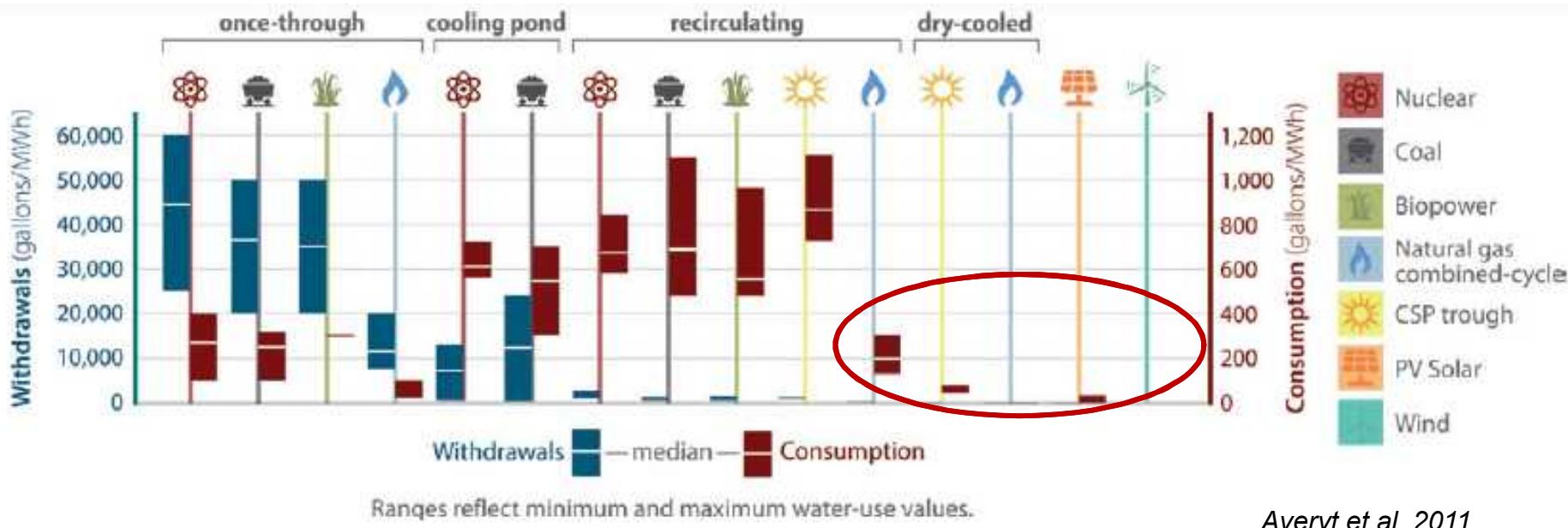
with Projections to 2040



Water for Thermoelectric Power

- Water use influenced by:

- Fuel type,
- Cooling type,
- Emission controls,
- Age, and
- Location



Technology Improvement

*Unique collaboration between
industrial research institute and
National Science Foundation*

NSF/EPRI Collaboration on "Water for Energy"- Advanced Dry Cooling for Power Plants

PROGRAM SOLICITATION

NSF 13-564



National Science Foundation

Directorate for Engineering
Division of Chemical, Bioengineering, Environmental, and Transport Systems

EPRI

Electric Power Research Institute

Full Proposal Deadline(s) (due by 5 p.m. proposer's local time):

August 19, 2013

IMPORTANT INFORMATION AND REVISION NOTES

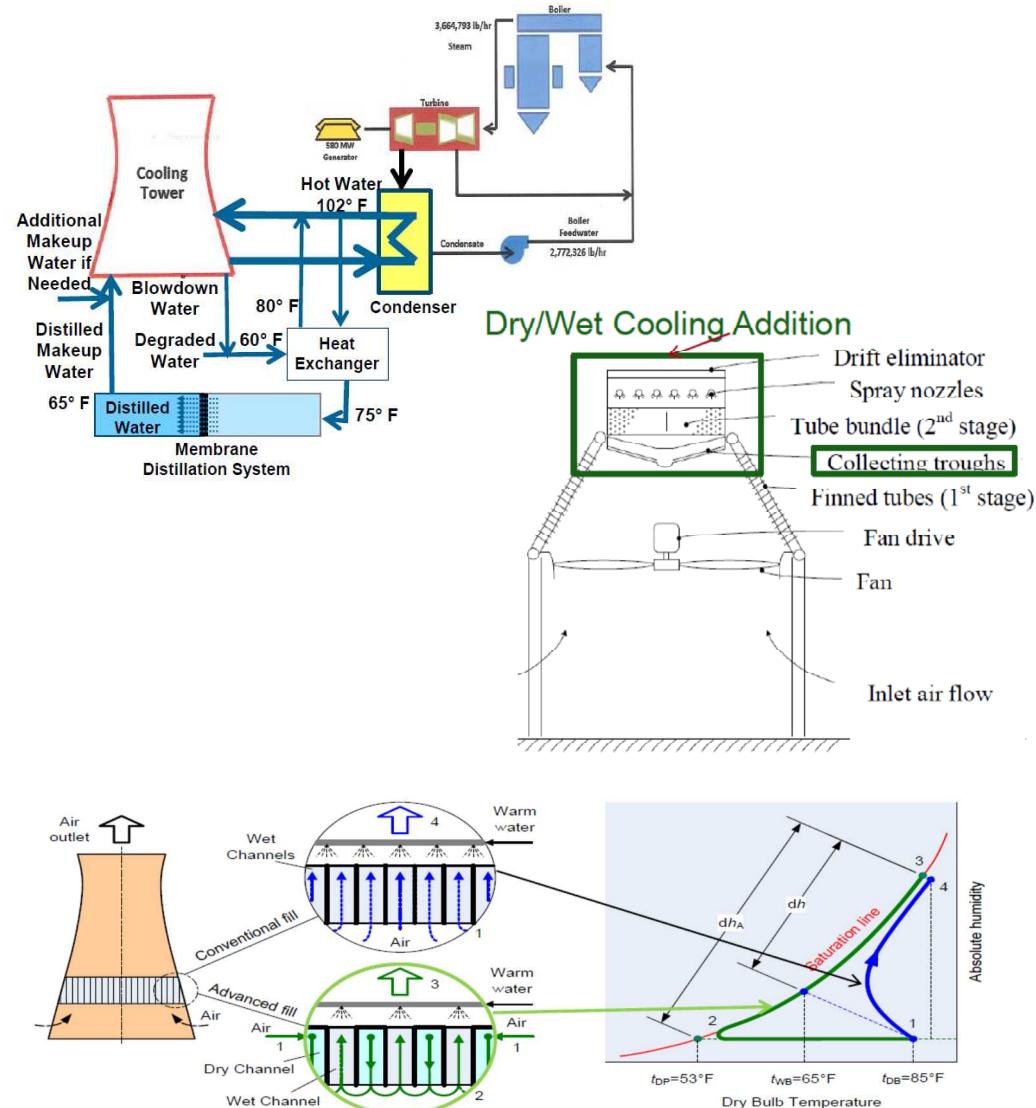
A revised version of the *NSF Proposal & Award Policies & Procedures Guide (PAPPG)*, **NSF 13-1**, was issued on October 4, 2012 and is effective for proposals submitted, or due, on or after January 14, 2013. Please be advised that the guidelines contained in **NSF 13-1** apply to proposals submitted in response to this funding opportunity. Proposers who opt to submit prior to January 14, 2013, must also follow the guidelines contained in **NSF 13-1**.

Please be aware that significant changes have been made to the PAPPG to implement revised merit review criteria based on the National Science Board (NSB) report, *National Science Foundation's Merit Review Criteria: Review and Revisions*. While the two merit review criteria remain unchanged (Intellectual Merit and Broader Impacts), guidance has been provided to clarify and improve the function of the criteria. Changes will affect the project summary and project description sections of proposals. Annual and final reports also will be affected.

A by-chapter summary of this and other significant changes is provided at the beginning of both the *Grant Proposal Guide* and the *Award & Administration Guide*.

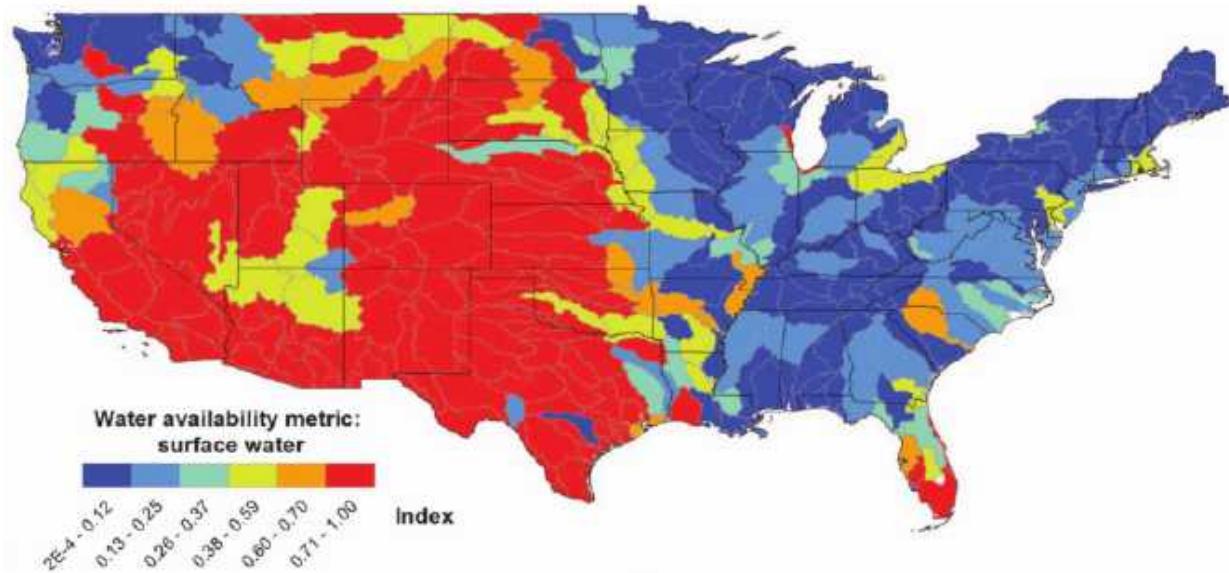
Please note that this program solicitation may contain supplemental proposal preparation guidance and/or guidance that deviates from the guidelines established in the *Grant Proposal Guide*.

SUMMARY OF PROGRAM REQUIREMENTS

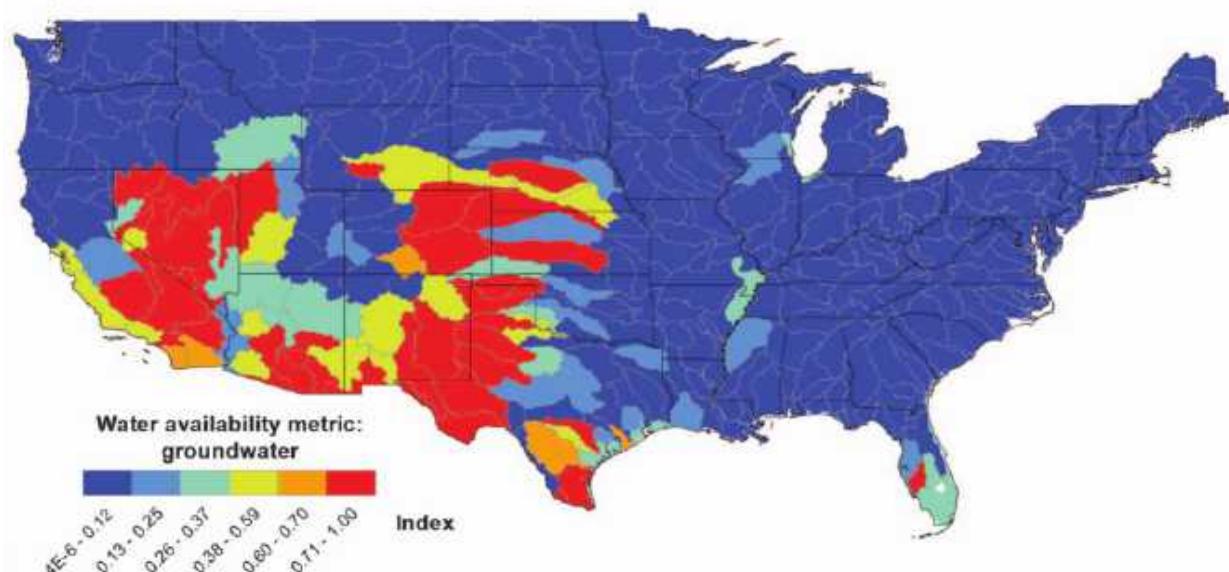


Water Limited Basins

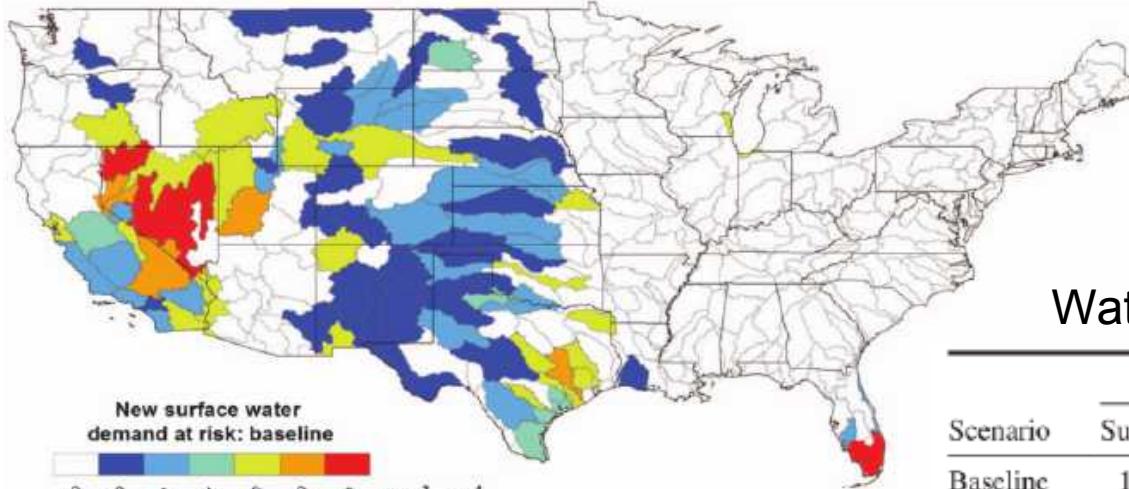
Surface Water Availability



Groundwater Availability

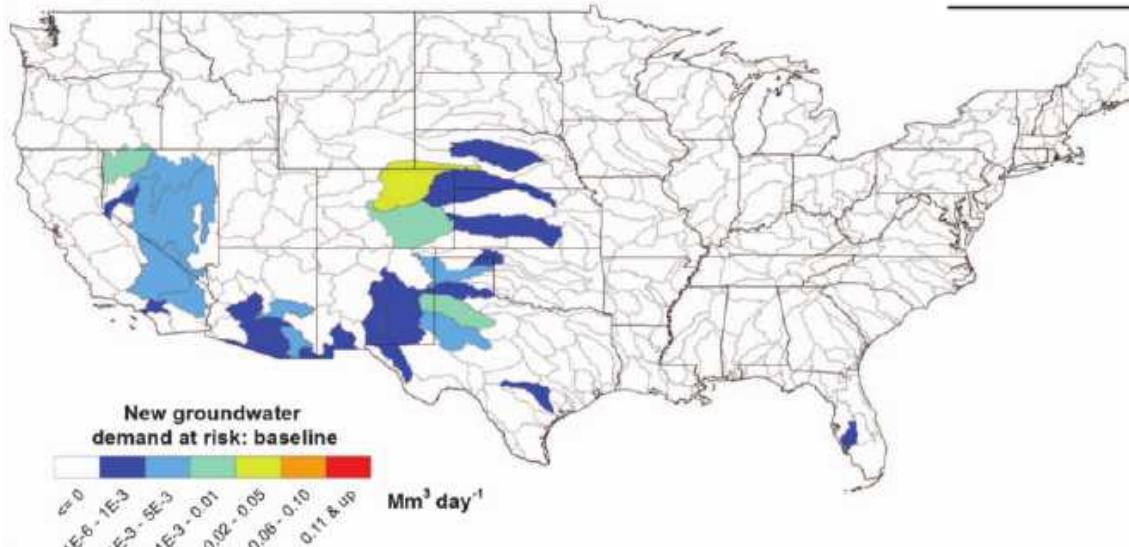


Thermoelectric Development in Water Limited Basins



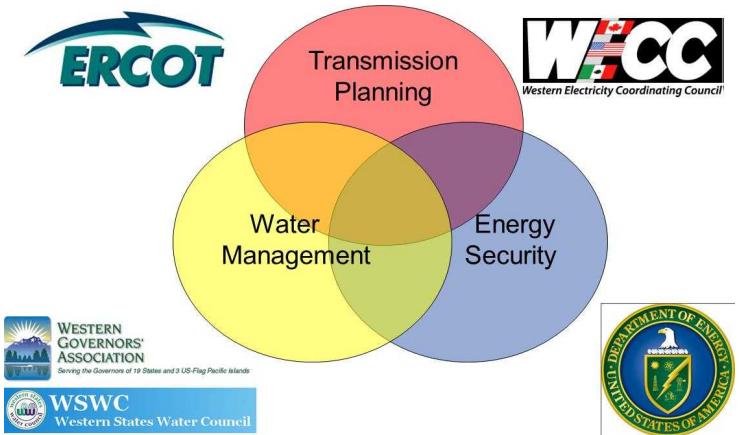
Water and Power at Siting Risk

Scenario	Power (MMWh)		Water (Mm^3/day)	
	Surface water	Ground water	Surface water	Ground water
Baseline	163 (18%)	11 (1%)	1.18 (24%)	0.06 (1%)
Fossil	139 (15%)	19 (2%)	1.24 (23%)	0.10 (2%)
Renewable	84 (9%)	5 (0.5%)	0.85 (19%)	0.04 (1%)

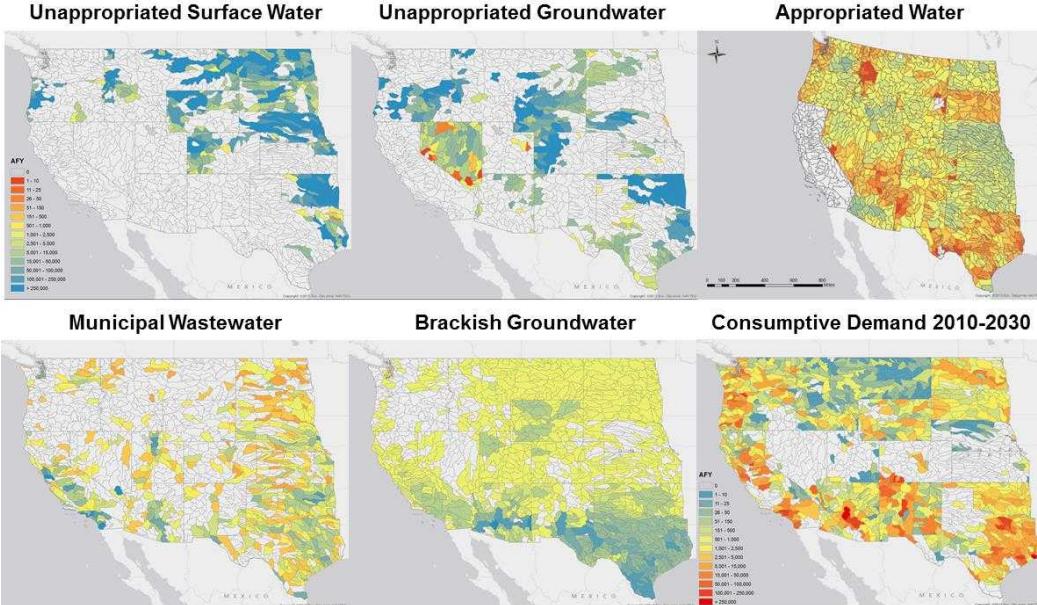


Tidwell et al. 2012

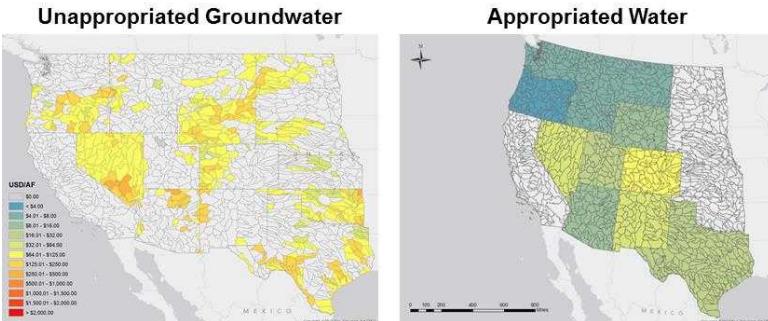
Integrated Energy-Water Planning



Water Availability Metrics

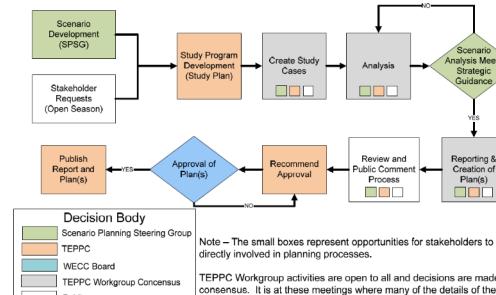


Water Cost Metrics



Note – The small boxes represent opportunities for stakeholders to be directly involved in planning processes.

TEPPC Workgroup activities are open to all and decisions are made by consensus. It is at these meetings where many of the details of the planning process are decided.



Water from Retiring Plants

Change in non-thermoelectric water use 2009-2035

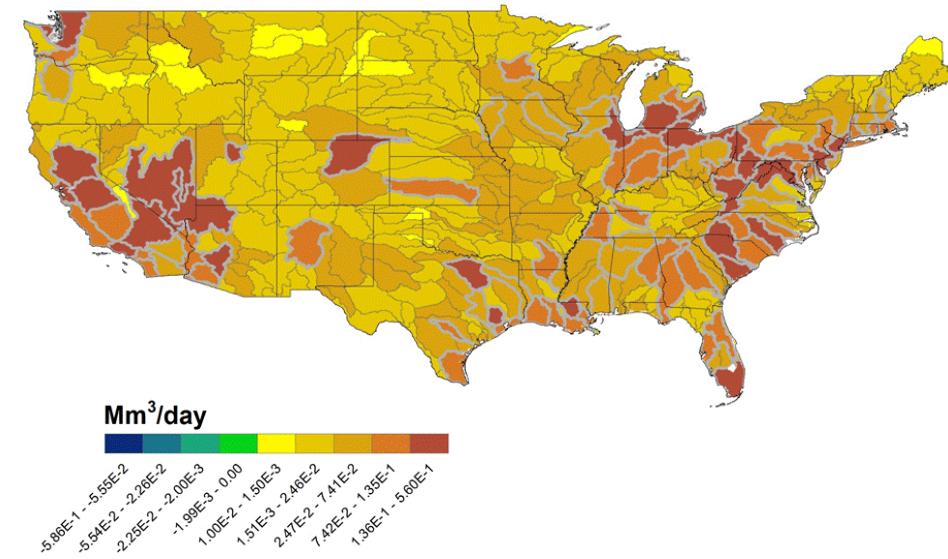
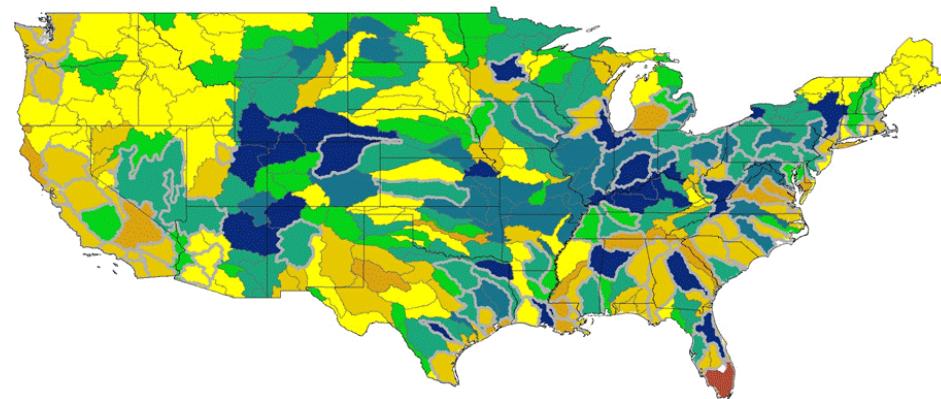


Table 3. Thermoelectric Power Production and Associated Freshwater Consumption at Siting Risk Due to Limited Water Availability. T^a

	electricity (TWh)	water consumption (Mm^3/d)
reference	154	0.55 (0.53, 0.57)
\$15 CO ₂ no retrofit	135	0.47 (0.44, 0.51)
\$15 CO ₂ full retrofit	146	0.96 (0.93, 1.0)
\$25 CO ₂ no retrofit	113	0.44 (0.41, 0.48)
\$25 CO ₂ full retrofit	127	0.95 (0.92, 0.99)

- New capacity in U.S. is largely renewables and natural gas
- Retirement or de-rating of older plants result in net water savings

Change in thermoelectric water use: \$15/tonne CO₂ no retrofit

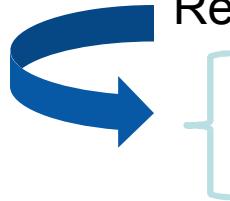


Tidwell et al. 2013

Transitioning to Zero Freshwater Withdrawal

Retrofits considered: *average difficulty, according to EPA guidelines*

Recirculating cooling (first step for once-through cooling systems)



- Dry cooling
- Municipal wastewater
- Brackish groundwater

Costs:

- Capital
- Operating and Maintenance (O&M) costs
- Capture (e.g., conveyance costs for wastewater, drilling and pumping costs for brackish groundwater)
- Treatment
- Parasitic energy losses

Availability:

Municipal wastewater: within 50 miles

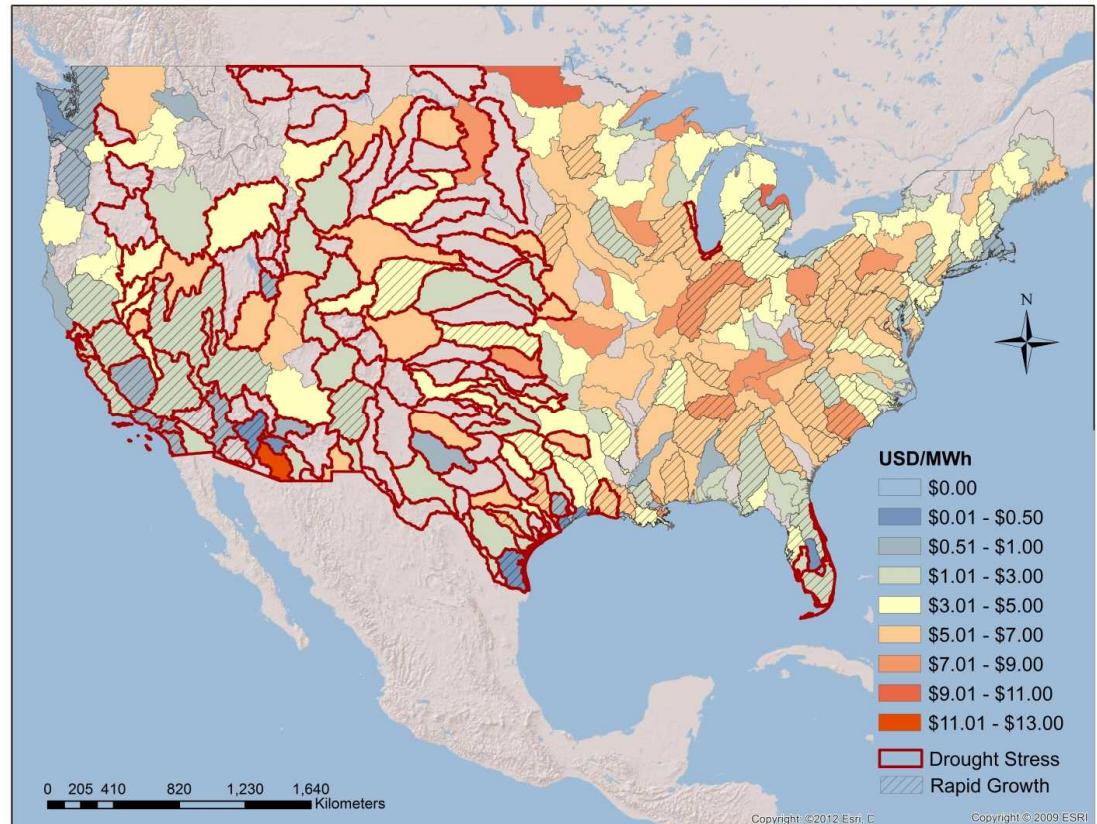
Brackish water: <2500 ft deep, salinities>10,000 TDS

* NOTE: not taking into consideration site-specific constraints such as land availability, local regulations, technology vintage

Cost Associated with Retrofit

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

Note: Δ LCOEs tend to be lower in the West, Texas Gulf Coast and south Florida, which are areas prone to drought stress



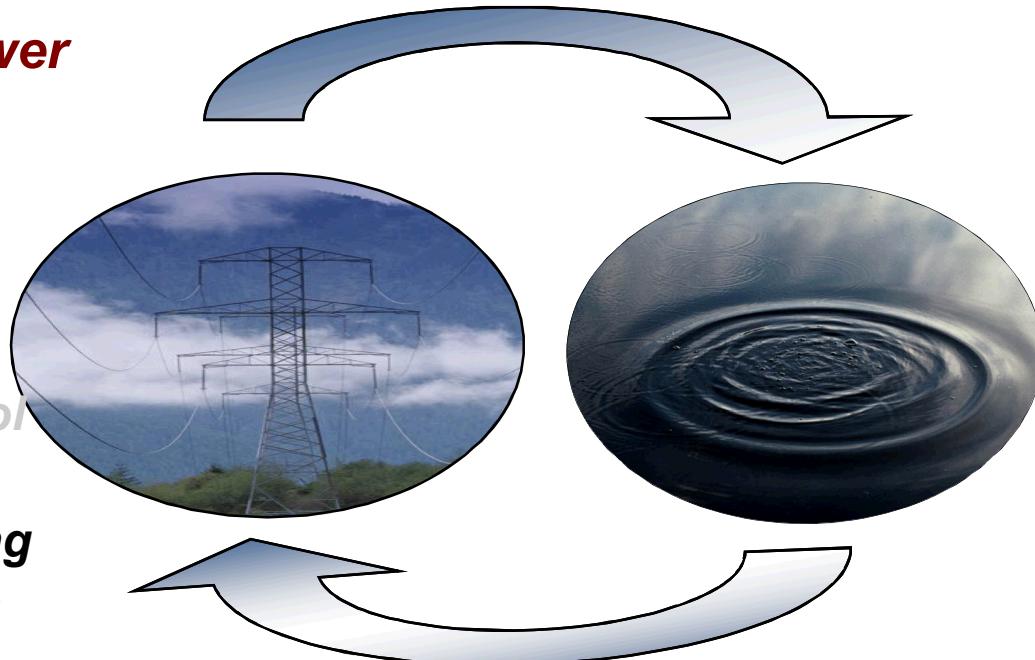
With wholesale cost of electricity about \$40/MWh, many retrofits could be accomplished at levels that would add less than 10% to current power plant generation expenses.*

*average 2012 wholesale cost over 3 US trading hub regions

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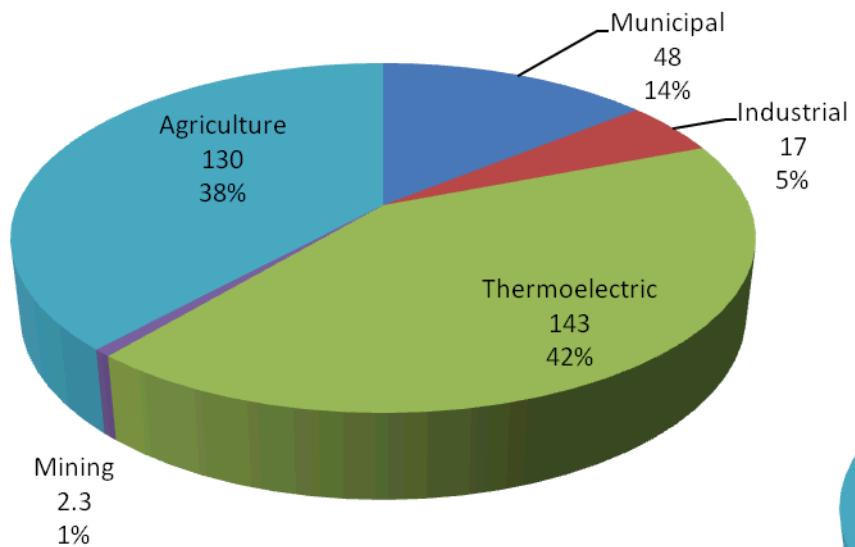


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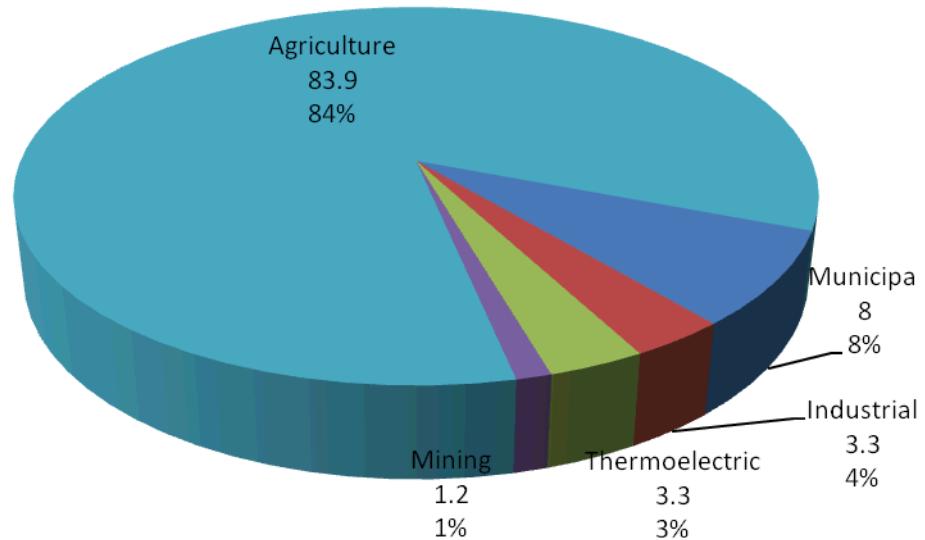
Water for Fuel Extraction and Processing

Water Withdrawal (BGD) 2005



*Estimated at ~1 BGD consumed
in mining and fuel processing*

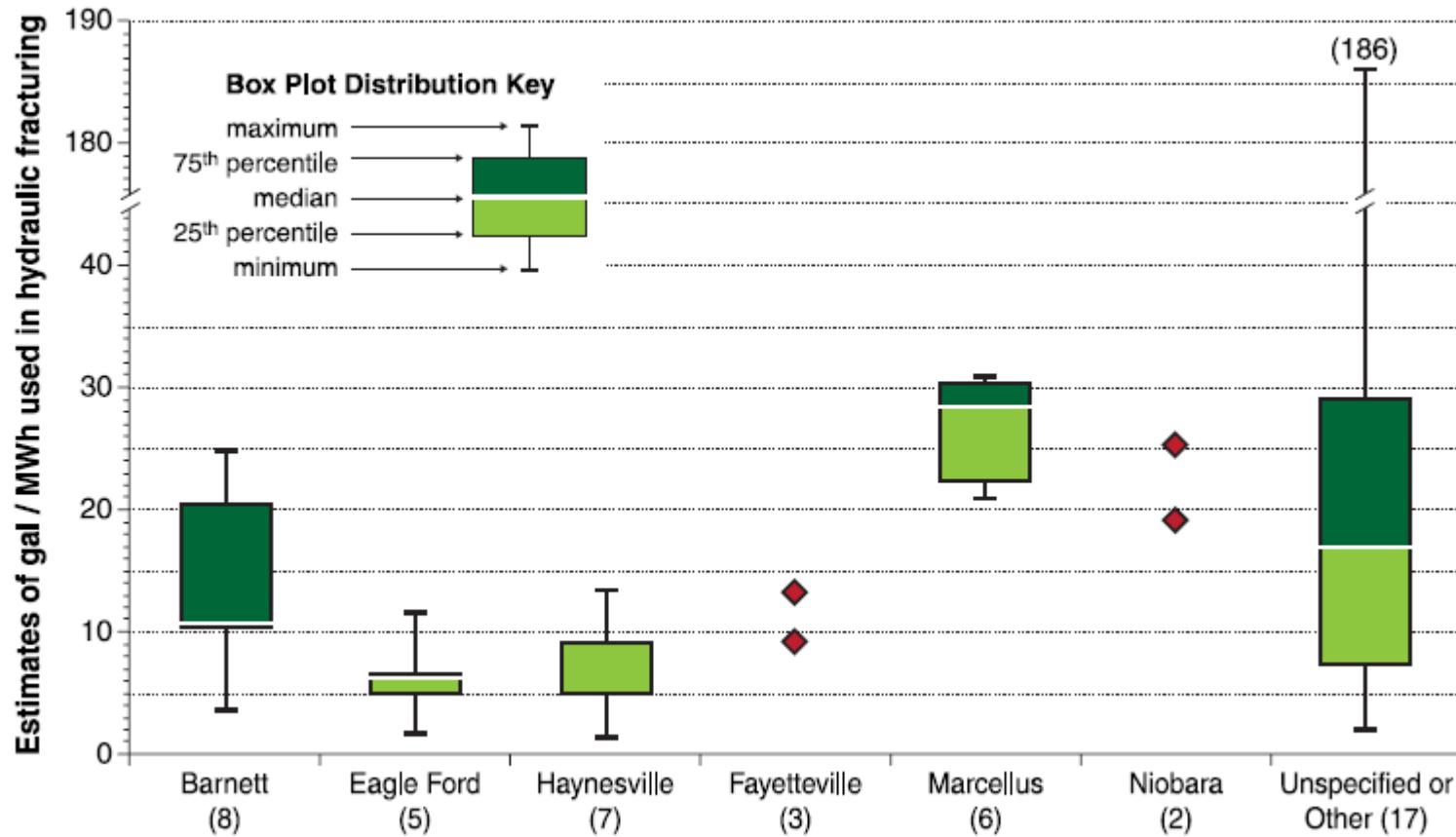
Water Consumption (BGD) 1995



Gas and Oil Shale Development



Water Use in Hydraulic Fracturing



Reducing Water Impacts

- Re-use of produced water
- Use of brackish water
- Protection of fresh water resources



EPA United States Environmental Protection Agency

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EPA's Study of Hydraulic Fracturing and Its Potential Impact on Drinking Water Resources



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Key Links

- Published Scientific Papers
- 2013 Technical Workshops
- Progress Report 2012
- Questions and Answers

Latest News

- On January 28 EPA hosted a webinar on the Technical Roundtable held on December 9, 2013. See the presentation.

Other Resources

- Main hydraulic fracturing page
- Multi-agency collaboration on unconventional oil and gas research
- Follow us on Twitter and Google+

At the request of Congress, EPA is conducting a study to better understand any potential impacts of [hydraulic fracturing](#) on drinking water resources. The scope of the research includes the full lifespan of water in hydraulic fracturing. The [progress report](#) was released in December 2012 and a draft report is expected to be released for public comment and peer review in 2014.

[What is the hydraulic fracturing water cycle?](#)



How EPA Is Doing the Research

- Final study plan
- Research approaches
- Quality assurance and integrity
- Transparency
- Questions and answers about the study

How You Can Get Involved

- [Click here](#) to learn more about technical stakeholder engagement and how you can participate in public meetings.

Publications

- Published Scientific Papers
- Progress report 2012
- Final study plan
- Fact sheets
- Other publications
- Archive

Peer Review

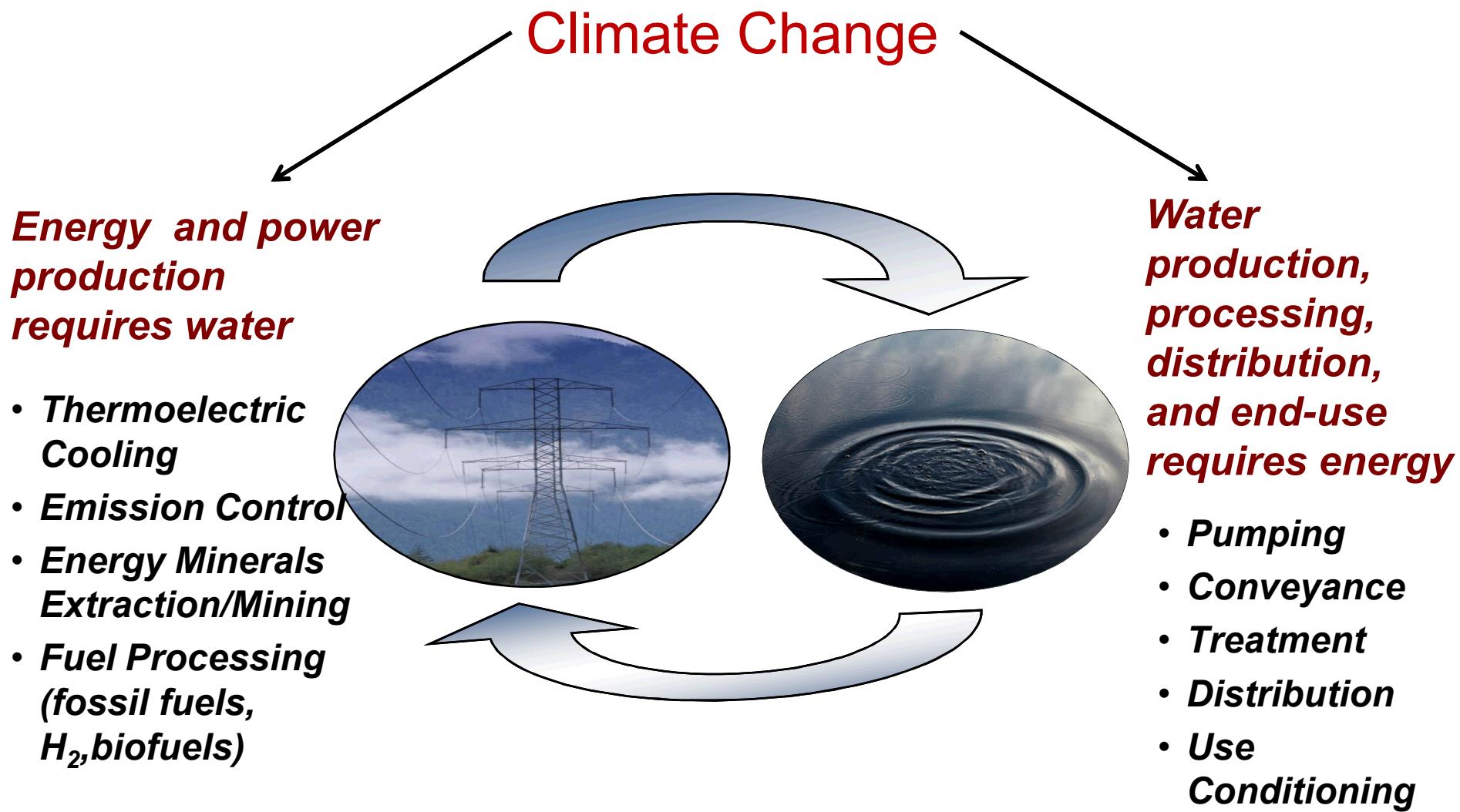
- Peer review activities
- EPA Science Advisory Board (SAB)

Contact Us to ask a question, provide feedback, or report a problem.

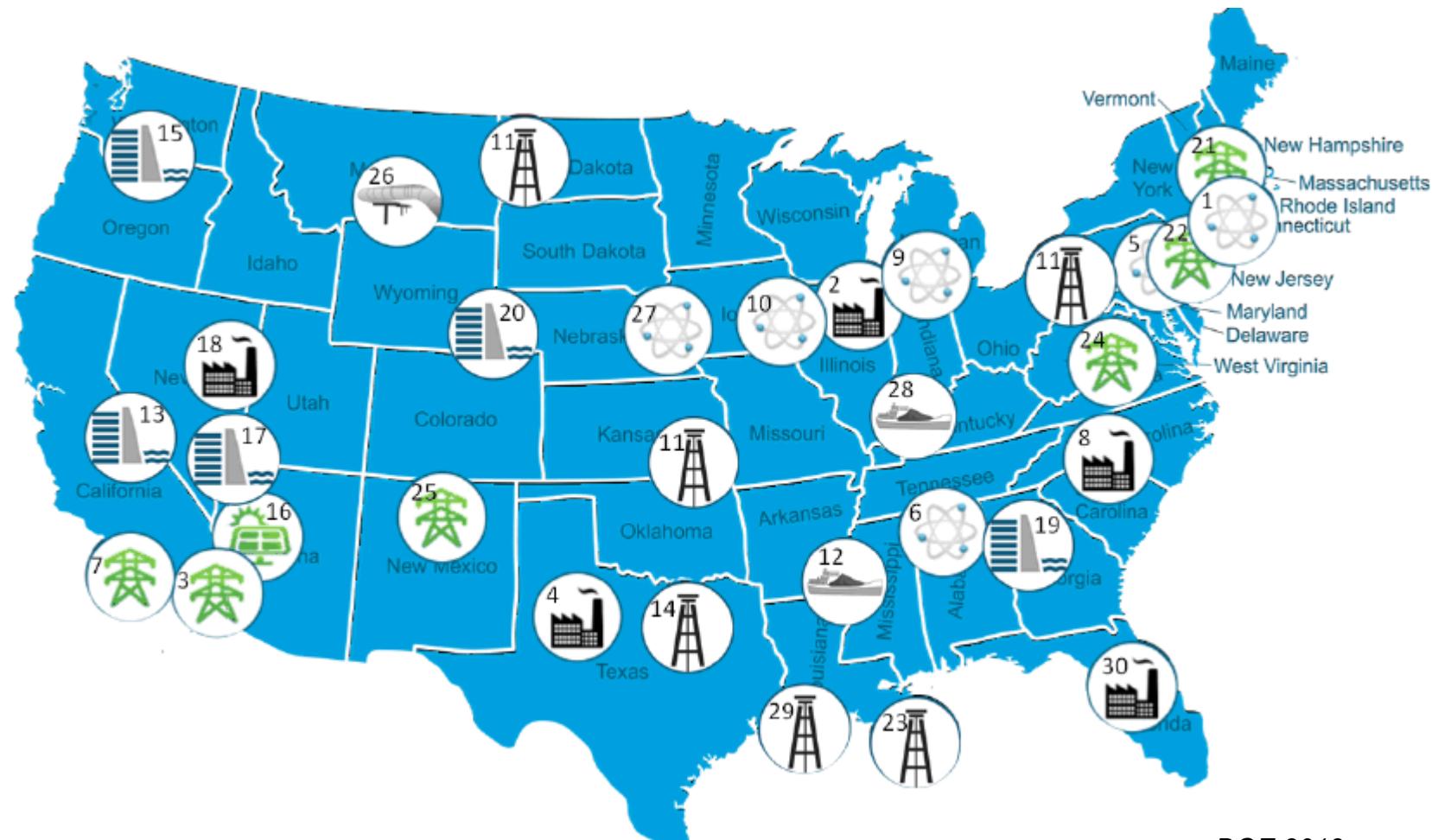
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Energy-Water-Climate Nexus



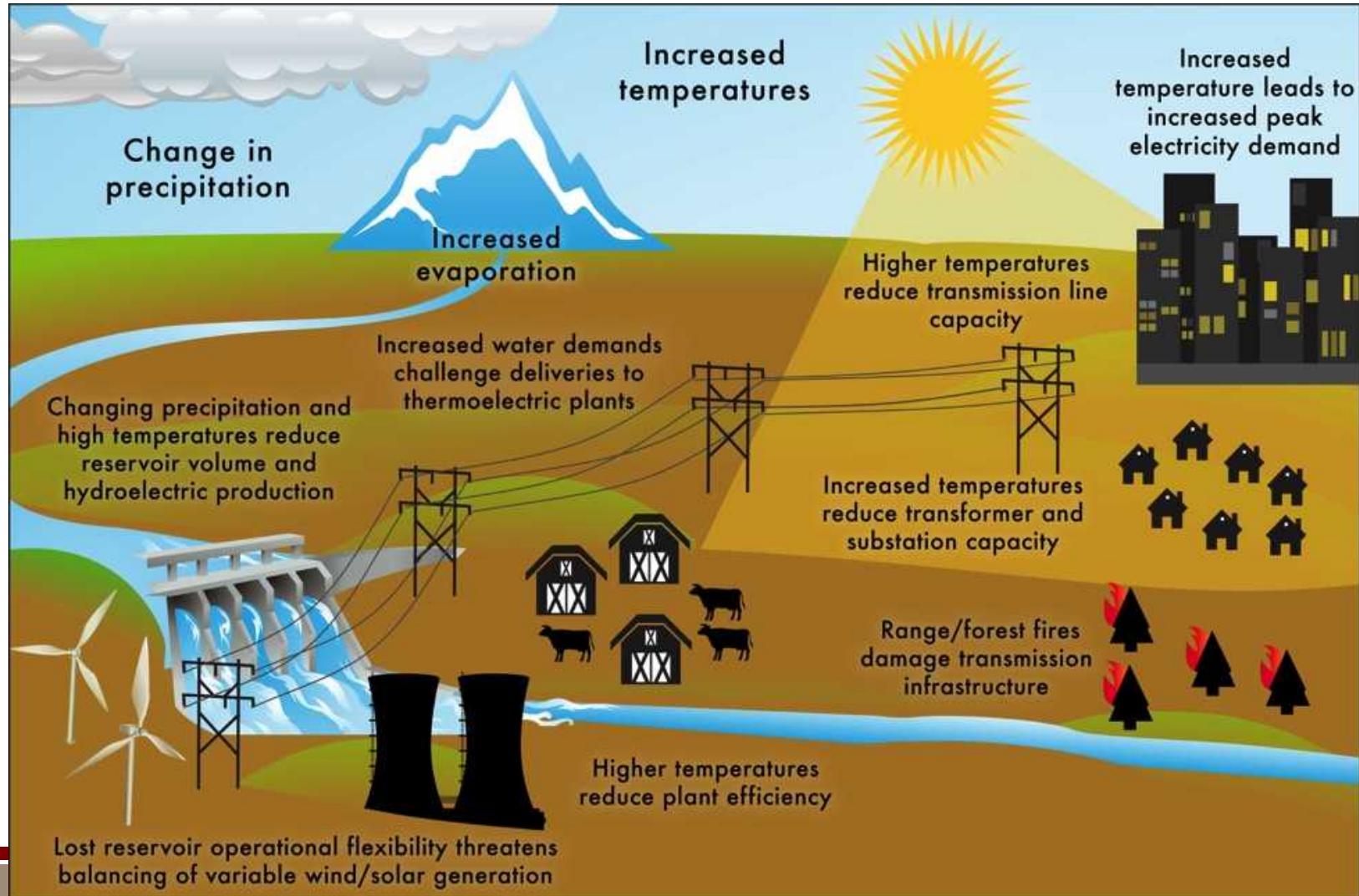
Energy-Water-Climate Nexus in the News



DOE 2013

Cascading Impacts of Climate Change

Delivery of electricity may become more vulnerable to disruption due to climate-induced impacts



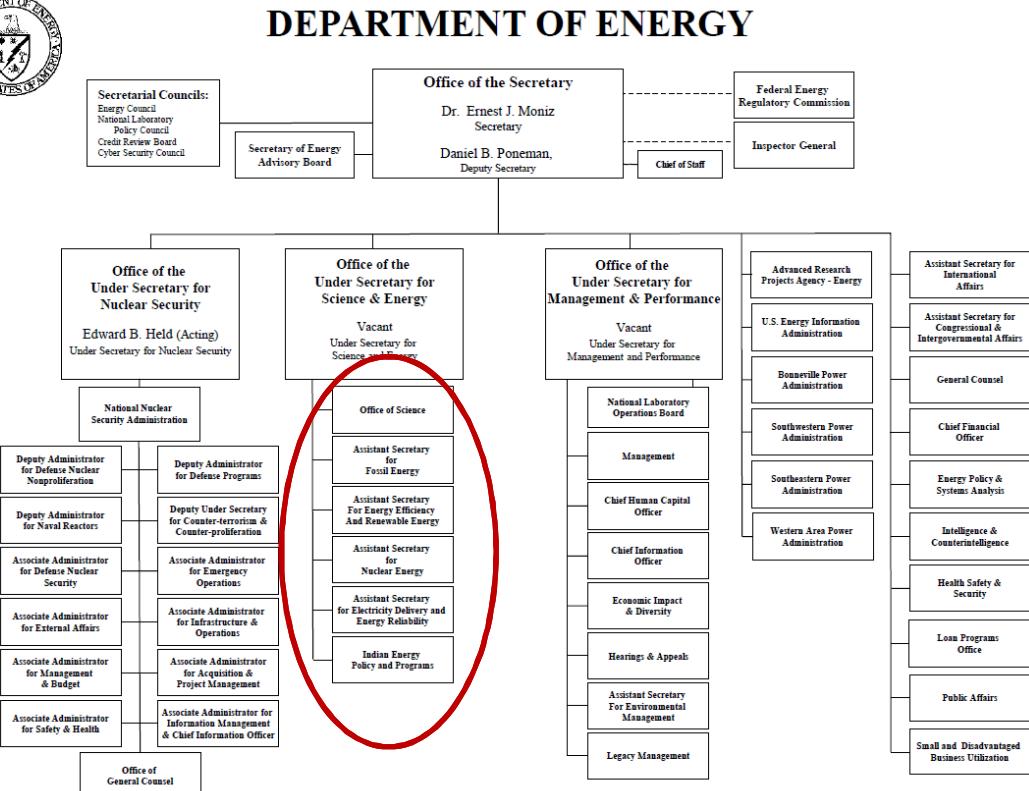
Energy-Water Nexus



- A challenge that we both share
- We are not that different
 - Share similar climates
 - Use similar energy and water technologies
 - Share similar opportunities to manage the energy-water nexus
 - Share similar concerns over the impacts of climate change
- Many benefits to be realized if we work together

Points of Coordination

- Department of Energy: Water-Energy Technical Team
- Environmental Protection Agency:
 - Water/Wastewater
 - Energy/Water efficiency
- Electric Power Research Institute: Industry Partner



17 Jan 2014