Estimate of Water Use by Thermoelectric Power Plants in Nevada

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EXECUTIVE SUMMARY

Water reserves in the southwestern United States have been severely depleted because of the growth of large urban areas and persistent droughts, which has increased scrutiny of various water uses and conservation practices. Currently, the three largest water-use categories in the United States are thermoelectric energy, irrigation, and municipal water, which cumulatively account for 90 percent of the national water use. Water demands have led to extensive withdrawals from water bodies that are already drying up. Water withdrawal from lakes and reservoirs increases ecological uncertainties as well as water-level fluctuations. A warmer climate and anthropogenic activities have prolonged droughts and increased aridity in the Southwest. The extended severity of drought events has also increased the frequencies of large wildfires each year. Furthermore, the lingering drought in the Southwest has affected water-dependent industries such as farming, ranching, tourism, and recreation, causing multibillion-dollar losses in revenue each year.

Available water resources will continue to be constrained because water demands will accelerate as populations increase. Nevada's population increased more than 30 percent between 2000 and 2010, and growth is expected to continue. Population increases have also increased energy demands, which have further constrained water resources because energy and water are interconnected. More than 80 percent of the electricity in Nevada comes from thermoelectric power plants that use coal and natural gas as their fuel sources. These plants require huge amounts of water for cooling, fuel source preparation (e.g., mining, processing, and transporting fuels), flue gas cleaning, and pollutant scrubbing. The demand for electricity in the state was estimated to be approximately 42 million megawatt hours (MWh) by 2022 and 47 million MWh by 2032. Although more efficient cooling systems and energy-generating technologies have substantially decreased water use since 2005, thermoelectric energy generation in the United States still withdraws approximately 161 billion gallons of water per day (approximately 45 percent of the total national withdrawal) (USGS, 2014a).

This report estimates and compares the amount of water used for thermoelectric power generation and photovoltaic (PV) solar electricity generation in Nevada. The term "water use" includes both water withdrawal and water consumption from a water body. Water use in thermoelectric plants over the past decade was calculated using established water coefficients based on the various cooling systems and fuel types reported from past studies. The power plant data collected from the Energy Information Administration (EIA), such as the types and number of generating units in each power plant, were combined with the established water coefficients to calculate the operational water use. Operational water use refers to the water withdrawal and consumption throughout the process of generating electricity. A preoperational water coefficient refined from past studies was then integrated into the operational water use to obtain the total water use of all thermoelectric power plants in Nevada. Preoperational water use refers to the water used to acquire and prepare the fuel sources. The same calculation was applied to calculate the operational water use for PV solar electricity generation. Preoperational water use was considered to be zero because PV solar requires no water for fuel. Therefore, only the operational water use of current and future thermoelectric and PV solar energy projections were compared.

System dynamics models were constructed using STELLA® software to validate the calculated water-use projections. These models will also provide a convenient adjustment for supplementary scenario simulations in future PV solar electricity generations. The models simulated the interplay of the selected aspects to create different generation scenarios, which allowed the amount of water used by thermoelectric energy to be compared with the amount of water used by PV solar energy. The results were integrated into the system dynamics model to assess how much water was saved using a renewable energy source, such as PV solar energy, as a substitute for a portion of conventional thermoelectric energy.

Based on Nevada's current population growth rate of 0.79 percent per year, the projected population will be 3.02 million in 2022 and 3.3 million in 2032. Currently, thermoelectric power plants in Nevada withdraw an average of 33 billion gallons of operational water per year and consume approximately 6.3 billion gallons of operational water per year. Thermoelectric generating units use approximately 115 gallons of water per MWh per year on average. The model projected four PV penetration scenarios of 3 percent, 5 percent, 7 percent, and 10 percent of the total electricity generation in Nevada. These cases were then compared with the penetration of PV electricity generation (2.84 percent) in 2014. In 2014, Nevada saved approximately 56 million gallons of water by generating electricity using PV solar power. Based on the projected electricity demand in 2022 and 2032, if PV solar continues to generate energy at only three percent of the total electricity generation, approximately 216 million gallons of water could be saved in 2022 and 243 million gallons of water could be saved in 2032. If PV solar energy can generate five percent of the total electricity generation in the state, then approximately 360 million gallons per year of water could be saved by 2022. The estimates presented in this report demonstrate that the operational water demands for thermoelectricity generation are substantial compared with PV solar electricity generation. The difference in water use will be further pronounced if the preoperational water use is included.