Assessing the freshwater needs for power generation: the thermoelectric water footprint in Spain

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Abstract:

From the invention of the steam engine to the present, water has represented a significant input to the energy system, although this has been mostly ignored in the literature. Energy and water are valuable resources that support human wellbeing. Consequently, the mutual vulnerability of water and energy (the water-energy nexus, as known in the literature) is considered one of the most important concerns of the future and, for this reason, it remains a challenge in achieving the Millennium Development Goals (MDGs). In this context, great amounts of water are needed in power generation, mainly for cooling processes, and the water sector needs energy to extract, treat and transport water. Moreover, population growth and the rapid expansion of the economy are generating additional demands for water, so that some regions of the world are experiencing water and energy shortages.

The production of electrical power results in one of the largest uses of water worldwide. Thus, within all types of technologies, thermal power plants (those destined to the burning of fossil fuels or those dependent on nuclear reactors) are those that need more water to operate, mainly for cooling. Concretely, it has been demonstrated that for each available cooling technology, nuclear needs and consumption of water tend to be larger per MWh generated.

Moreover, in Spain, the most arid country in Europe, studies about water footprint typically just consider domestic, agricultural and industrial water uses, but water requirements for the electricity sector are omitted despite our dependence on thermal power. In historical terms, we can point out that Spain went from less than 20% of thermal electricity before 1960 to exceed 80% from 1980, a trend that was reversed at the beginning of the 21st century thanks to wind and solar energy.

Only recently Public Utilities and companies have begun to publish data on water use in environmental statements (i.e. Hydrographic Confederations, Nuclear Safety Board (CSN) and NGOs environmental reports, among others), and are still insufficient to have an overall estimate.

For all these reasons, we believe that this work is a pioneering approach in order to provide an estimate of the water resources required for the country's electricity production. Our first results focused on nuclear power plants show a key date: the decade of 1980s. This period is characterized by the incorporation of the most nuclear plants to the Spanish industrial scene. In this way, we can observe a spectacular nuclear production growth and subsequent increase in water consumption. For example, water withdrawals grew from 1,472 hm^3 to 4,641 hm^3 between 1981 and

1991. Likewise, water consumptions grew from 11 hm^3 to more than 128 hm^3 in the same period. These increases are stabilized in the 1990s up to the present.

The results also allow the comparison between sectors (for example, water for agricultural or urban uses) and in terms of river basins, allowing us to scale the figures and appreciate the importance of this analysis. Will water limit our energy future? Should water be taken into account when planning the electric mix in the future? These are some of the issues to be resolved.