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Integrating Water in Electric Transmission Planning

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Environmental Vision-An International Electricity Sector Conference
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U.S. DEPARTMENT OF ENERGY

NNSA National Nuclear Security Administration

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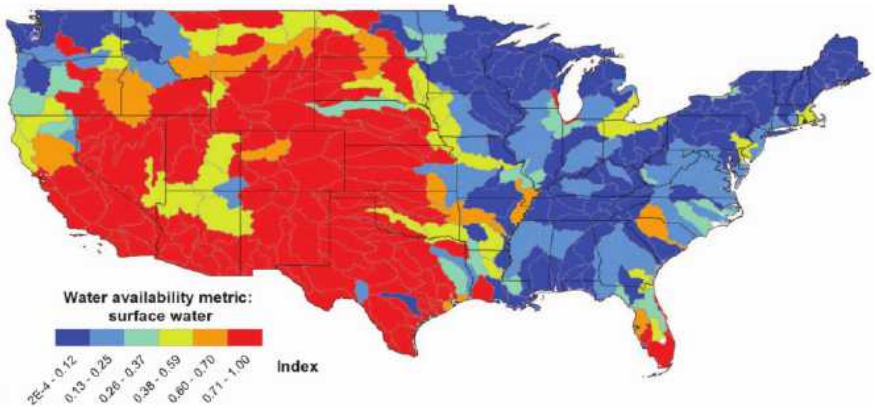
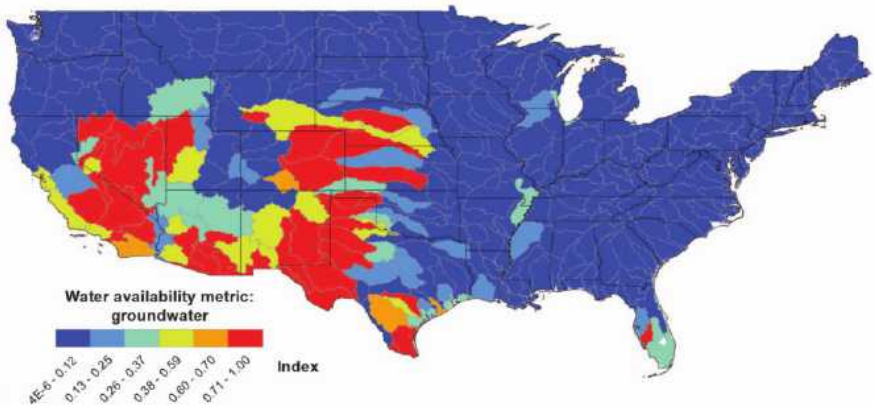
The Challenge

- Where is water for a growing electric sector going to come?
- Significant competition of available supplies of water.
- Available water supplies are not uniformly distributed over the United States.
- Historically, limited interaction between water and electric expansion planners.

Surface Water Availability



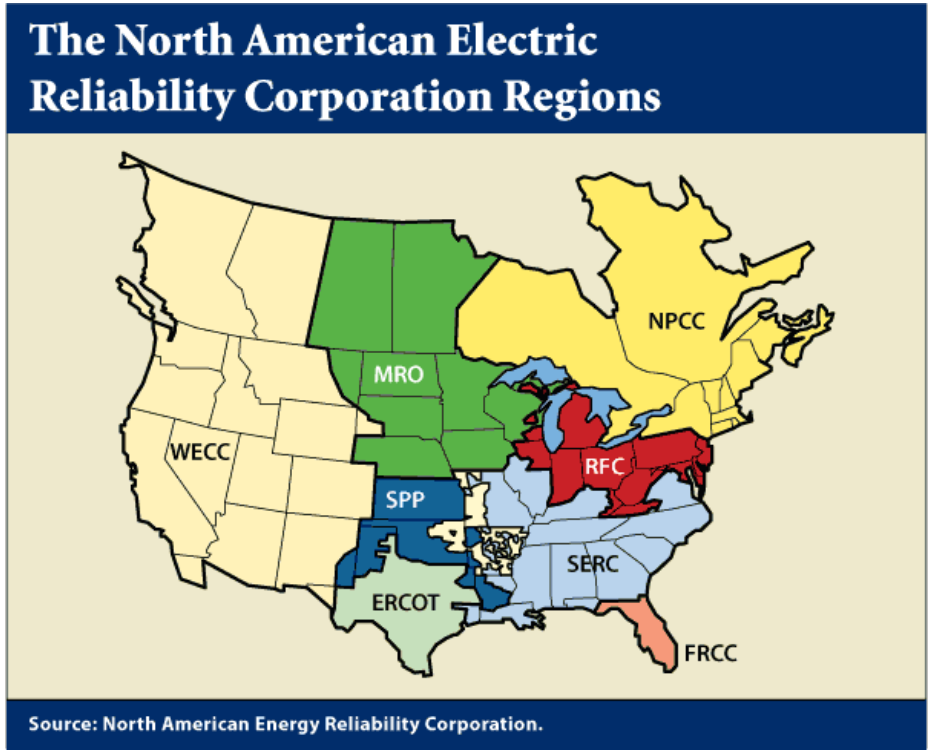
Groundwater Availability



Objective

- Integrate water related concerns into long-range transmission expansion planning (20 yrs.) of WECC:
  - Siting of new power plants
  - New transmission capacity

WECC

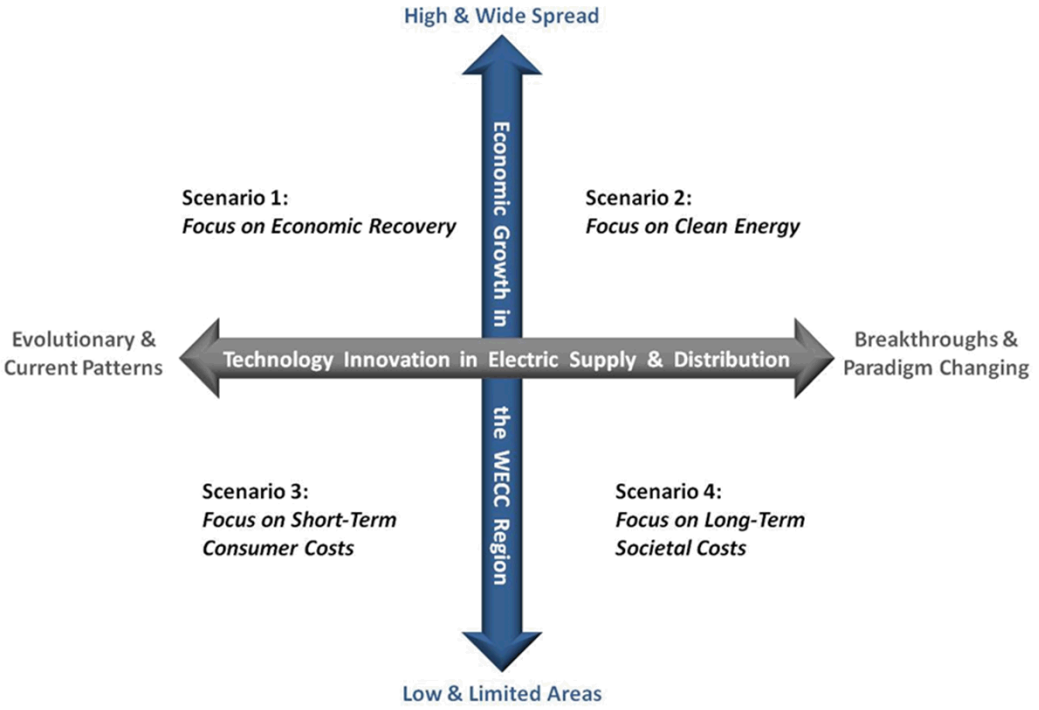


Western Governors' Association
Serving the Governors of 19 States and 3 US-Flag Pacific Islands

WSWC
Western States Water Council

Methods: Scenario Development

- ***Reference Case:*** adopted trajectory of recent WECC planning information.
- ***Scenario One:*** favored continued trends in growing use of natural gas and renewables.
- ***Scenario Two:*** distinct shift toward renewables, energy efficiency and significant carbon tax.
- ***Scenario Three:*** reliance on traditional technologies while simply meeting current state renewable portfolio standards.
- ***Scenario Four:*** similar technology development and policies as in scenario two except limited by sluggish economic growth.

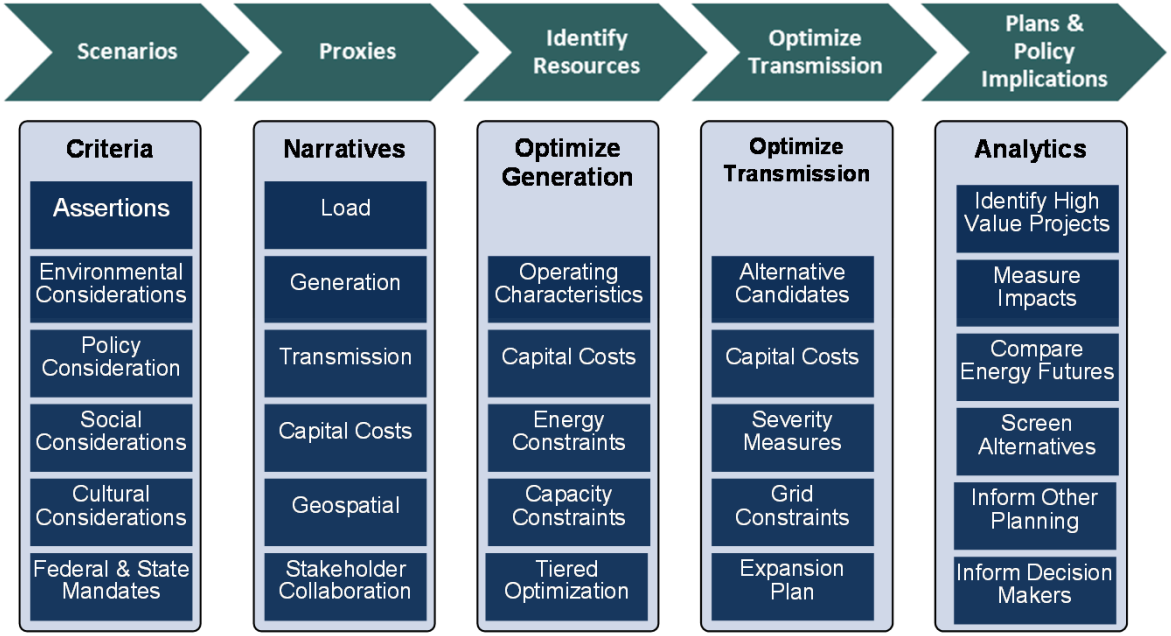


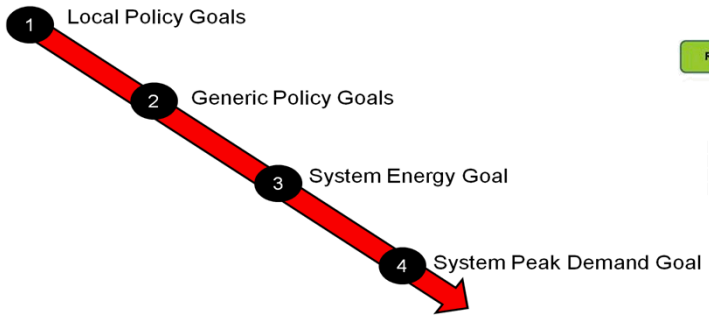
Source: WECC 2013

Methods: Capital Cost Expansion Tool

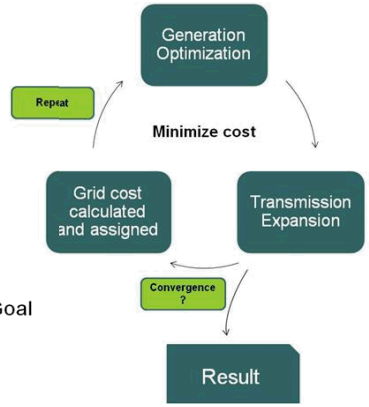
- Co-optimize generation and transmission additions.
- Least cost solution subject to goal related constraints:
  - Energy,
  - Policy,
  - Environmental, and
  - Societal conditions.
- Water is one of many considerations.

Source: WECC 2013





Generation Selection
Structuring of Goals

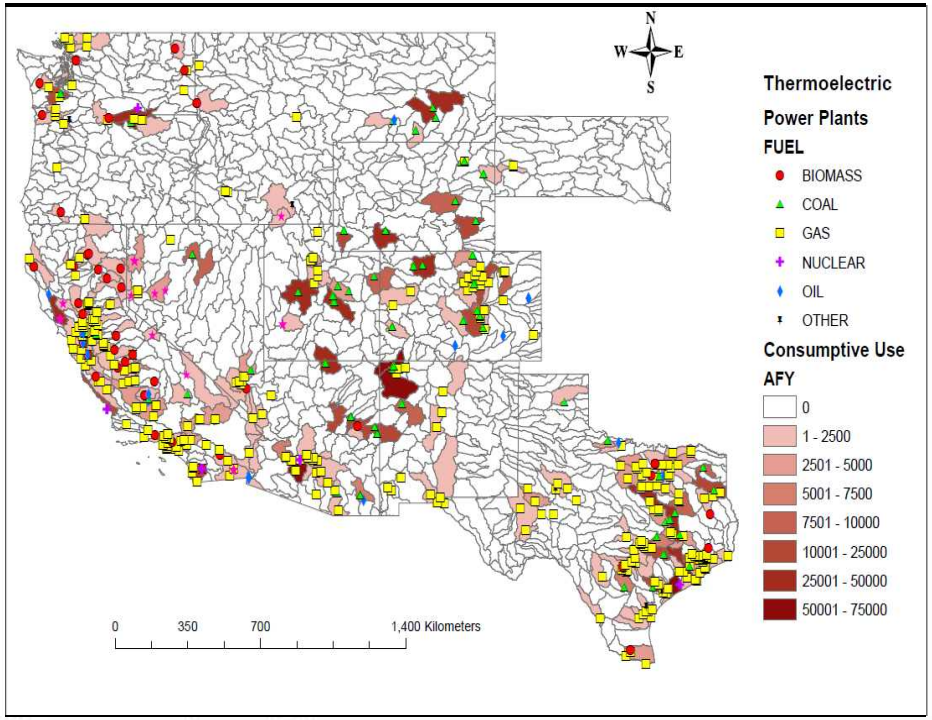


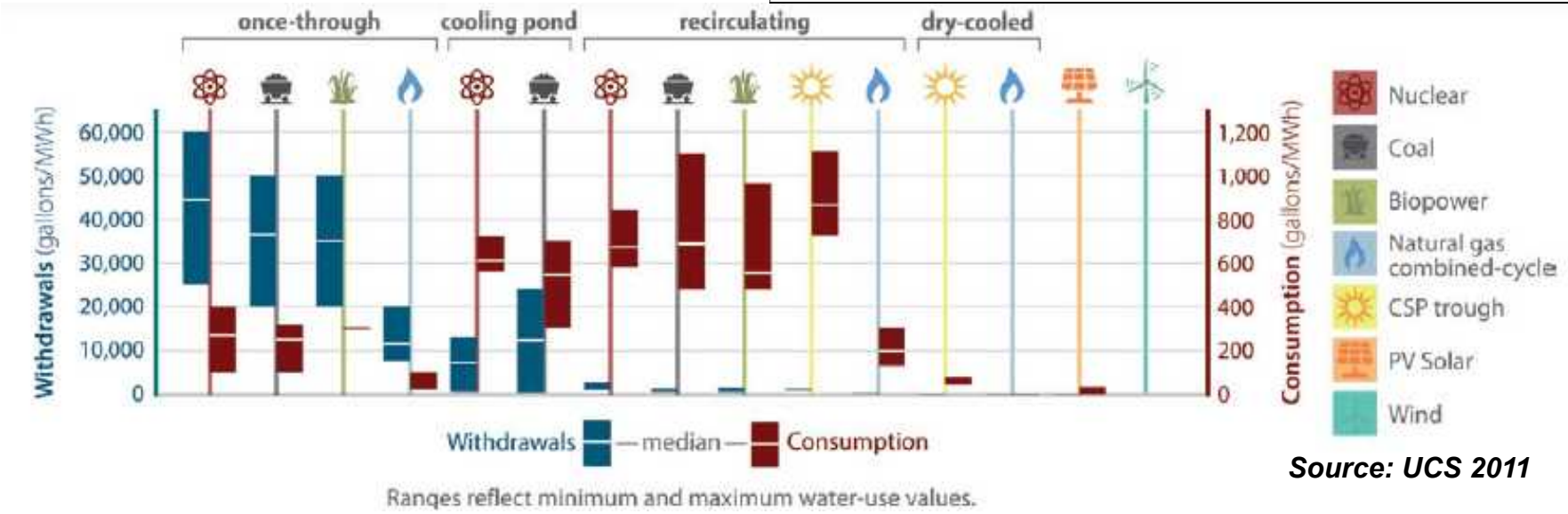
Optimization Iteration

Methods: Water for Thermoelectric Power

- Water withdrawal and consumption at existing power plants
- Water intensity of future thermoelectric power plants

Water Consumption for Existing Power Plants

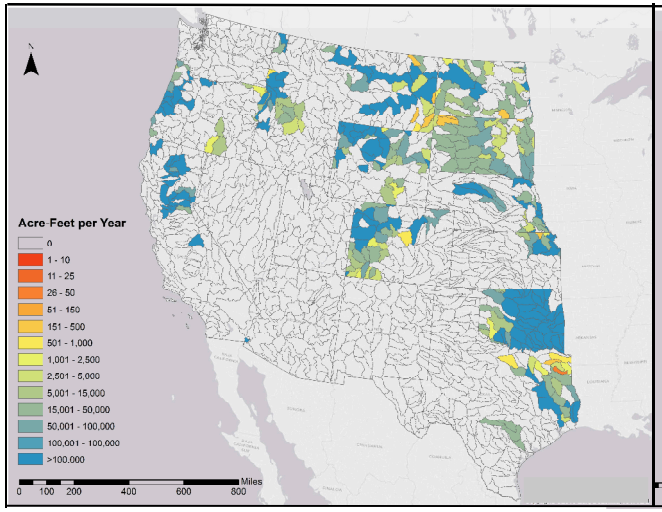




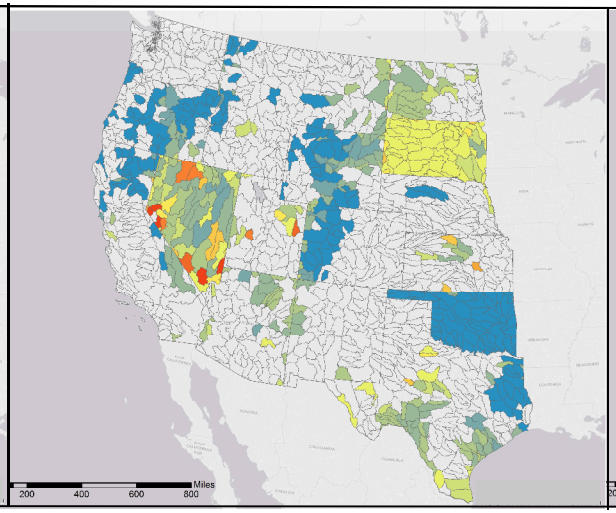
Source: UCS 2011

Methods: Water Supply Availability

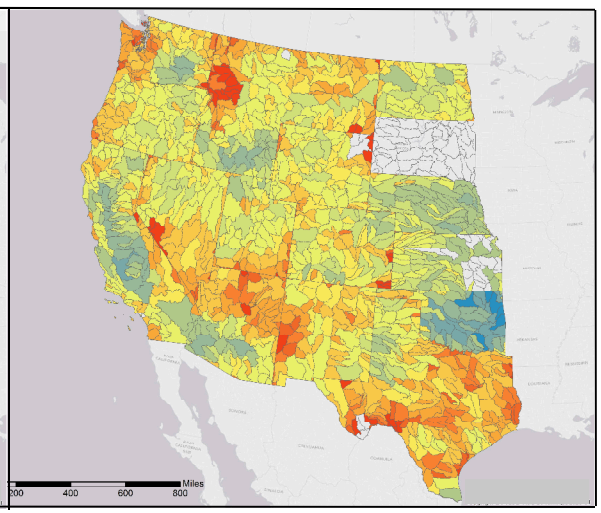
Unappropriated Surface Water



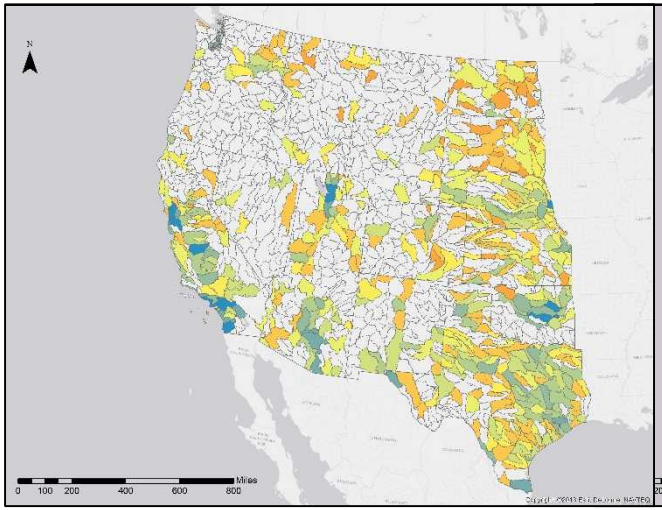
Unappropriated Groundwater



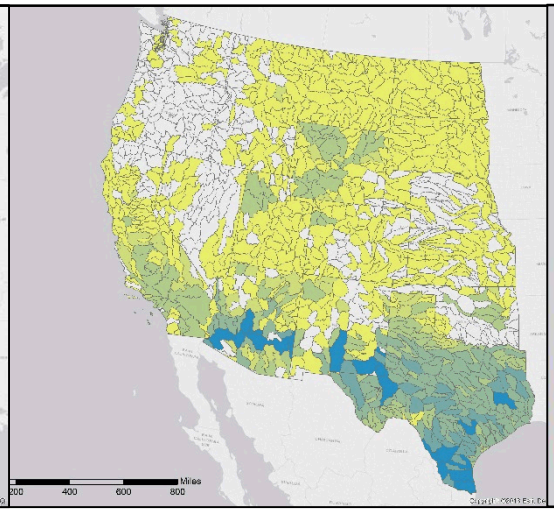
Appropriated Water



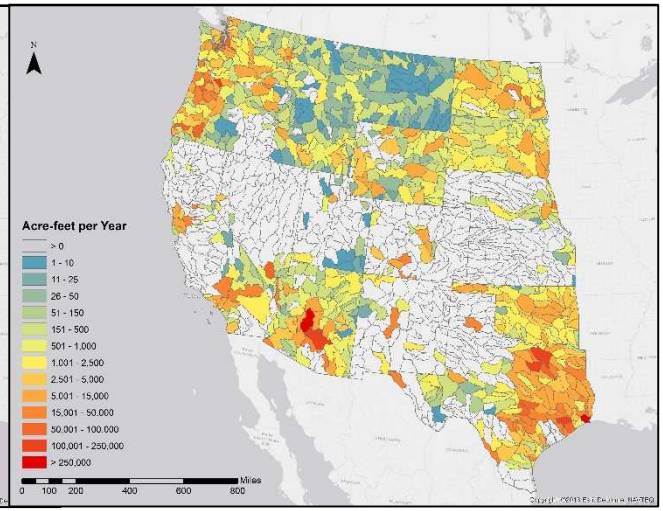
Municipal Wastewater



Brackish Groundwater

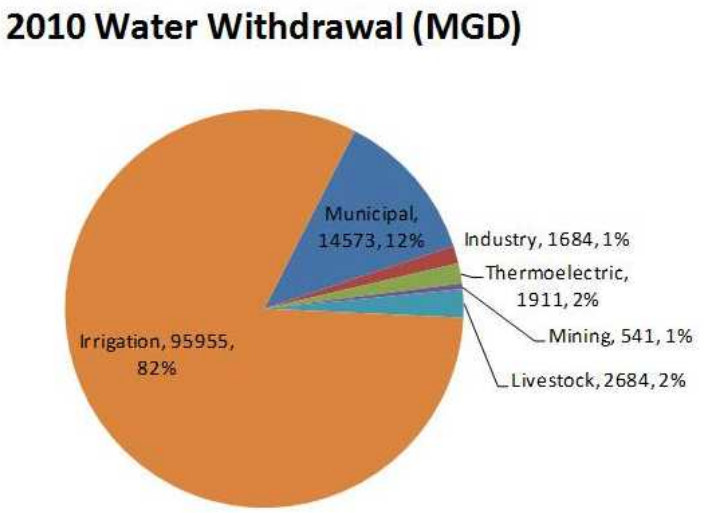


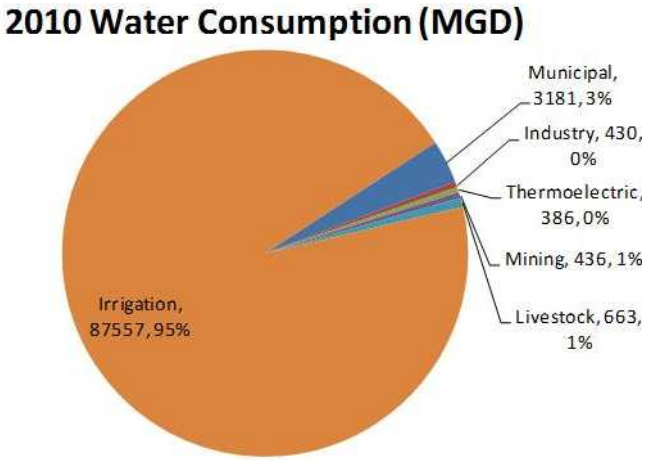
Consumptive Demand 2010-2030



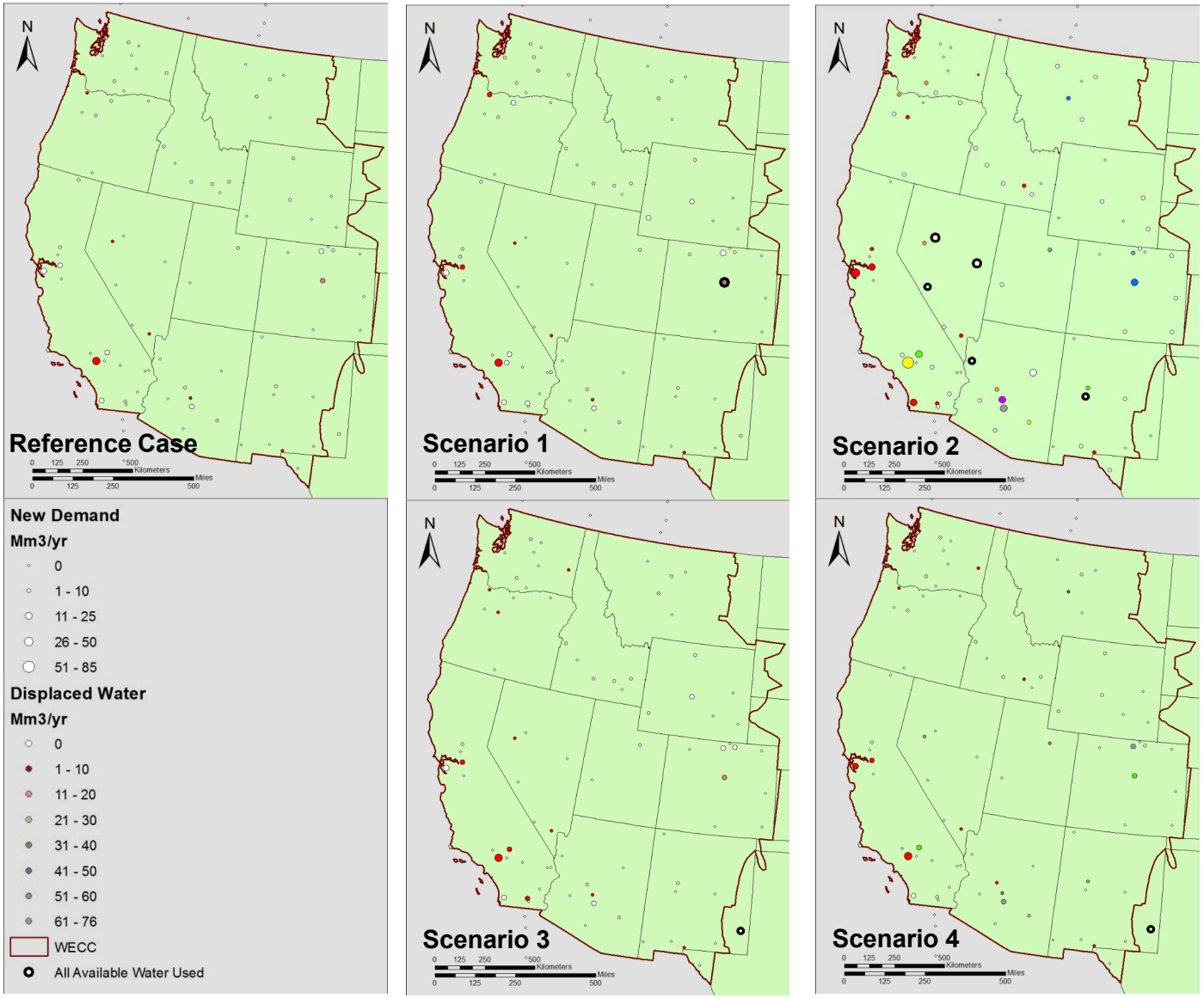
Results: Understanding Current Use

- Current thermoelectric water use is small relative to other sectors:
  - ~2 percent of withdrawals, and
  - <<1 percent of consumption.
- Largely result of closed loop cooling in West and high agricultural irrigation.
- Issue facing planners is not current use but where is the next drop of water coming from to meet *future use*?



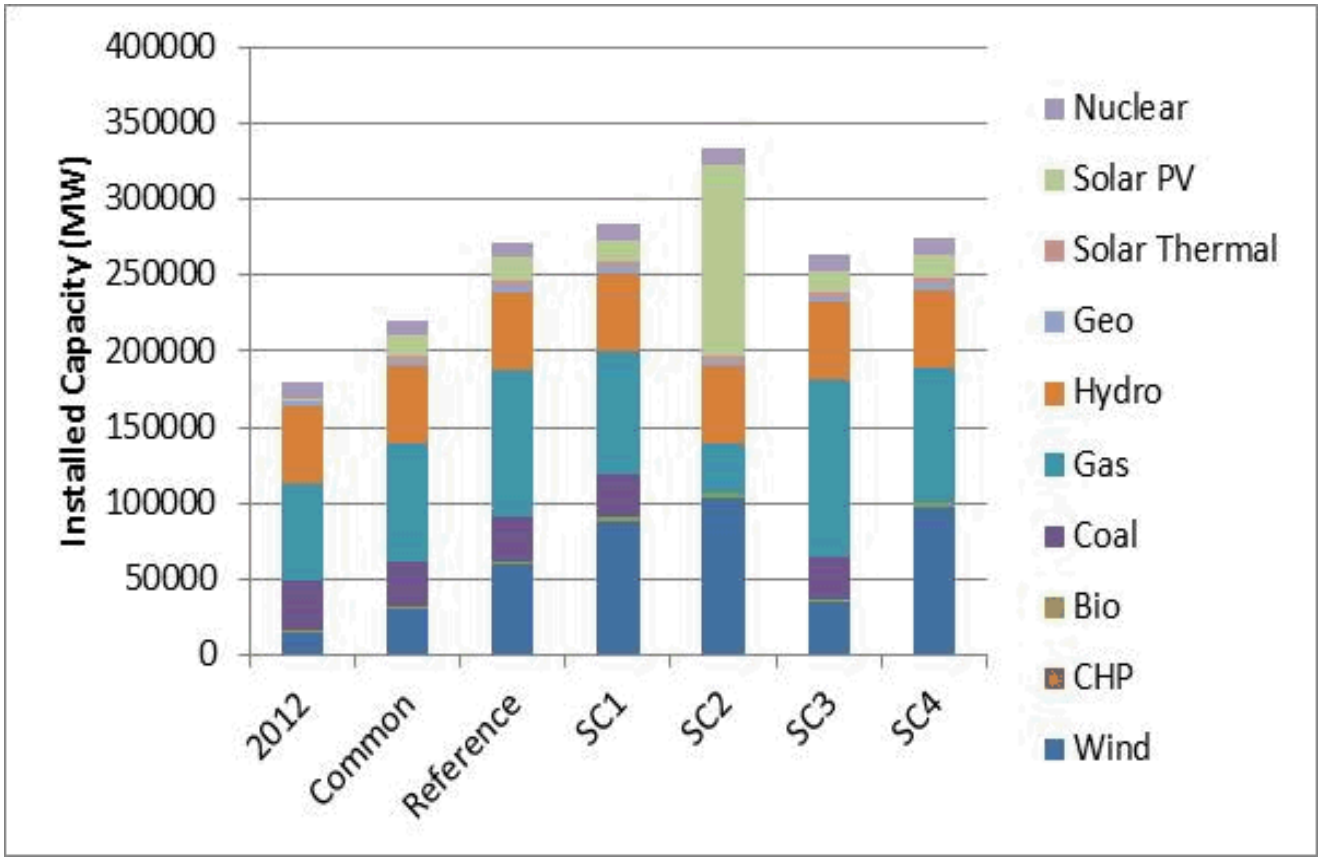


Results: Water Constraint

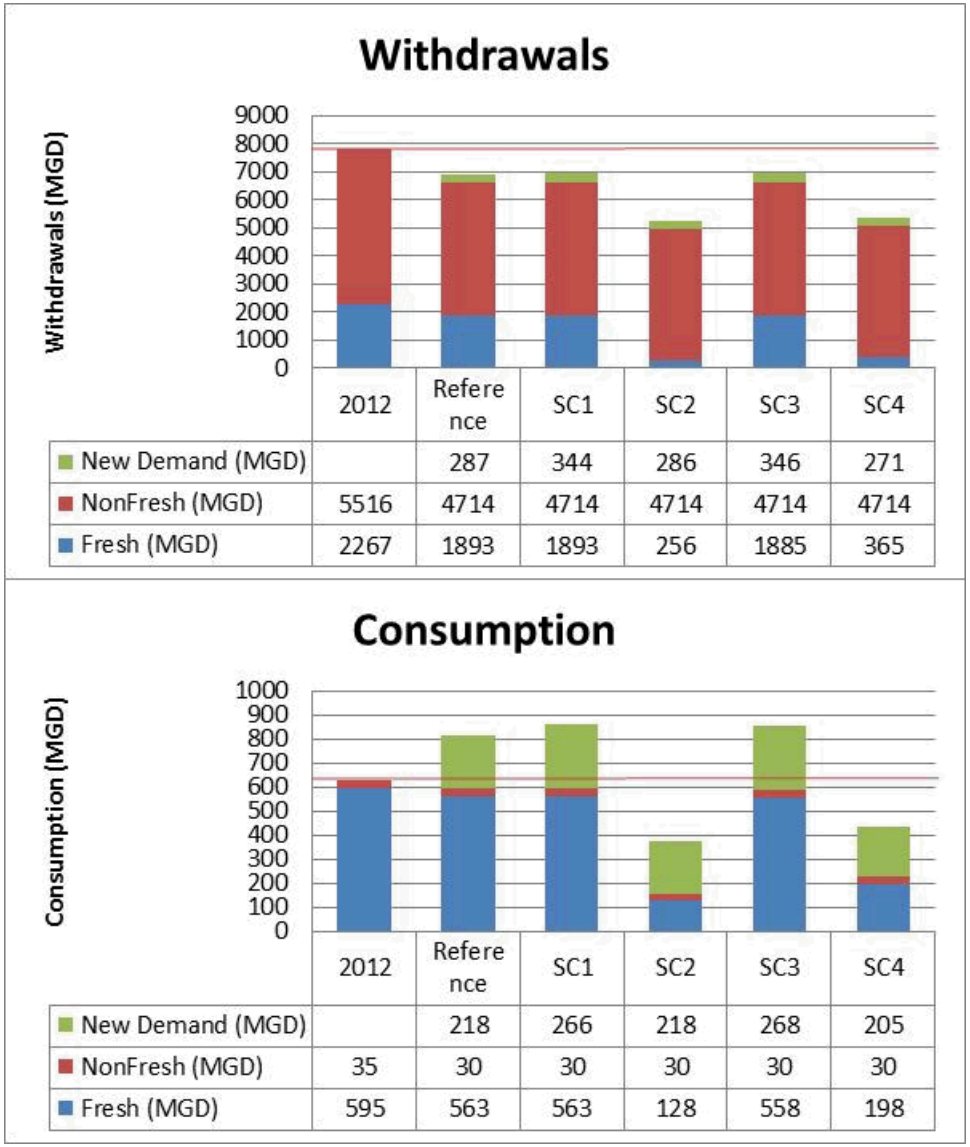


Results: Generation Expansion

- Uniform mix of additions across five scenarios:
  - Natural Gas Combined Cycle,
  - Wind, and
  - Solar PV.
- Coal generation displaced in Scenarios 2 and 4 due to emission policies.

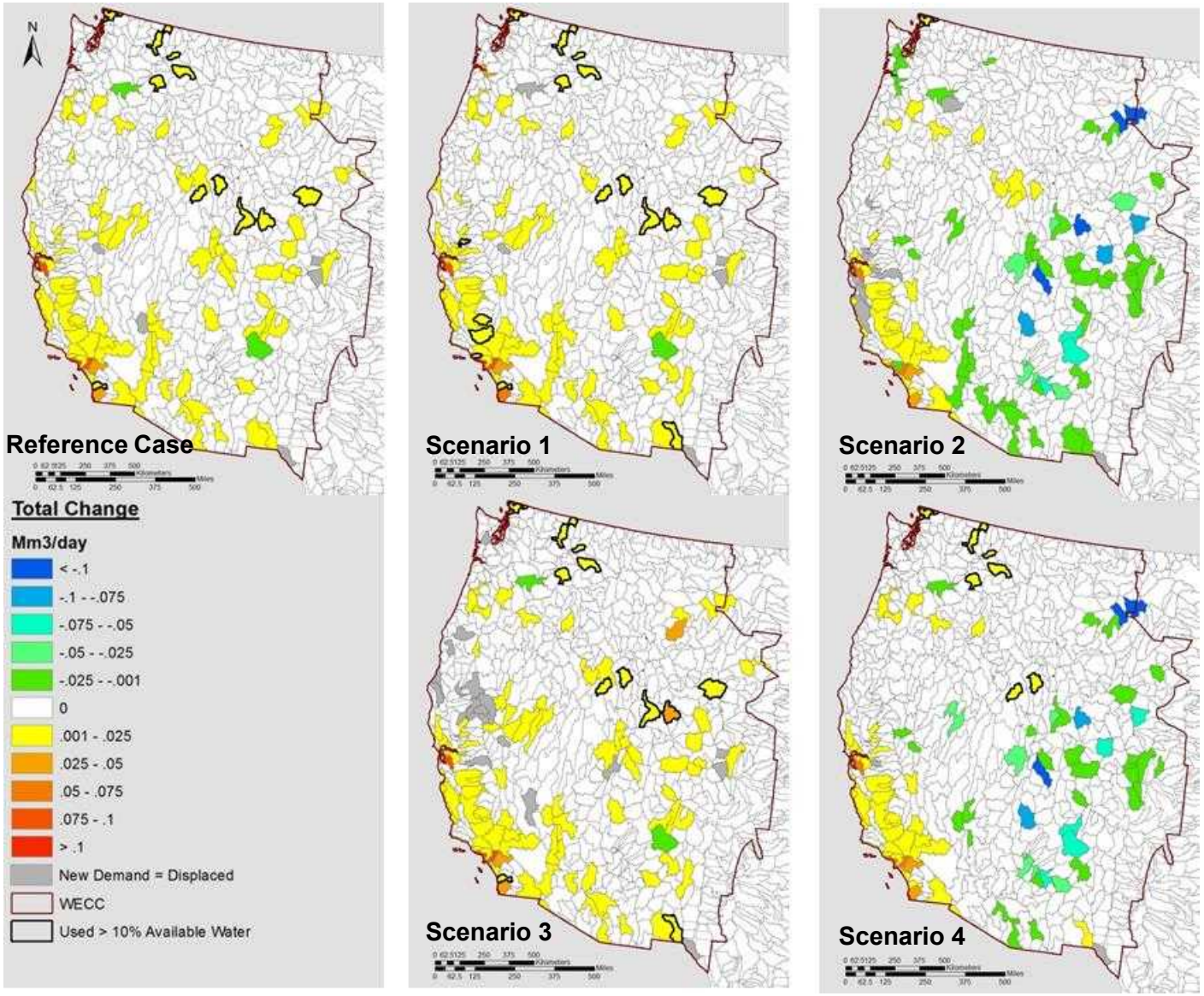


Results: Water Use

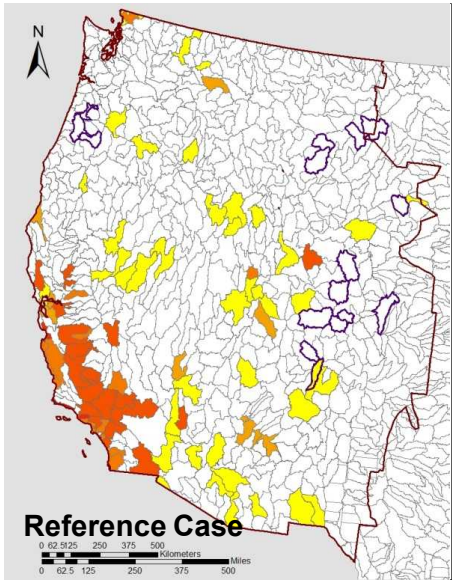


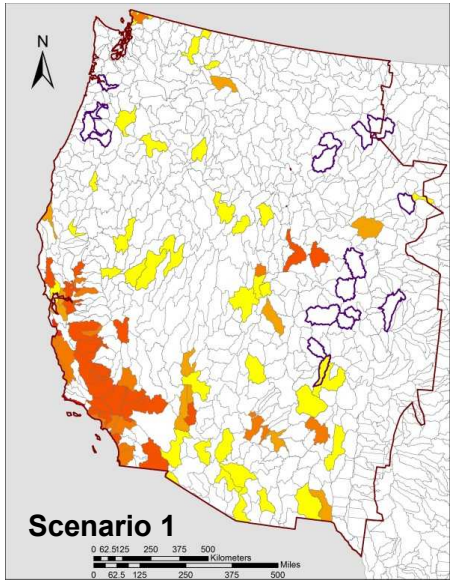
- Uniform reductions in withdrawals:
  - Similar additions across scenarios,
  - Retirements of 14% of seawater and 4 % freshwater withdrawals,
  - >70% displacement of freshwater withdrawal in scenarios 2 and 4
- Consumption varies by scenario:
  - Uniform additions,
  - >30% decrease for scenarios 2 and 4 (displaced coal)
  - >30% increase for other scenarios

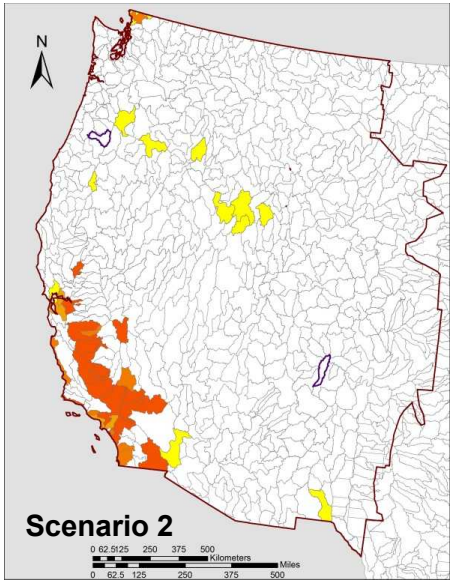
Results: Watershed Supply Analysis

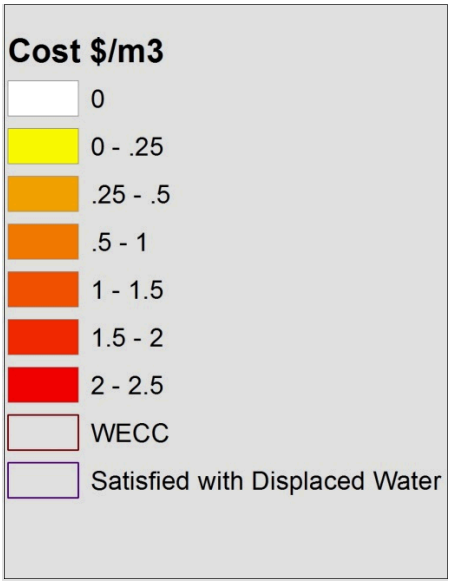


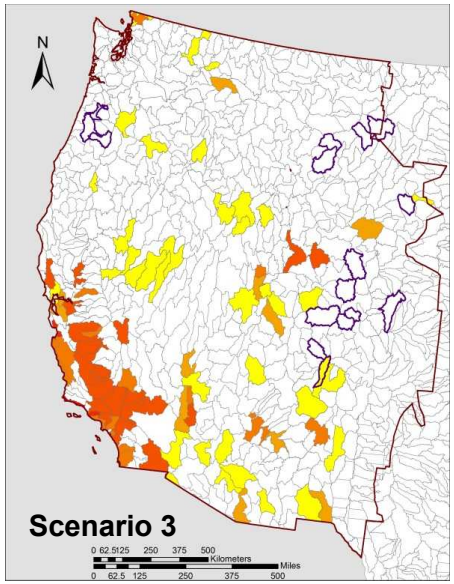
Results: Watershed Cost Analysis

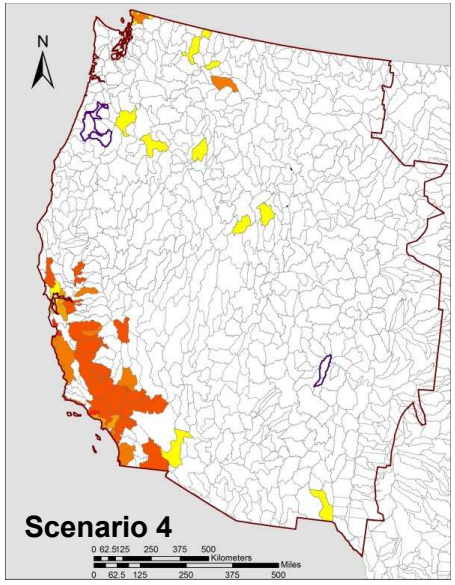










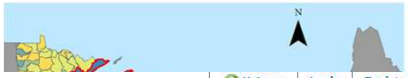


Takeaways

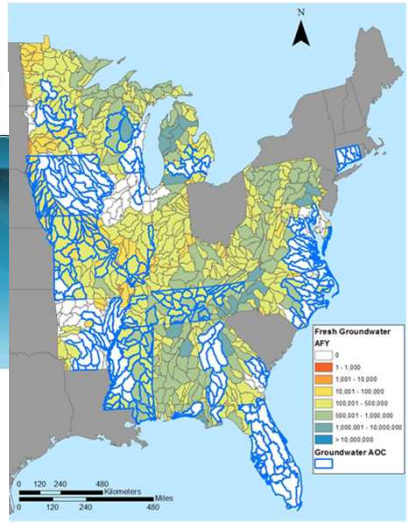
- Time and effort required to begin to “speak the same language.”
- Factors indirectly related to water (e.g., technology cost, energy policy) had greatest influence on future thermoelectric water use.
- Big difference in water use across scenarios, 30+% increase to a 30+% decrease in water consumption.
- Thermoelectric expansion can occur with limited impact on water resources of the West.
- Expansion will likely require increased use of non-traditional waters.

Eastern Interconnection

Fresh Surface Water



Fresh Groundwater



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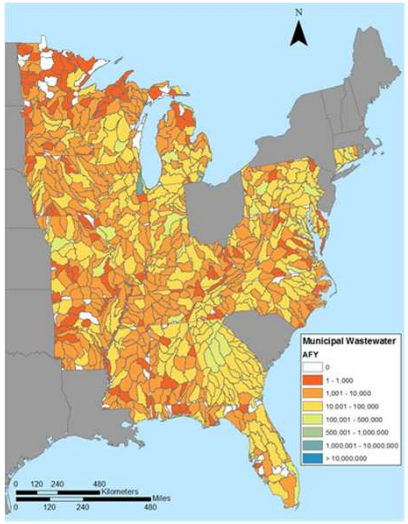

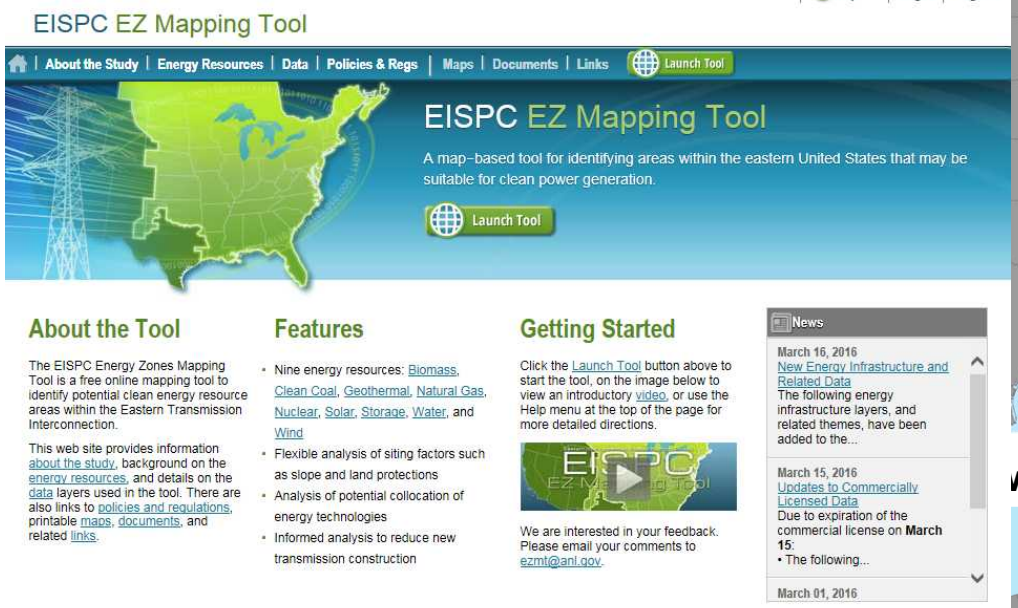

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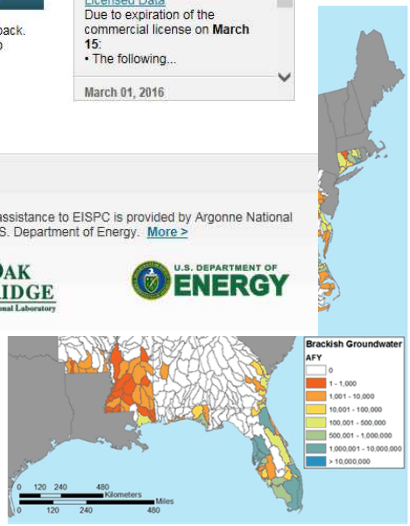

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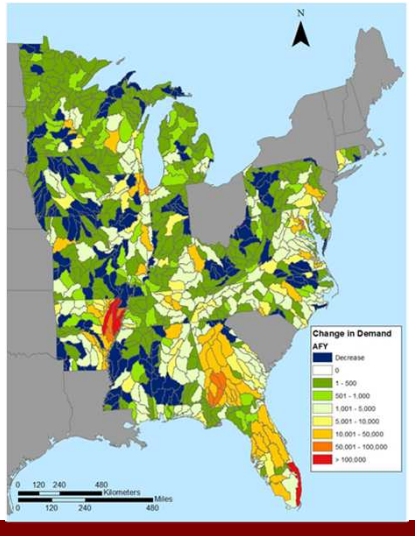
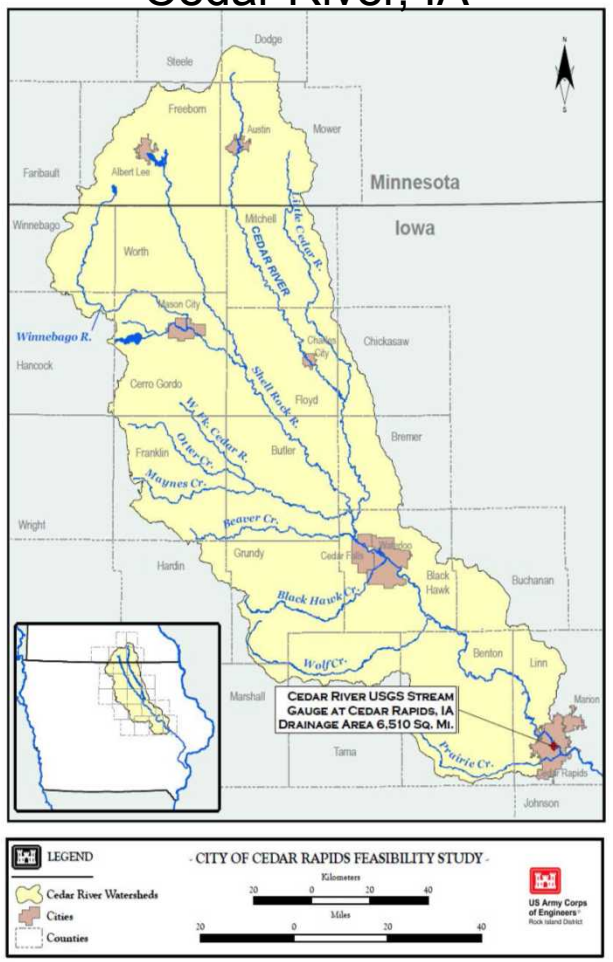


Electricity-Water-Climate Nexus

- How will climate variability impact operations of electric power systems:
  - Electricity demands,
  - Water deliveries,
  - Hydropower production, and
  - Extreme events?

San Juan River, NM

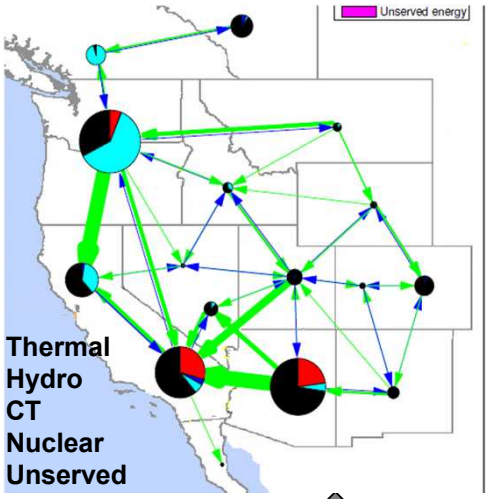
Cedar River, IA



Electricity-Water-Climate Nexus

- Framework that links natural and engineered systems to evaluate climate vulnerabilities:
  - Multiple interdependent systems,
  - Multiple interacting scales, and
  - Multiple stakeholders.

Western Grid



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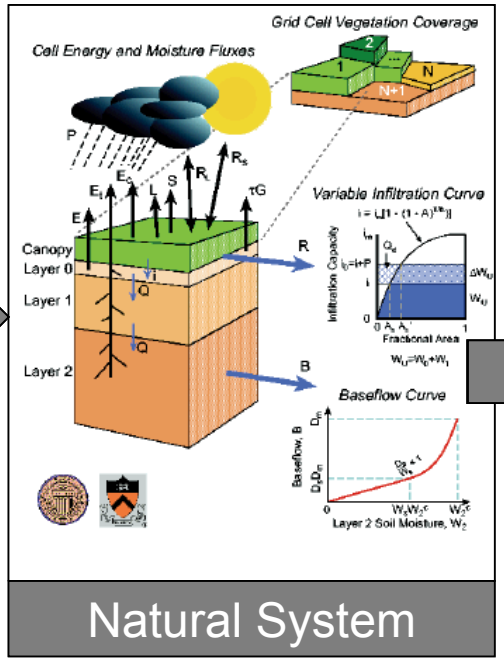
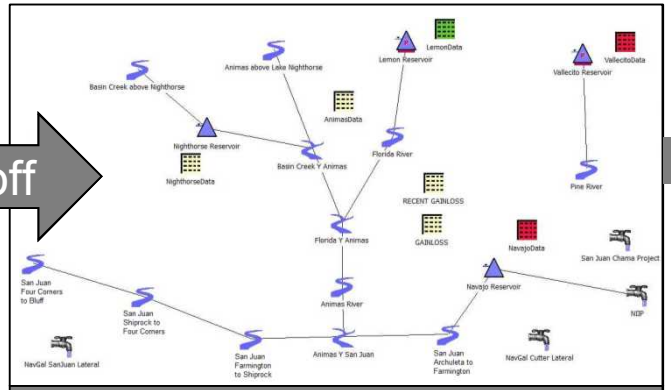
Climate



Natural System

Runoff



Engineered System

Deliveries

- Electric Power
- Irrigation
- Instream Flows
- Compact Native American

- Project data available at:

http://energy.sandia.gov/?page_id=1741

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