PROJECT FACT SHEET

The Water Costs of Electricity in Arizona

Water and energy are not only our most important and precious natural resources, they are inextricably linked. Providing electricity requires water just as providing water requires electricity. For environmental sustainability and the public good, the relationships between water and energy are among the most vital we must consider. The aim of this research was to provide information for our increasingly critical choices on the best approaches to power generation, alternative energy sources, and water supply and conservation.

PROJECT TEAM

Investigators
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PROJECT FUNDING CYCLE

2007

PROJECT GOALS

This is the first 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 the water needed to generate the electricity, 3) assess the water losses from state-based hydroelectric installations, and 4) identify policy considerations based on the research.

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.

KEY SCIENCE FINDINGS

The two most significant uses of water for power generation are for supplying the mechanical energy at hydroelectric dams and for use as the cooling fluid at thermoelectric plants. At hydroelectric reservoirs, evaporative loss occurs before power generation; while at thermoelectric plants, evaporative losses and wasting 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 (MWhr) of electricity generated, followed by coal at 510 gal/MWhr and single-cycle natural gas at 415 gal/MWhr (see Figure 1).

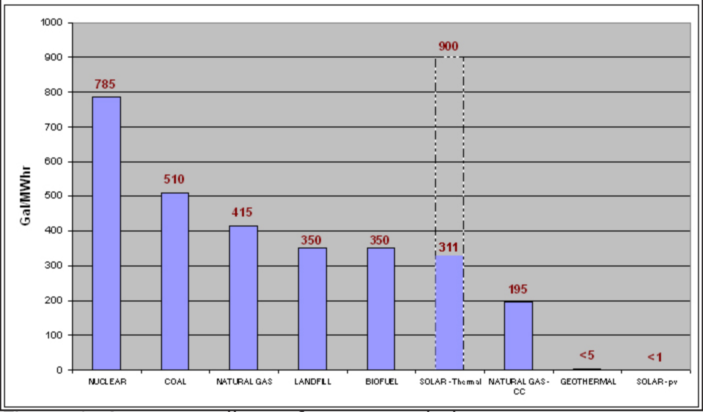

Figure 1. Average gallons of water needed to generate one MWhr of electricity from generating facilities supplying Arizona. Electricity from geothermal power plants is imported from one plant in Imperial Valley. Solar thermal is based on one facility near the Sahuaro fossil plant, northwest of Tucson but should be expected to be higher when more data are available.

The project team used a more comprehensive approach to calculate the water cost of hydroelectric power generation than used by investigators in previous efforts. At Arizona's hydropower reservoirs an average of approximately 56,000 gallons of water is lost to evaporation for each MWhr of electricity generated. A challenging and controversial task is determining how to apportion these reservoir evaporative losses among the multiple-use benefits provided by the reservoirs. Although some would argue hydropower production is an incidental use on reservoirs built principally for water supply or flood control, this study estimated the economic value of all benefits derived from a reservoir used for multiple industries such as agriculture, electricity generation, domestic water supply, and tourism and recreation. 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, this method estimated the average water cost of hydroelectricity as 30,078 gal/MWhr.

Like other thermoelectric plants, solar thermal plants lose water used for condenser cooling, as well as for solar panel washing. The water cost of power generation for the only solar thermal plant in Arizona, a one megawatt Saguaro facility northwest of Tucson (see Figure 2), was estimated at 311 gal/MWhr. However, estimates for solar thermal plants operating in California and being proposed elsewhere in Arizona are in the range of 800 to 1,000 gal/MWhr, so 900 gal/MWhr may be a better average water consumption to use for solar thermal plants with wet cooling. In contrast, the water cost associated with generating electricity from solar photovoltaic cells is negligible compared to other means of power generation.

On an overall water budget basis, Arizona exports electricity that consumes about 52,000 acre-feet of water per year to generate and imports electricity that consumes about 22,000 acre-feet per year. Thus, the net loss of water consumed in Arizona to generate electricity that is exported out-of-state is about 30,000 acre-feet per year, enough to supply 120,000 people at the current rate of use in Arizona (see Figure 3).

KEY STAKEHOLDER ENGAGEMENT & 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 & RECOMMENDATIONS

Among the study's conclusions were: 1) over 75% water savings could be realized with the use of dry or hybrid cooling technology, 2) permitting policies should require the consideration of water use in power plants that largely or wholly sell electricity

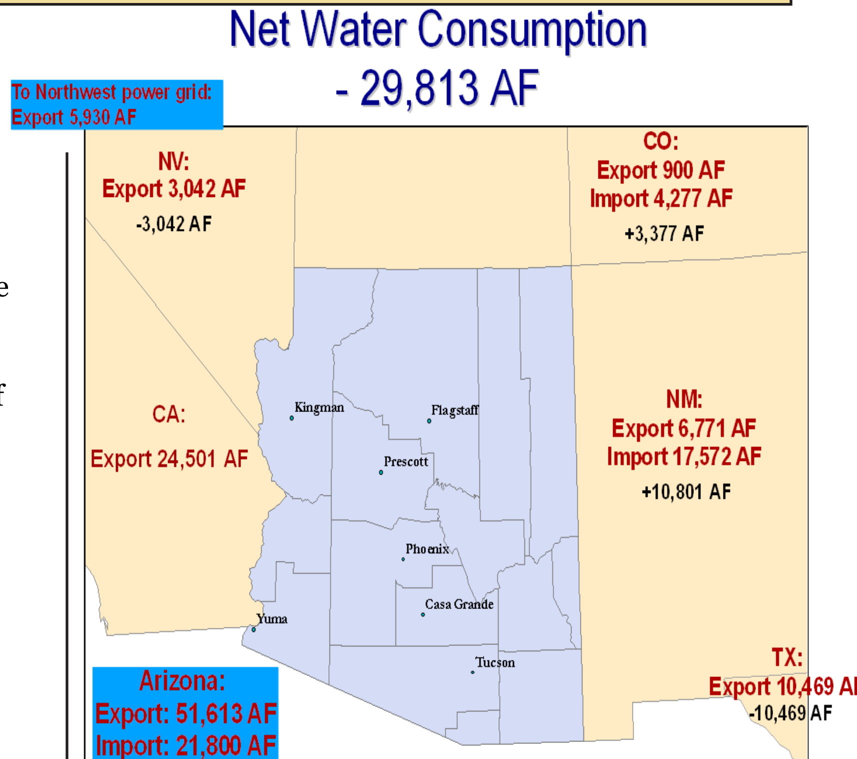

Figure 3. Importing and exporting electricity results in a virtual import and export of the water needed to generate the Importing and exporting electricity results in a virtual import and export of the water needed to generate the electricity. Arizona runs a net water deficit of about 30,000 acre-feet per year—water consumed for thermo-electric generation exported to other states.

out of state, and 3) consideration of the value of water saved and 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 companion study should examine the other side of the coin—the energy embedded into every unit of water delivered and used in Arizona.

Figure 2. APS Saguaro Solar Facility, Red Rock, Arizona. Solar thermal plants like this one use water for cooling and mirror washing.

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