California’s Energy-Water Nexus: Water Use in Electricity Generation

Authors: Bliss Dennen, Dana Larson, Cheryl Lee, James Lee, Stacy Tellinghusen
Advisors: Arturo Keller, Bob Wilkinson

Background
Water and energy are interrelated. Large amounts of water are needed for energy production, and large amounts of energy are needed for the extraction, conversion, treatment, and distribution of water. In the future, both the availability of freshwater and the need for energy will likely become limiting factors of economic development and population growth.

Objectives & Approach
Key Questions:
• How much water is required to produce electricity at each step of the process?
• How much water will California need to satisfy future electricity demands?

Main Goals:
• Support integrative planning at water and energy intersections
• Identify potential synergies and trade-offs between water and energy

Approach:
• Conducted quantitative water requirements for the following primary energy sources:
  - Biomass
  - Coal
  - Nuclear
  - Hydroelectric
  - Natural Gas
• Data sources included peer-reviewed literature, industry and government sources, and primary research

Developed a spreadsheet that captures water inputs at every step of electricity generation for all energy sources.

Conducted projected water withdrawals for four California counties with 2002 estimations of water withdrawals for thermoelectric power generation.

Created scenarios of different energy portfolios for California under expected demand levels in 2010, 2020, and 2030, and projected associated freshwater requirements.

Web-Based Tool
The web-based tool was developed from the spreadsheet (described above).

The tool allows users to calculate the water requirements for different energy portfolios.

Web-based tool is located at: www.bruin.uci.edu/energywater nexus/

Results
Water Required for Electricity Production
Water withdrawal requirements vary depending on the primary energy source, conversion technologies, and cooling.

Highest withdrawals:
• Energy generated from dedicated energy plants
• Thermoelectric facilities using once-through cooling
• Hypothetical facilities

Lowest withdrawals:
• Energy generated from nuclear plants using dry cooling
• Thermoelectric facilities using dry cooling
• Biomass facilities
• Wind turbines

Comparison of Freshwater Requirements for Various Energy Portfolios

Future Planning Considerations
• Load profile consistency and supply reliability
• Environmental impacts of electricity generation
  • Air and water pollution
  • Greenhouse gas emissions
  • Water and energy impacts
  • Energy efficient technologies

Recommendations
Increase utility investment in water-efficient energy generation:
• Solar photovoltaics
• Wind power
• Combined heat and power (CHP)

Implement policies to encourage conservation:
• Develop integrated programs that reduce water and energy use
• Energy-efficient drinking water use

Integrate planning for water and energy infrastructure:
• Co-locate wastewater treatment and electricity generation facilities

Additional research gaps:
• Perform a lifecycle analysis of water use in electricity generation
• Conduct a feasibility analysis of water-efficient energy portfolios

Research supported by funding from Southern California Edison (SCE) and Electric Power Research Institute