The National Academy of Sciences Water Energy Nexus

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Recent Water Issues Affecting Power Plants

- Farley – drought in ACF* River Basin
- Browns Ferry – reduced power output due to water temperatures
- Indian Point – New York imposing requirements for cooling towers
- Future concerns relating to effects of climate change on water supplies

Lake Lanier, GA

Cooling towers, TN

Cooling water intake

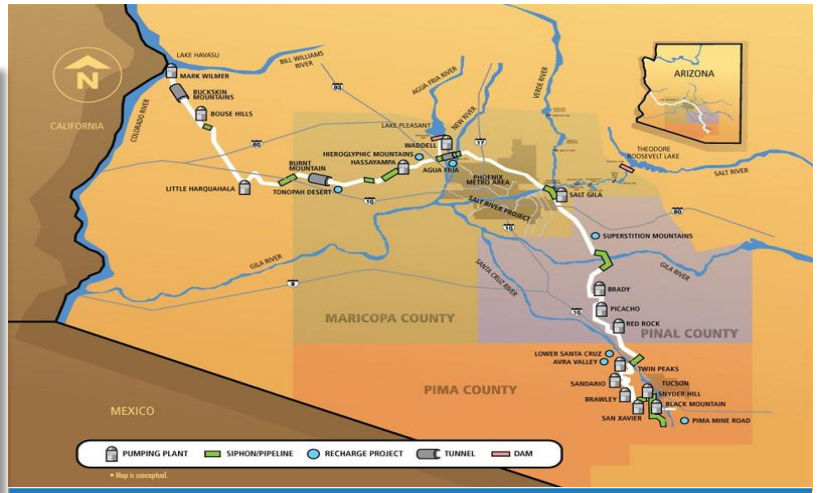
* Apalachicola/Chattahoochee/Flint

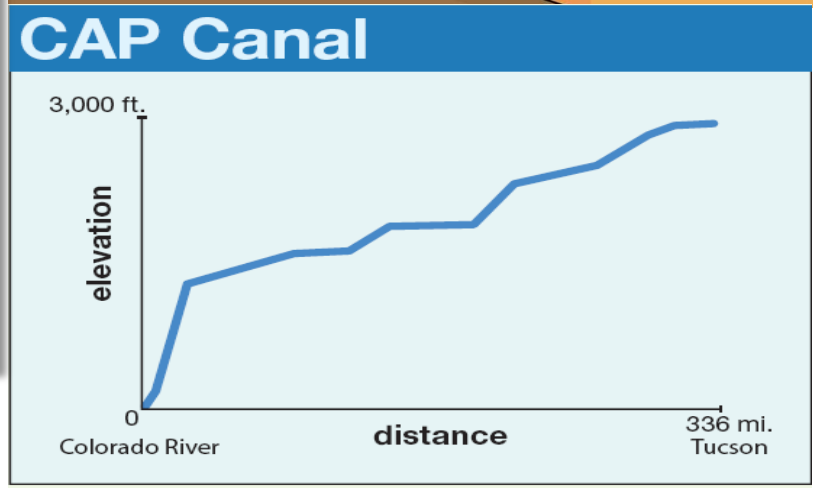
Federal Policy

- CWA - 316(a) (Thermal Impact) & (b) (Aquatic Impingement)
  - –May require close loop cooling systems decreasing freshwater withdrawals but increasing consumptive use
  - –Retrofit could be very expensive and impact power production

This rendering shows what cooling towers might look like at Diablo Canyon nuclear power plant. COURTESY PHOTO

Federal Policy - Central Arizona Project Largest Arizona Power User





CAP consumes 2.8 million MWHs annually to deliver up to 1.6 million acre feet per year

3200 kWh to pump one acre-foot of CAP water from the Colorado River to Tucson.

Wet and Dry Combination

- For water savings > 15% large dry section required that cannot be integrated above the wet section of the cooling tower
- Investment cost & life cycle cost significant, varies based on the size of the dry section
- Significantly larger footprint
- Water savings dependent on size of dry section

Comanche Power Plant

Water-Energy Nexus
National or State Policies

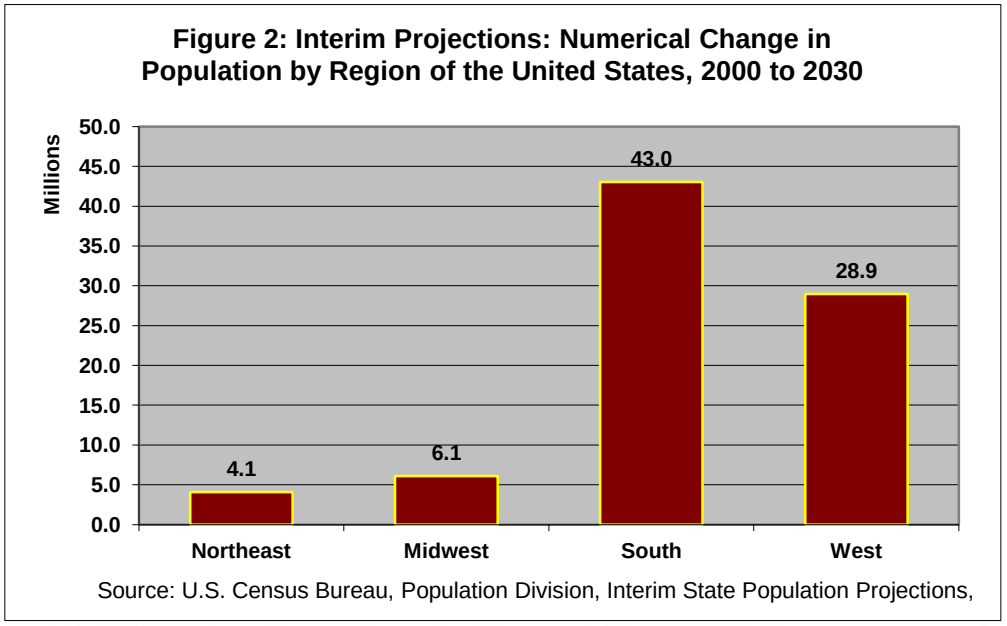
- Energy Demand Continue to Increase
  - Expected to increase thermoelectric generation capacity by 15% - 20% by 2030 (EIA Energy Outlook 2013)
    - Will increase freshwater consumptive use by 14% - 28%
- National Policies
  - Energy Policy Act 2005
    - Request to look at "Energy Demands on Water Resources"
  - Introduction of S 351 and H.R. 3598
    - Energy & Water Integration (Research) Act 2009
- State Policies
  - States have required
    - alternative cooling technologies
    - Use of alternative water supplies
  - Regulators take cost impact to residents into consideration

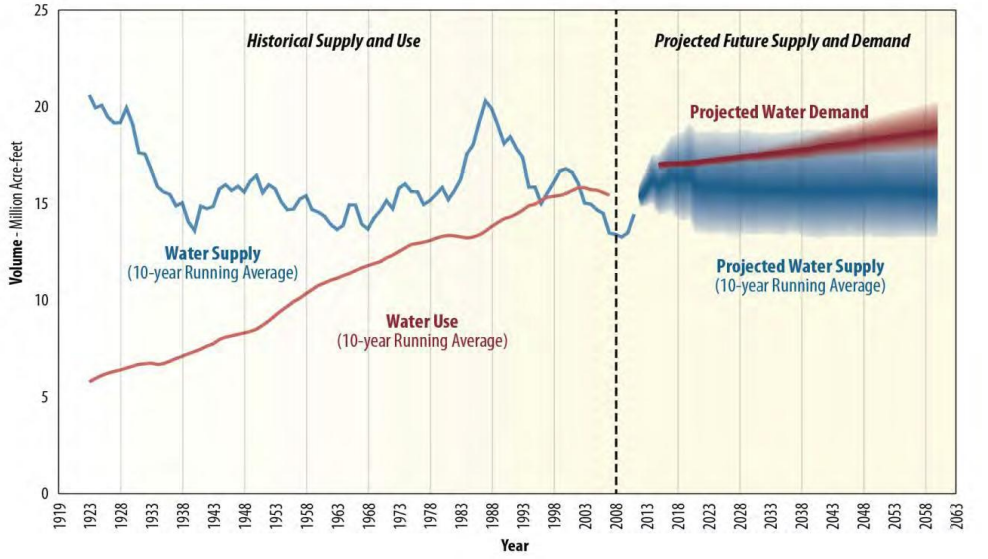
Population

•Population will continue to increase in the Southeast and Southwest at a higher rate than the rest of the country

•Colorado River Basin Study Group is evaluating alternatives to support future water needs

- •Conservation
- •Augmentation
- •Cloud seeding
- •Rain water harvesting



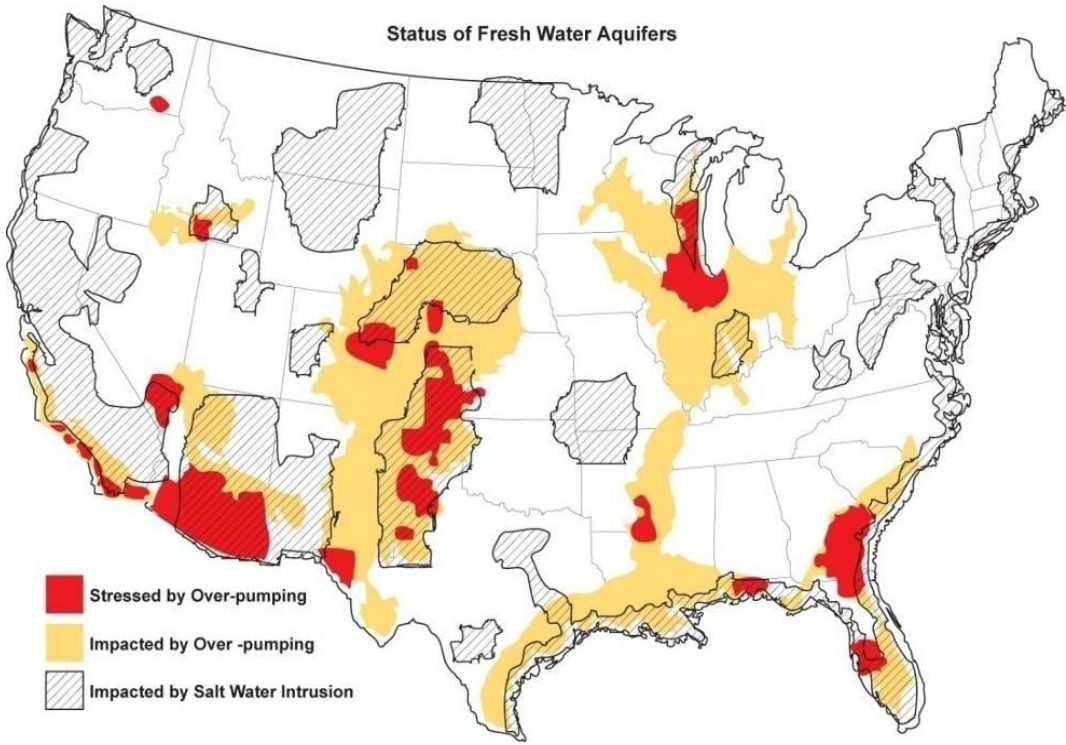


Environmental Impacts

- Continued Drought placing strain on water resources
  - –Current state in the West
    - Central Arizona Project 1.6MAF fully allocated
    - BOR projects ~ 3MAF imbalance on the CRB
    - Groundwater continues to be over drafted
    - Surface water is over appropriated
  - –As the strain on water supplies increase, costs rise
    - Greater emphasis will be placed on conservation measures
    - Alternative supplies will become cost effective to utilize

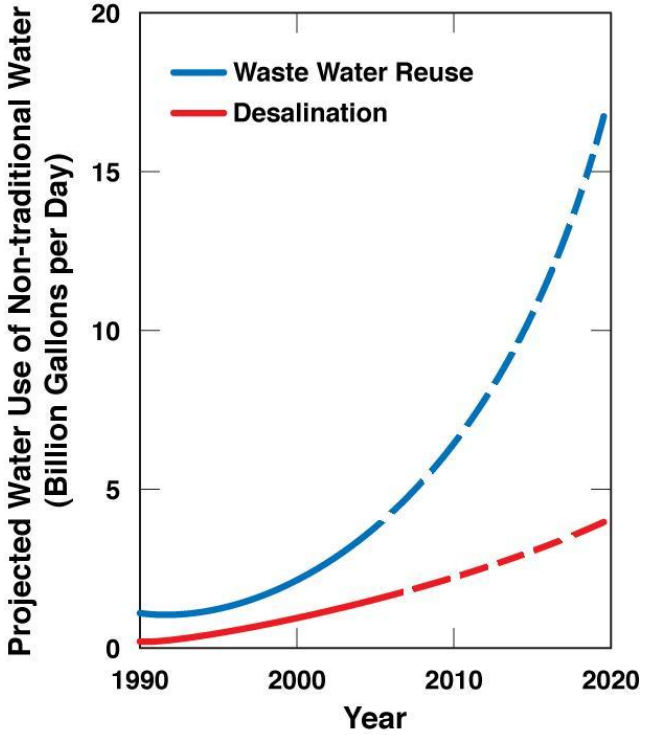
Growing Limitations and Impacts on Ground Water Availability

- Many major ground water aquifers seeing reductions in water quality and yield

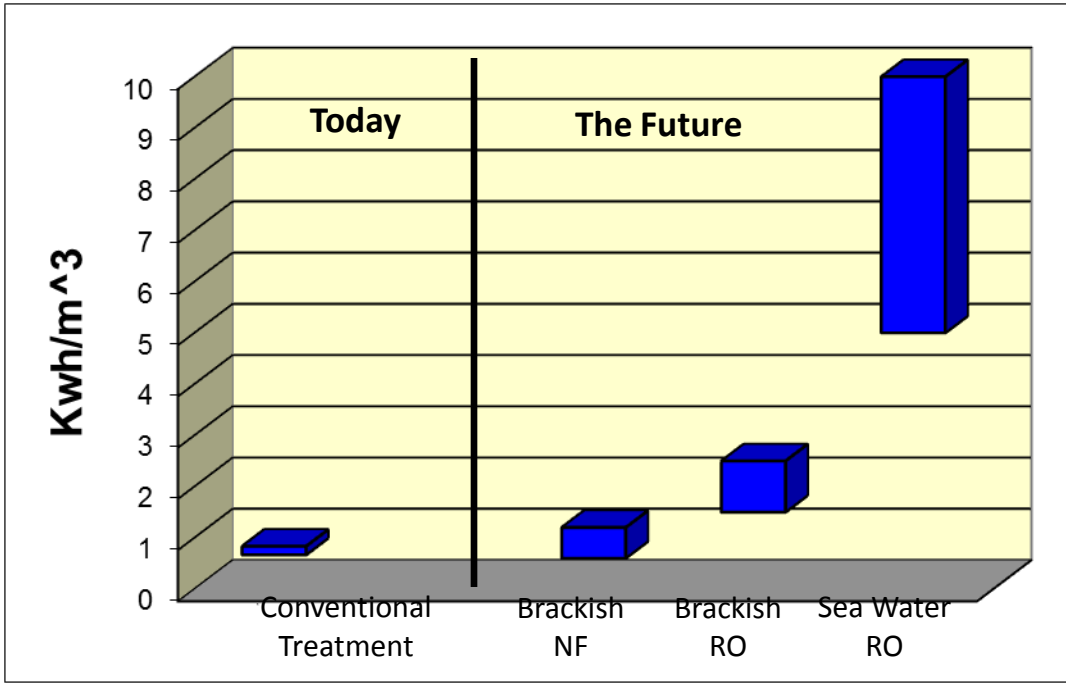


(Shannon 2007)

Growing Use of Non-traditional Water Resources



Power Requirements For Treating



(From EPA 2004, Water Reuse 2007, Mickley 2003)

- SDWA identifies new MCL's **(Einfeld 2007)**
- More stringent discharge requirements for WWTP's NPDES
- Desalination growing at 10% per year, wastewater reuse at 15% per year
- Non-traditional water use is energy intensive

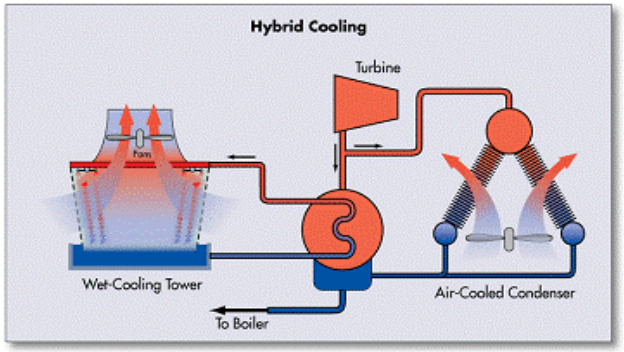
Cooling Tower Alternatives

- 100% Wet Cooling
  - Lowest cost solution
  - Highest net generation
  - Alternative supplies can be utilized
- 100% Dry Cooling
  - Highest cost
  - Lowest net generation
- Hybrid Cooling
  - Investment cost & life cycle cost varies based on the size of the dry section
  - Water savings dependent on size of dry section

Research and Technology

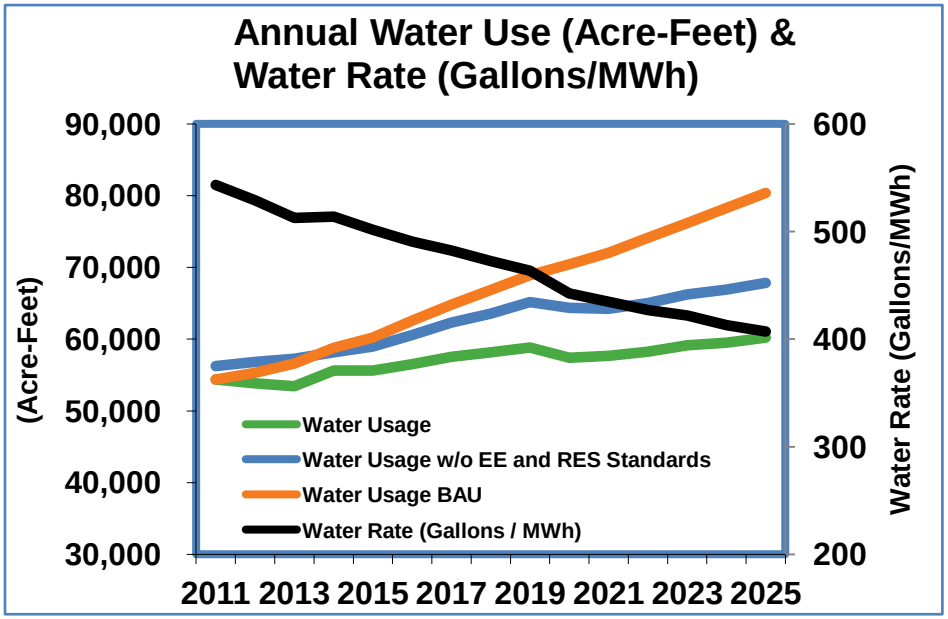
Water Research Center– Plant Bowen

1. Advanced Cooling Technology
2. Process wastewater treatment
3. Zero liquid discharge options
4. Moisture recovery processes
5. Solids landfill water management
6. Carbon technology water issues
7. Water use modeling - monitoring for best management practices



Future Water Usage for APS

- Renewable Energy – PV, Wind
- Energy Efficiencies & Distributed Energy
- Continue to evaluate cooling alternatives
- Ensure reliability/ sustainability of water supplies



Looking Forward

- Water and Energy are Interrelated - Conservation of one conserves the other
  - Promote water/energy conservation
  - Identify alternative cooling strategies
    - Investigate practical application of wet, dry, or hybrid cooling towers
  - Identify alternative cooling water sources
    - Right Water For "The Right Use"
      - Utilize impaired waters, where practical, and treat those waters to a quality suitable for use as cooling water
      - Conserve higher quality waters for use as potable water
  - Arizona has confronted these issues via
    - Blue Ribbon Panel on Reuse
    - Water Resource Development Commission
    - Colorado River Basin Supply and Demand Study
    - Central Arizona Salinity Study

The future will require all stakeholders working together to balance environmental concerns with cost impacts