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Water as a Constraint on Transmission Expansion Planning

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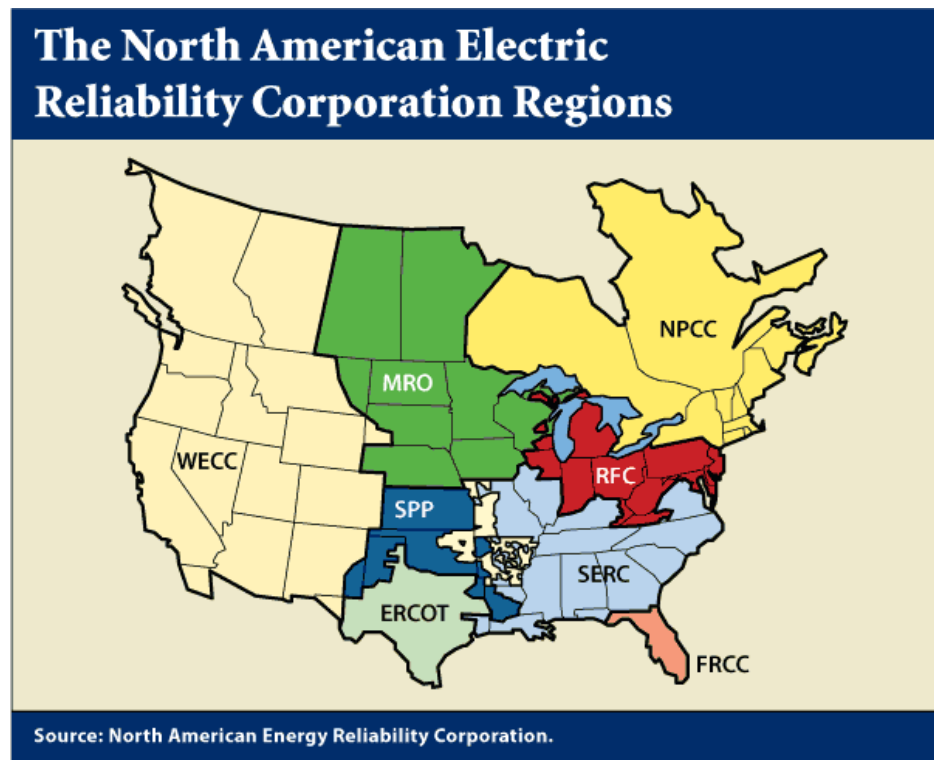
West Coast Climate Strategies Forum
San Diego, October 20, 2016



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Integrated Planning of Water and Energy

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



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WECC

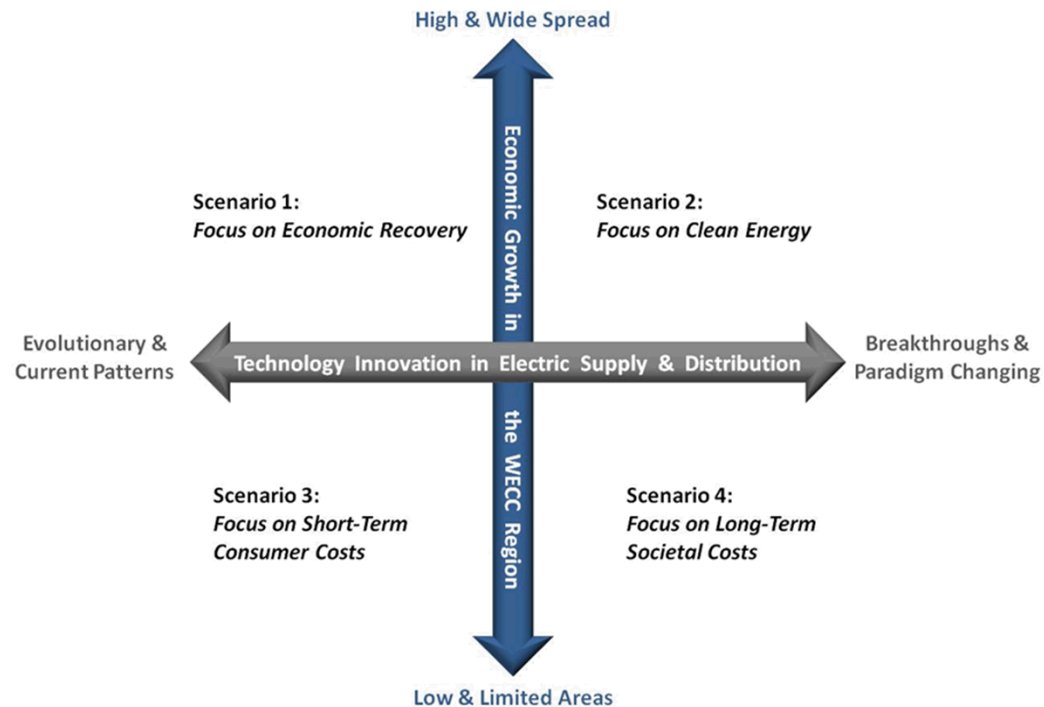


WSWC

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.

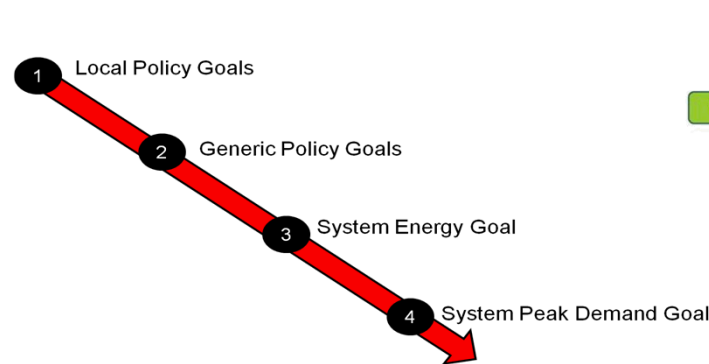
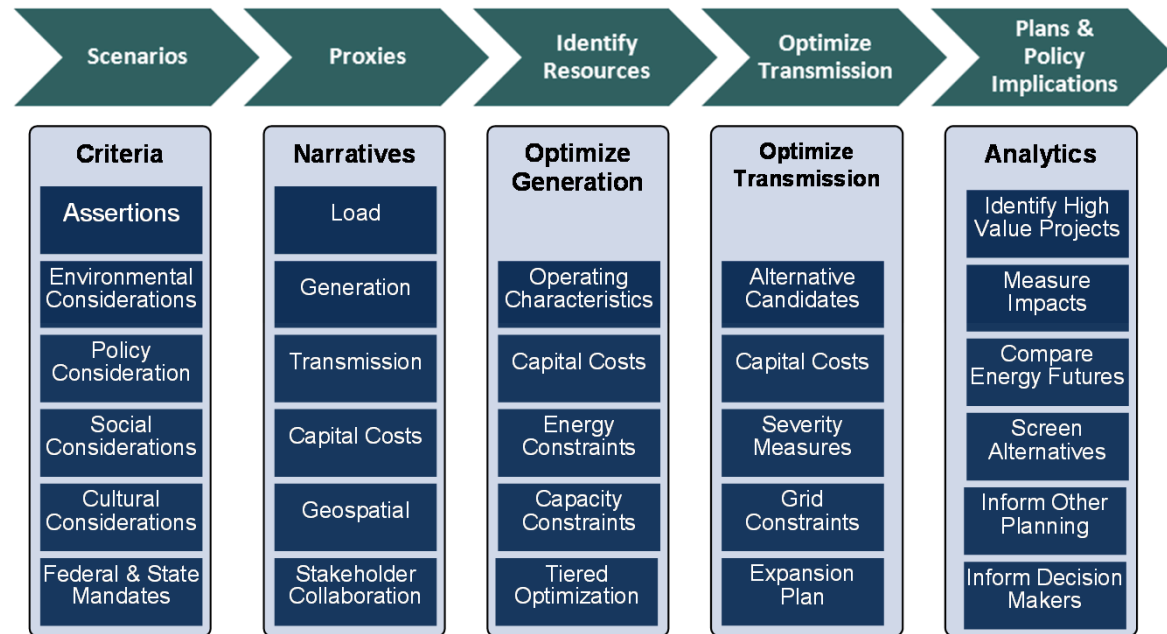


Source: WECC 2013

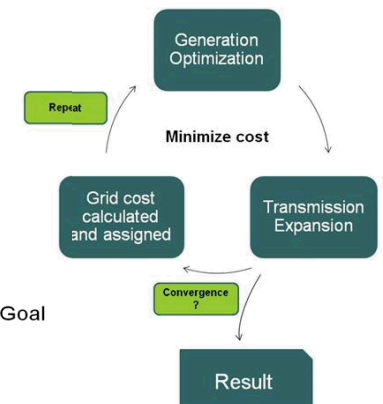
Methods: Capital Cost Expansion Tool

Source: WECC 2013

- 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.



*Generation Selection
Structuring of Goals*

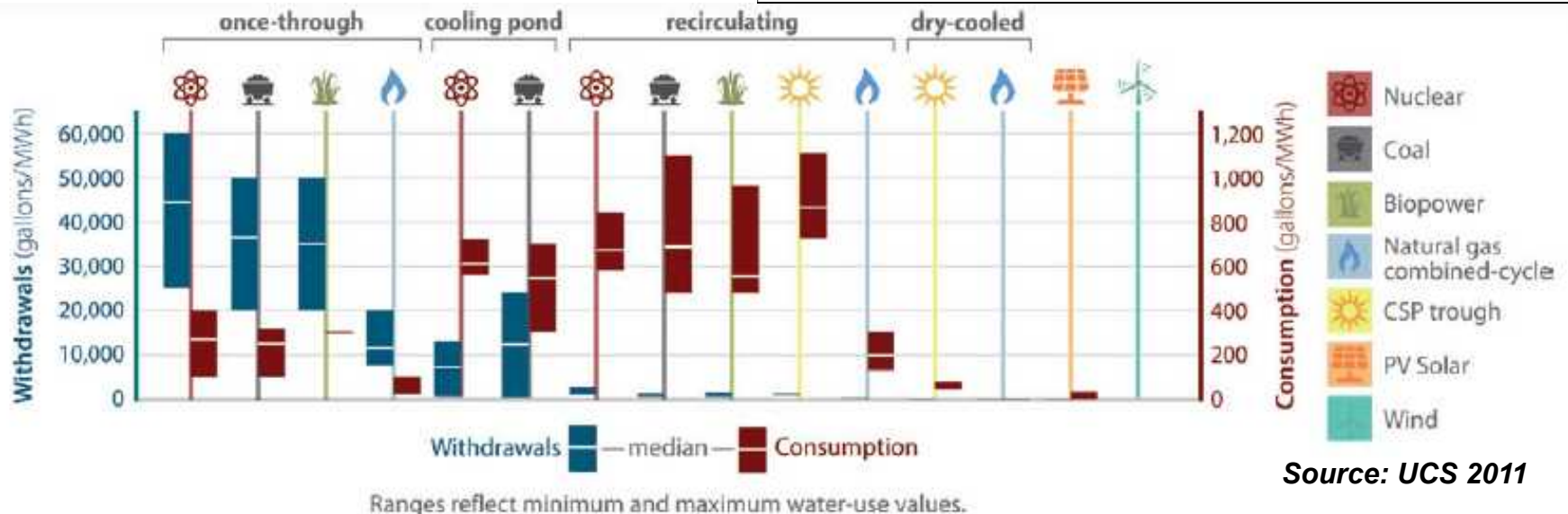
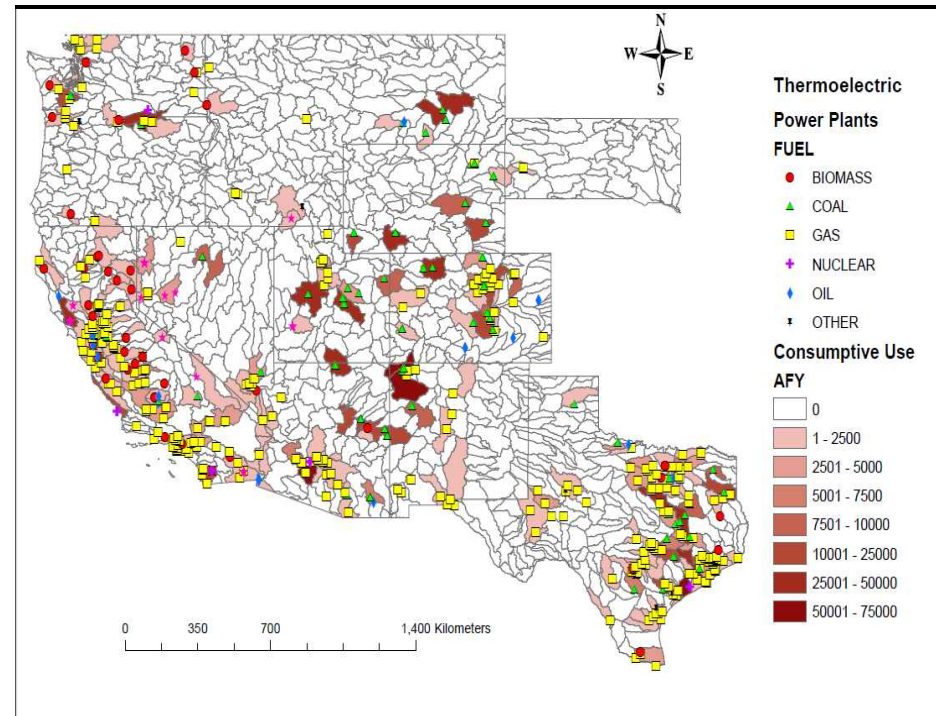


Optimization Iteration

Methods: Water for Thermoelectric Power

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

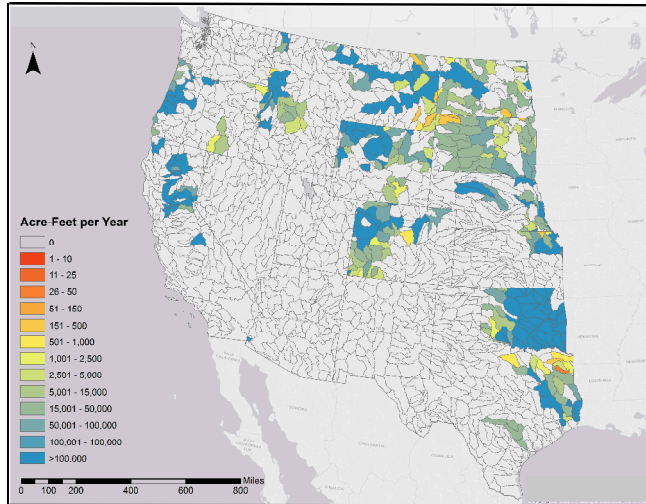
Water Consumption for Existing Power Plants



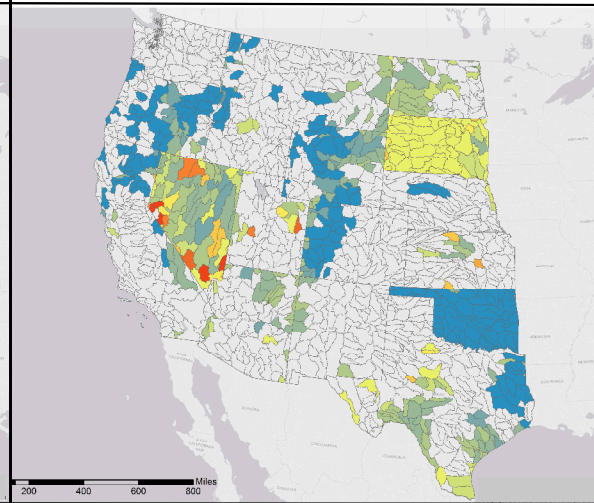
Source: UCS 2011

Methods: Water Supply Availability

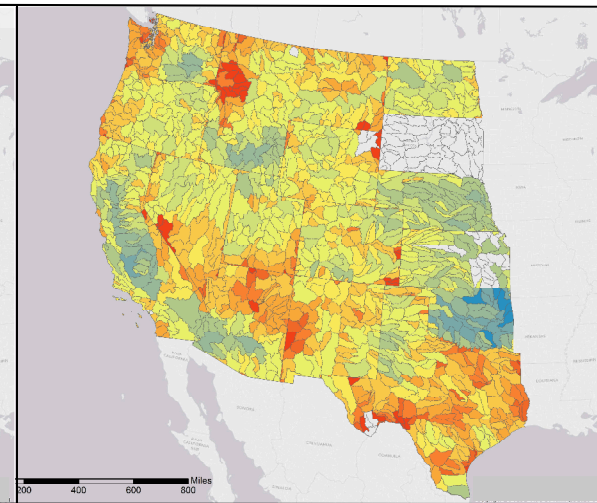
Unappropriated Surface Water



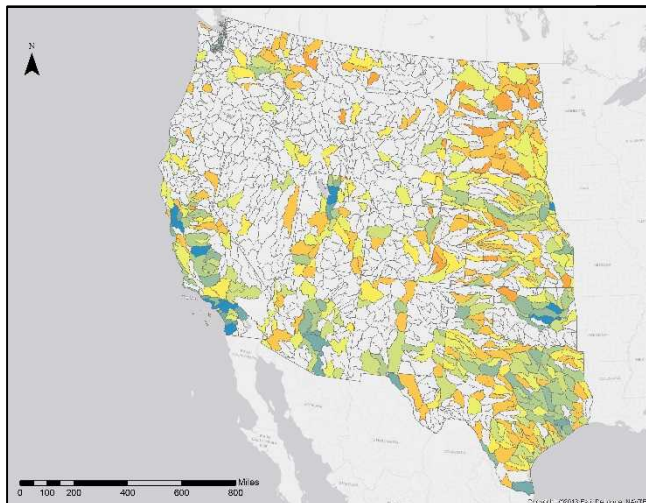
Unappropriated Groundwater



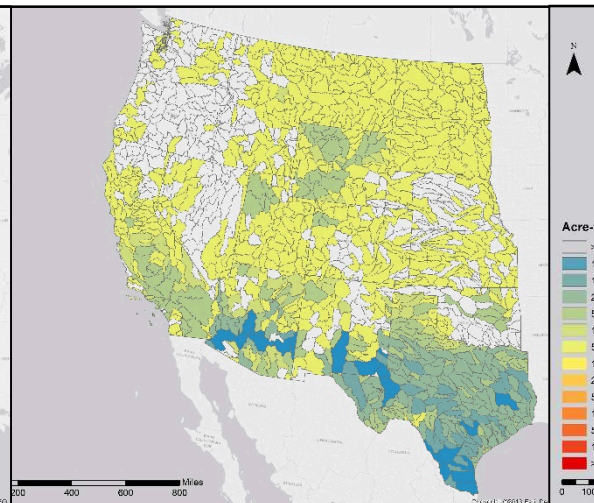
Appropriated Water



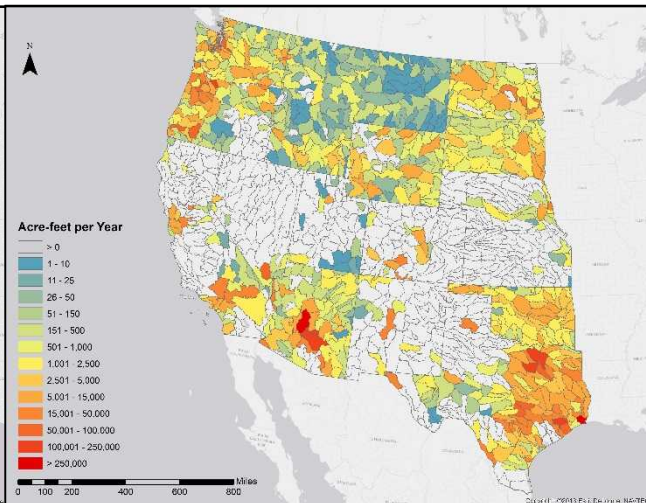
Municipal Wastewater



Brackish Groundwater

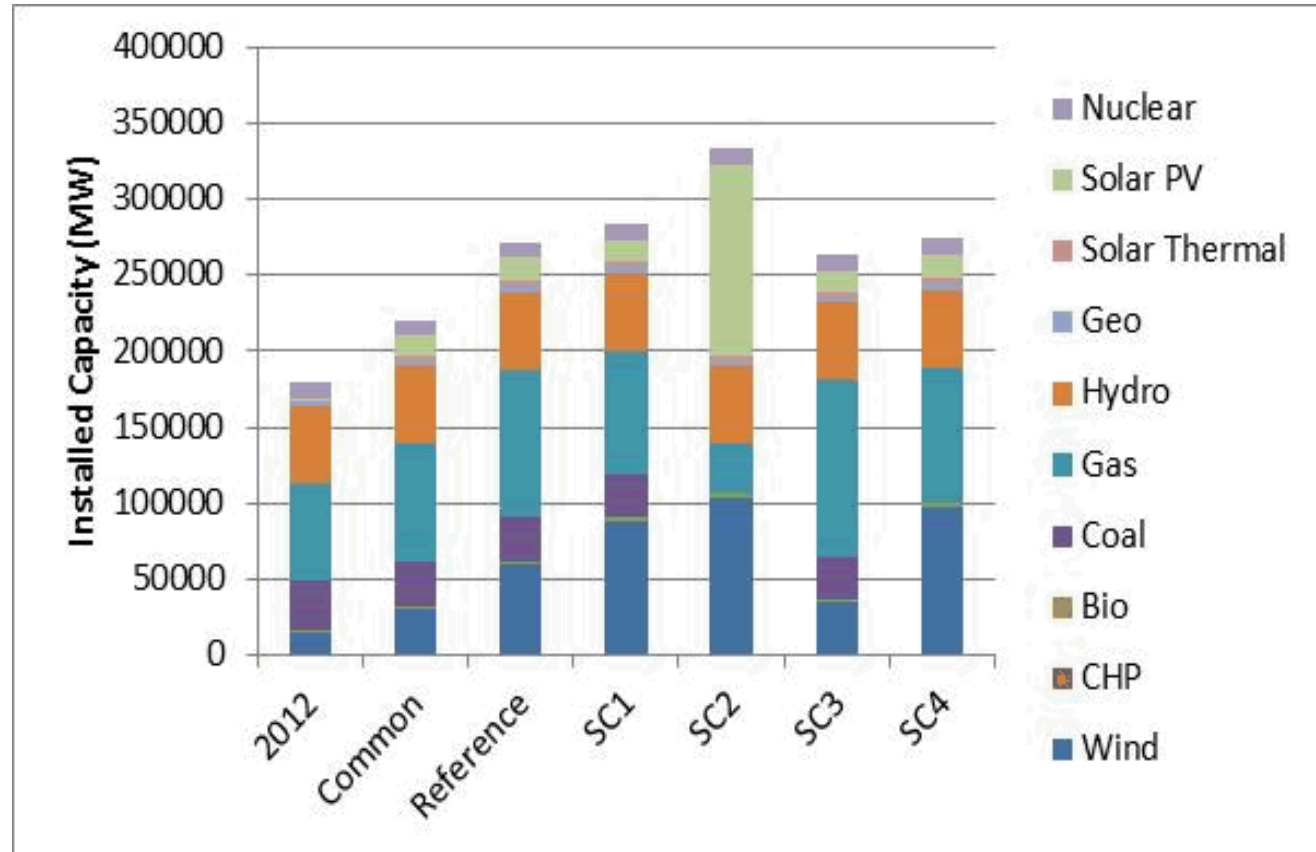


Consumptive Demand 2010-2030

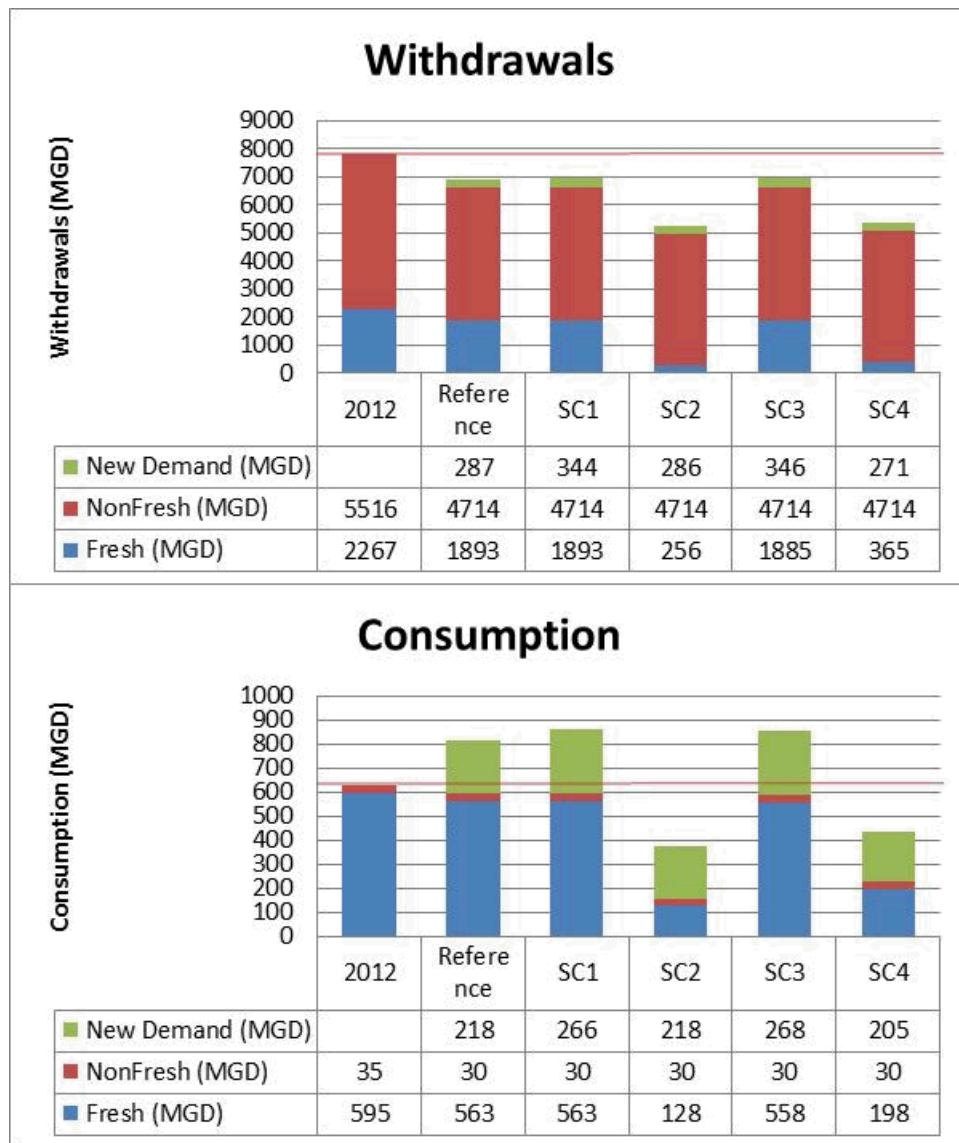


Results: Generation Expansion

- 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.

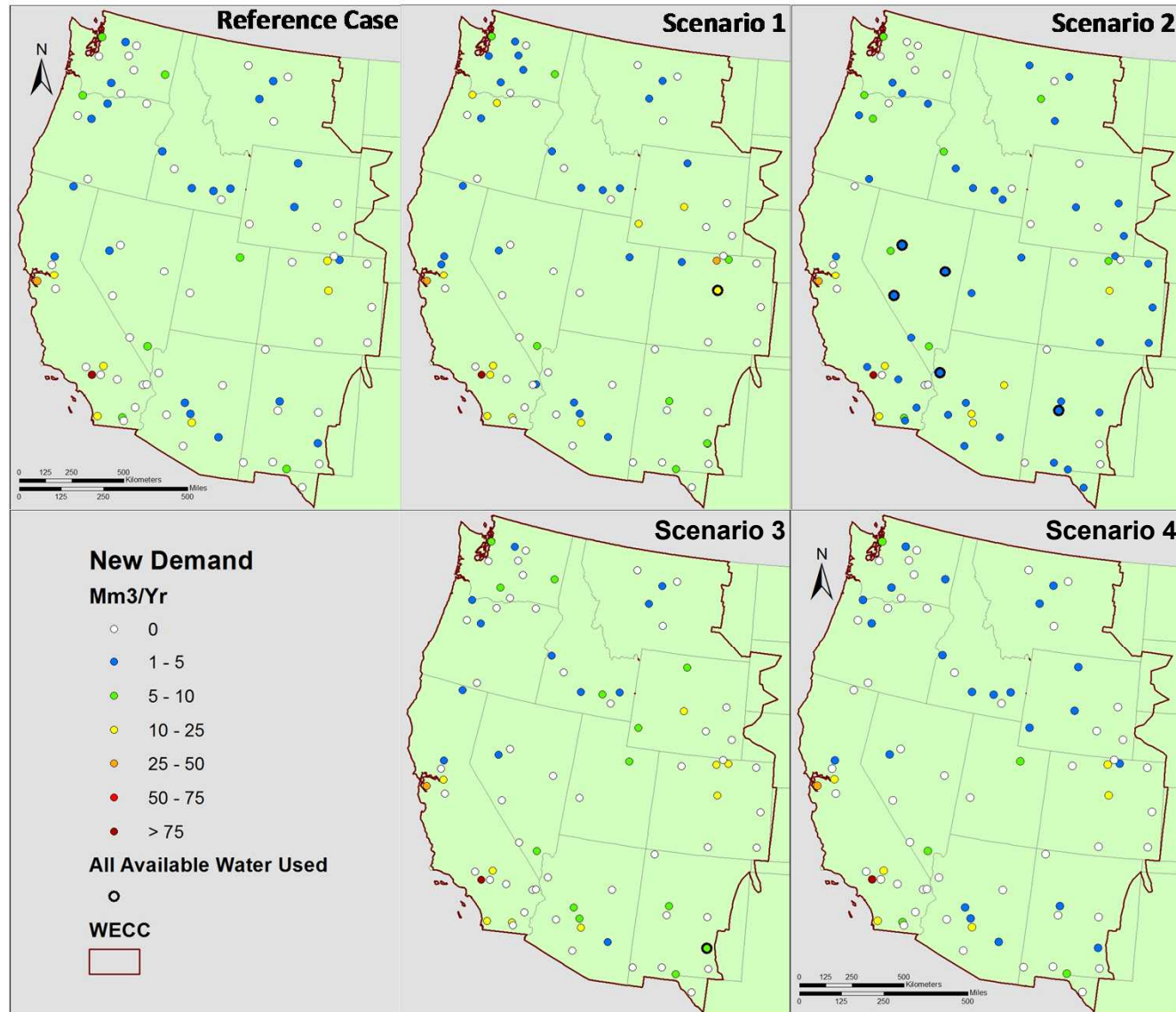


Results: Water Use

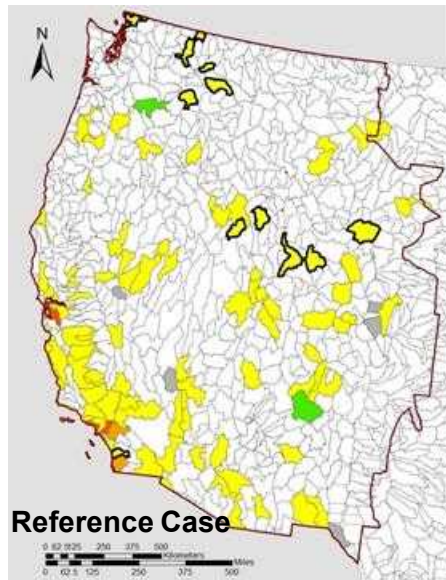


- Uniform reductions in withdrawals:
 - Similar additions across scenarios,
 - Retirements of 14% of seawater and 4 % freshwater withdrawals,
 - >70% displacement of freshwater withdrawal in scenarios 2 and 4
- Consumption varies by scenario:
 - Uniform additions,
 - >30% decrease for scenarios 2 and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

Results: Water Constraint



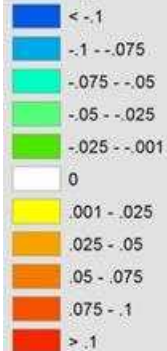
Results: Watershed Supply Analysis



Reference Case

Total Change

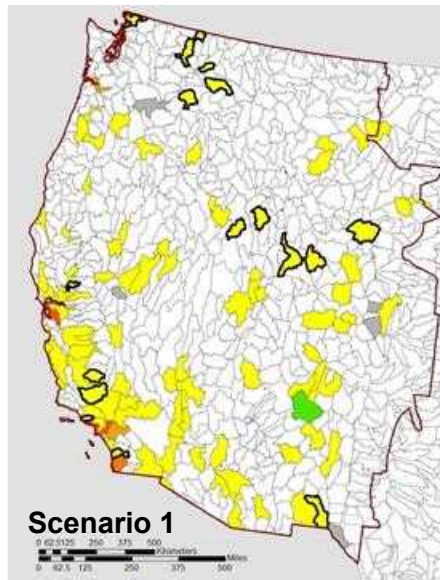
Mm3/day



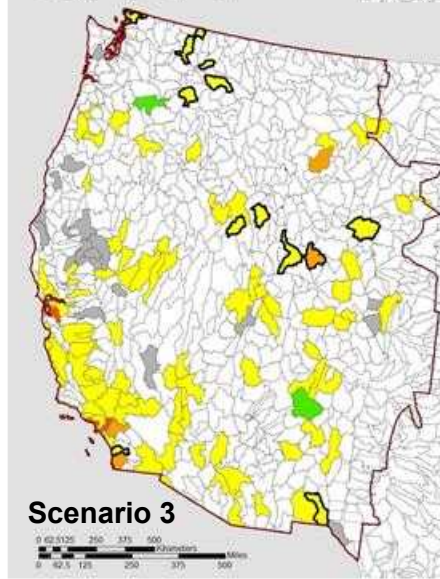
Gray New Demand = Displaced

Pink WECC

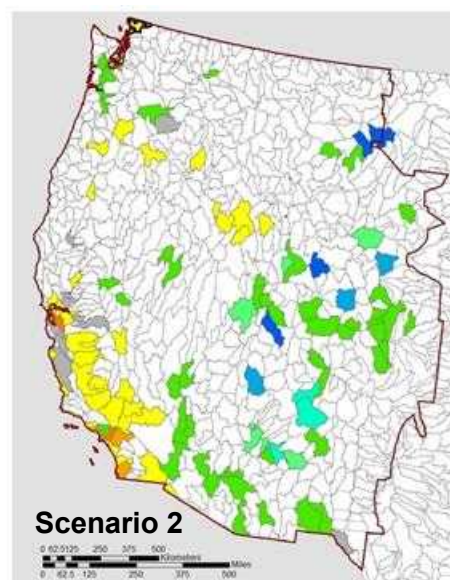
White Used > 10% Available Water



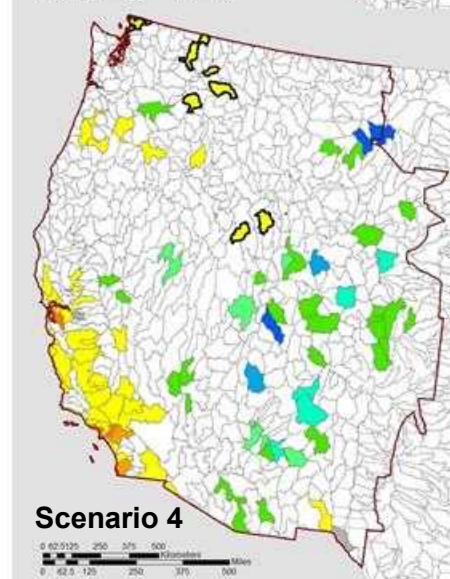
Scenario 1



Scenario 3



Scenario 2



Scenario 4

Results: Importance of Alternative Water

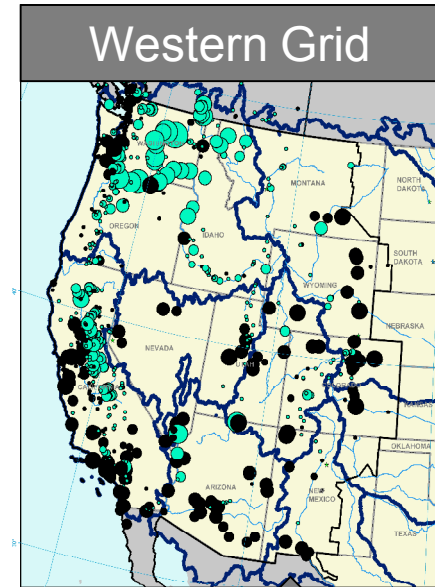
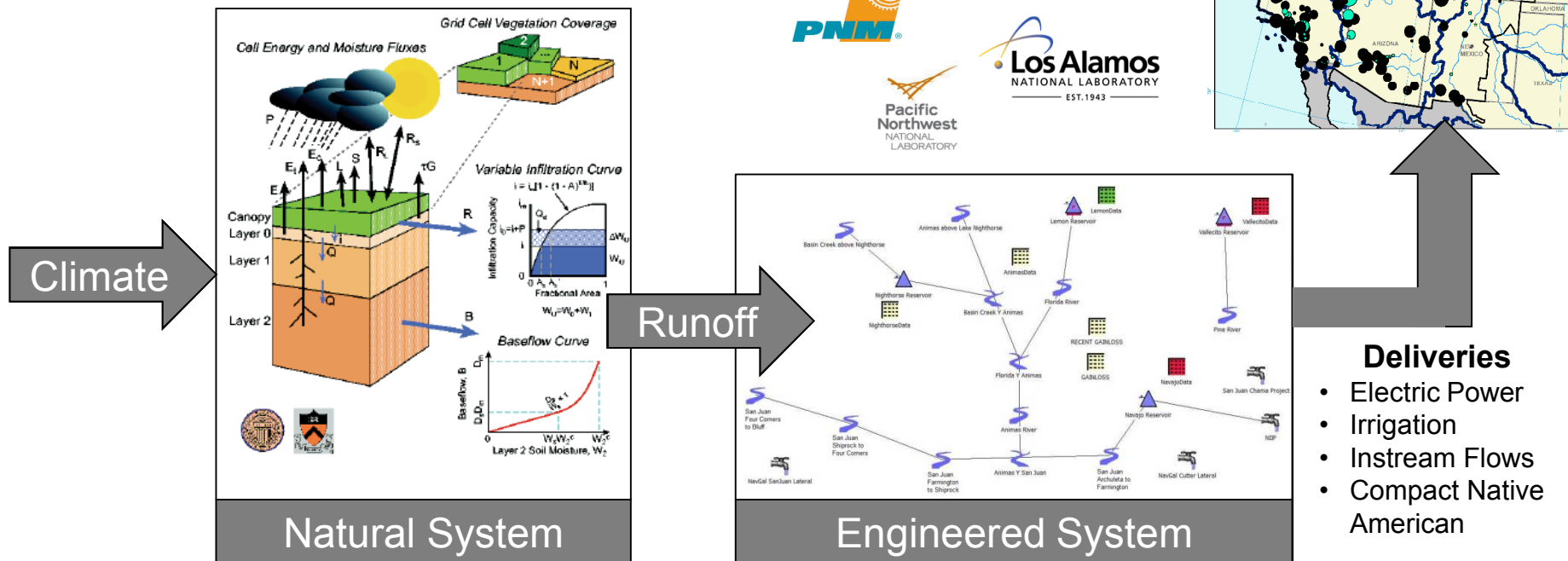
Scenario	Surface Water (%)	Groundwater (%)	Appropriated Water (%)	Wastewater (%)	Brackish Ground Water (%)
Reference Case	11	6	12	37	34
Scenario 1	16	6	10	35	33
Scenario 2	1	5	4	51	39
Scenario 3	16	7	12	31	34
Scenario 4	2	2	5	52	39

Takeaways

- Big difference in water footprint across scenarios, 30+% increase in consumption vs. 30+% decrease.
- Factors indirectly related to water (e.g., technology cost, energy policy) had greatest influence on water footprint.
- Thermoelectric expansion can occur with limited impact on water resources of the West.
- Expansion will likely require increased use of non-traditional waters.

Climate Vulnerability

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



■ Project data available at:
http://energy.sandia.gov/?page_id=1741

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The screenshot shows the Sandia National Laboratories website. The main navigation bar includes 'Energy and Climate' and sub-sections like 'RENEWABLE SYSTEMS', 'CLIMATE/ENVIRONMENT', 'ENERGY INFRASTRUCTURE', 'ENERGY RESEARCH', and 'ABOUT EC'. The page title is 'Energy and Water in the Western and Texas Interconnects'. Below the title, there's a 'Background' section with a list of bullet points: 'Hydroelectric power generation', 'Thermoelectric power plant cooling and air emissions control', and 'Energy-resource extraction, refining, and processing'. There are three images: a power plant, a wind turbine, and a solar panel. A text block states: '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:'. Below this is another list of bullet points: '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', and 'Uncertainty about the impact of climate variability on future water fresh surface and ground water resources'. There are social media links for Facebook, Twitter, YouTube, and RSS. A 'GO TO TOP' link is at the bottom right.

The footer section contains several columns of links and information. The first column is 'EC' with links to 'About Energy and Climate (EC)', 'Energy Security', 'Climate Security', 'Infrastructure Security', 'Energy Research', 'Key Facilities', and 'Partnerships'. The second column is 'EC Highlights' with links to 'Sandia Report Presents Analysis of Glac Impacts of Vernalis Solar Power Site', 'Sandia Wins Award for Best Paper at IEEE Photovoltaic Specialist Conference (PVSC)', 'Sandia Completes Hydrostructural Analysis of Coastal Renewable Power Company's TIGER™ Turbine', and 'The Influence of Solar Blade Design on Wake Development'. The third column is 'EC Top Publications' with links to 'Solar Energy Grid Integration Systems: Final Report of the Florida Solar Energy Center Team', 'Modeling System Losses in PVarray', 'Improved Test Method to Verify the Power Rating of a Photovoltaic (PV) Project', and 'Solar Energy Grid Integration Systems (SEGIS) Productive Intelligent Advances for Photovoltaic Systems'. The fourth column is 'Related Topics' with links to 'Concentrating Solar Power', 'CSP EPRC Energy', 'Energy Efficiency Energy', 'Security Infrastructure', 'Infrastructure Security National', 'Solar Thermal Test Facility', 'NSTTF photovoltaic', 'Photovoltaics PV', 'Renewable Energy solar Solar', 'Energy solar power Solar', 'Research Solid-State', and 'Lighting SSLs'. The fifth column is 'Connect' with links to 'Contact Us', 'RSS', 'Google+', 'Twitter', 'Facebook', 'LinkedIn', and 'YouTube'. The footer also includes the text 'Exceptional service in the national interest'.