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Effect of the dense network of surface reservoirs on the power demand for water distribution in a semiarid basin

Antônia Tatiana Nascimento, Natália Cavalcanti, and Pedro Medeiros
Federal Institute of Education, Science and Technology of Ceará - IFCE, Brazil

Population and economic growth have increased the demand for energy. In Brazil, the production of electric power is mostly from hydroelectric plants, however, in recent years the country has been experiencing water crises. The Brazilian Northeast (NEB) naturally suffers from water deficits, since the annual precipitation is of the order of 700 mm and the hydrological processes present high temporal variability. Due to its importance for water supply, a density of small dams has been built over time. Although incompatible with hydropower generation, which represents a conflicting use with human water supply in the region, small reservoirs present an energy benefit because they accumulate water at high altitudes. Still, water availability to the communities requires the installation of adduction and distribution systems, both with consumption of electric power. With this work, we aim to assess how the arrangement of small-, medium- and large-size reservoirs impact the power demand for water distribution in the Banabuiú River Basin – BRB (approximately 20,000 km^2), Brazil. The 1,405 reservoirs analysed were classified according to the storage capacities: class 1: $< 2x10^5$ m^3; class 2: $2x10^5$ to $5x10^5$ m^3; class 3: $5x10^5$ to $2x10^6$ m^3; class 4: $2x10^6$ to $3.5x10^7$ m^3; and class 5: $> 3.5x10^7$ m^3, and different scenarios were stablished for the estimation of power demand for water distribution in the BRB: I) actual reservoir arrangement; II) reservoirs of classes 2 to 5, only; III) classes 3 to 5; IV) classes 4 to 5; V) class 5; and VI) the Banabuiú reservoir (capacity of $1.6x10^9$ m^3). The water availability with 90% reliability was estimated through the water balance computation in the reservoirs, and the required electric power was obtained based on the water demand and height difference of the demand centre to the respective reservoir. In scenario I, the power required to pump water from the reservoirs to all the BRB human demand centres is 6.5 GWh/year, whereas in scenario II it is raised to 9.3 GWh/year. The relatively low energy demand in the actual reservoir arrangement results from the water distribution by small reservoirs in higher altitudes. In scenarios III and IV, as the smaller and more abundant reservoirs are withdrawn from the analysis, the energy demand increases accordingly. Scenario V comprises the 12 larger reservoirs of the BRB, which although presenting high water availability, demand more power to distribute water to the highest and most remote communities, totalling 45.3 GWh/year. In the scenario in which only the Banabuiú reservoir provides water, 195 GWh/year would be required annually. From the simulations it is concluded that, by storing water at high altitudes and distributing it spatially, the small reservoirs increase the energy efficiency on the water distribution system. In the Banabuiú River Basin, the power demand for water distribution may be increased by a factor of up to 30 in the scenarios without the smaller reservoirs.