The Water Costs of Electricity in Arizona: A White Paper

Water and energy are inextricably linked. It takes water to generate electricity and every gallon of water we use has electricity "embedded" in it: the electricity to pump the water from its source to final destination, to treat the water for drinking and other uses, and to treat the resultant sewage to make the wastewater safe for discharge or reuse. These relationships are still very poorly understood, but they are increasingly critical to planning for power generation, alternative energy sources, water supply and conservation.

PROJECT TEAM

Investigators
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PROJECT FUNDING CYCLE

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PROJECT GOALS

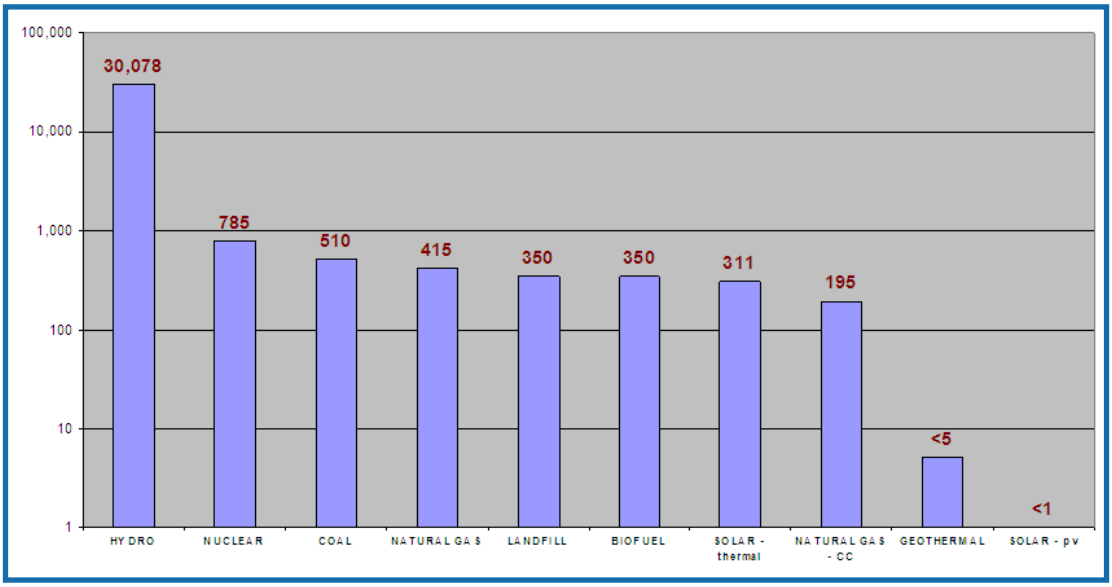
This is the first comprehensive, statewide study to examine the water costs of electricity in Arizona. The project had four main goals: 1) compare the water cost of electricity among different fuels, 2) determine the equivalent (virtual) import and export of water needed to generate the electricity, 3) assess the water losses from state-based hydroelectric installations, and 4) provide basic information on water use by solar power so as to allow accurate economic comparison with other means of power generation.

BACKGROUND/RESEARCH METHODS

The project team analyzed data on water use and power generation for nuclear, coal, and natural gas facilities, as well as for alternative landfill, biofuel, geothermal, and solar facilities. The team also assessed the water costs of hydroelectric power, a more complex and controversial task because of the difficulty of apportioning reservoir evaporative loss to the multiple-use benefits provided by the reservoirs, including power generation.

KEY SCIENCE FINDINGS

The two most significant uses of water for power generation are for supplying the mechanical energy at hydroelectric dams and the cooling fluid at thermoelectric plants. At hydroelectric reservoirs, evaporative loss occurs before power generation, while at thermoelectric plants, evaporative losses and bleeding off of salt-concentrated cooling water occur as a result of power generation. Disregarding hydroelectric power for the moment, the project team calculated that the water cost of nuclear power generation is greatest at 785 gallons of water used per one megawatt-hour of



Water cost of generating electricity for Arizona-based facilities (gallons of water used per one megawatt-hour of electricity generated). Vertical scale in powers of ten.

This Arizona Water Institute PROJECT FACT SHEET is part of a series detailing work supported by AWI in conjunction with partners and stakeholders. AWI is a consortium of the three state universities in partnership with the Arizona Departments of Commerce, Environmental Quality and Water Resources.

electricity generated (gal/MWhr), followed by coal at 510 gal/MWhr and natural gas at 415 gal/MWhr.

The project team used a more comprehensive approach to calculate the water cost of hydroelectric power generation than used by previous investigators. In this study, the economic value of all benefits derived from a multiple-use reservoir—agriculture, electricity generation, domestic water supply, and tourism and recreation—was estimated. Reservoir evaporative loss was then apportioned pro rata based on the relative economic benefits. When all Colorado River and interior Arizona reservoirs supplying electricity to Arizona are considered, the average water cost of hydroelectricity amounts to 30,078 gal/MWhr. While acknowledging that aspects of this new analytical approach may be open to debate, the investigators nevertheless believe it provides a truer comparison with other forms of power generation.

Like other thermoelectric plants, solar thermal plants lose water to blowdown and bleeding off of salt-concentrated cooling water. Water is also used for solar panel washing. The water cost of power generation for the largest solar thermal plant in Arizona, the one megawatt Saguaro facility northwest of Tucson, was estimated at 311 gal/MWhr. The water cost associated with solar photovoltaic plants, where water may be used for solar panel cleaning, is very small, negligible compared to other means of power generation.

On an overall water budget basis, Arizona exports power that consumes about 52,000 acre-feet of water per year to generate and imports power that consumes about 22,000 acre-feet per year. Thus, the net loss of water consumed in Arizona by generating power that is exported out-of-state is about 30,000 acre-feet per year, enough to supply 150,000 people at the current rate of use in Arizona (5 people/acre-feet).

KEY STAKEHOLDER ENGAGEMENT AND OUTCOMES

This study highlights the need for lawmakers, regulatory and planning bodies, and utility companies to consider more carefully the water costs when making energy/water decisions about new power generation facilities, sources of imported and exported electricity, and water conservation approaches. The investigators appreciate the input from APS, Tucson Electric Power, Salt River Project, and Arizona Power Authority.

CONCLUSIONS and RECOMMENDATIONS

Among the study's conclusions were: 1) a large volume of water can be saved by using hybrid wet-cooling, dry-cooling technology for thermoelectric generation, 2) policies should be discussed that limit granting of operating permits to merchant plants that largely or wholly sell power out-of-state considering the amount of water they consume in-state, and 3) consideration of the value of water saved (as well as carbon emissions reduced) by solar generation edges it into closer competition with fossil fuel and nuclear facilities.

This project examined the water costs of generating electricity in Arizona. A follow up study is needed to examine the other side of the coin—the energy embedded into every unit of water delivered and used in Arizona.

APS Saguaro Solar Facility, Red Rock, Arizona. Solar thermal plants like this one use water for cooling and mirror washing.

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