Agua dulce para refrigeración: una visión a largo plazo de la huella hídrica de las centrales nucleares en España

Diego Sesma Martín & M.d.Mar Rubio-Varas
Departamento de Economía, Universidad Pública de Navarra, 31006 Pamplona, España.
Institute for Advanced Research in Business and Economics (INARBE), España.

HIGHLIGHTS

Approximately, about 80 percent of the world´s electricity is generated in thermal power plants (IEA, 2013)

Approximately, 80 per cent of the world's electricity generation would cease to exist in absence of water; if we add the percentage corresponding to hydropower, the number will be close to 95 per cent.

The use of nuclear energy is one of the hottest debates in many societies although nuclear energy meets more than 20% of the world´s demand for electricity (IAEA, 1997)

For each available cooling technology, nuclear needs and consumption of water tend to be larger per MWh generated (IEA, 2012)

INTRODUCTION

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. Production of electrical power results in one of the largest uses of water worldwide. For this reason, accounting for water needs for the production of energy seems to be a key issue. Therefore, we must start thinking of water as the most needed natural resource for electricity generation.

OBJECTIVES

Our research pioneers a first approximation to the water footprint of the Spanish nuclear power plants operating with freshwater from 1969 to the present. Our aim is to calculate the consumptive use of water (i.e. the amount of water evaporated, transpired, or incorporated in energy production) for Spanish nuclear power plants, and the amounts of water withdrawals required for running nuclear power plants. To sum up, what is the water impact of our nuclear power plants? Will water limit our energy future? Should water be considered when planning the electricity mix in the future? These are some of the questions to solve.

METHODS

TABLE 1. Withdrawals and Consumption Factors of Nuclear Power Plants by Cooling technology

$(m^3\ MW^{-1}h^{-1})$	WATER WITHDRAWAL FACTOR			WATER CONSUMPTION FACTOR		
COOLING TECHNOLOGY	Min	Median	Max	Min	Median	Max
Cooling towers	3,03	4,17	9,84	2,20	2,54	3,20
open loop/once-through	94,64	167,88	227,12	0,38	1,02	1,51

Source: elaborated based on data from Macknick, J., Newmark, R., Heath, G., & Hallett, K. C. (2012). Operational water consumption and withdrawal factors for electricity generating technologies a review of existing literature. Environmental Research Letters, 7(4), 045802.

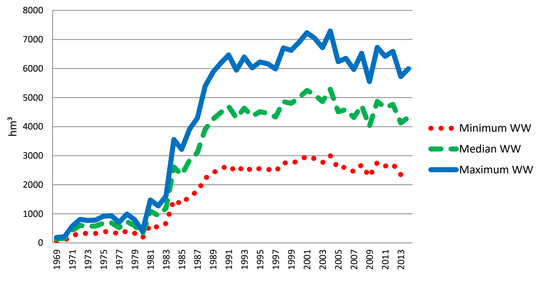
TABLE 2 Classification of Spanish Nuclear Power Plants by Type of Technology and Data Used

NUCLEAR POWER PLANT	COOLING TOWERS	OPEN LOOP/ONE-THROUGH	DATA TYPE
Trillo I	•		RDEB
Valdellós II		•	Estimation
Cofrentes	•		RDEB
Almaraz I		•	RDEB
Almaraz II		•	RDEB
Ascó I	•		Estimation
Ascó II	•		Estimation
Santa María de Garoña		•	Estimation
Jose Cabrera (Zorita)		•	Estimation

Source: own elaboration. Note: RDEB = Real Data Extrapolated Backwards

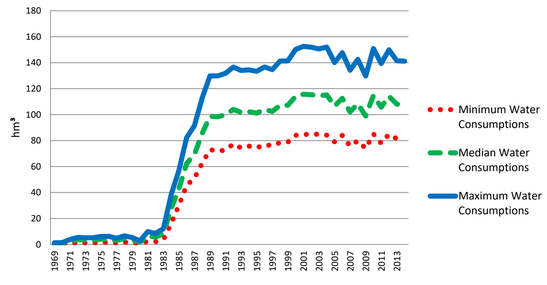
RESULTS & FIGURES

FIGURE 1. Evolution of total Water Withdrawals of Spanish Nuclear Power Plants (1969-2014)



Source: own elaboration

FIGURE 2. Evolution of total Water Consumptions of Spanish Nuclear Power Plants (1969-2014)



Source: own elaboration

We can determine a key date: the decade of 1980s, characterized because most Spanish nuclear power plants are incorporated to the industrial scene. We observe a spectacular nuclear production growth and subsequent increase in water consumption (i.e. for the period 1978-1988, Spanish electricity production deriving from uranium increased from 7.600 GWh to 50.400 GWh, corresponding to a percentage increase of 558%; whereas median water withdrawals increased from 730 to 3900 hm3, corresponding to a percentage increase of 433%). Moreover, to understand the implications of our results we must remark that in 1980 an important drought took place in Spain and continued up to 1995. This period represents a total of 15 years, which coincide with the great increases of water resources by nuclear power plants. Our results point at further research for the water history in Spain.

CONCLUSIONS

In conclusion, the consumption of water resources for cooling purposes by nuclear power plants in Spain could be considered a relevant issue when studying the available water resources and its different alternative uses. Thus, the location of nuclear power plants on the territory should be another important factor to analyze. In this way, we can conclude that locating nuclear facilities on the coastal sites would provide ample seawater supply for cooling. Advances in new technologies have allowed desalination costs have diminished in recent years, making it possible to establish desalination plants near the coast and nuclear power plants for cooling process. Moreover, desalination plants could be located near a nuclear plant to make use of its heat or electricity. Yet, locating nuclear plants on the coast conflicts directly with the major Spanish industry: tourism.

REFERENCES

IAEA (International Atomic Energy Agency), (1997). *IAEA Annual Report for 1997.*

IEA (International Energy Agency), (2012). Water for Energy: is energy becoming a thirstier resource?

IEA (International Energy Agency),(2013). World Energy Outlook.
http://www.iea.org/publications/freepublications/publication/WEO2013.pdf

Kenny, J. F., Barber, N. L., Hutson, S. S., Linsey, K. S., Lovelace, J. K., & Maupin, M. A. (2009). *Estimated use of water in the United States in 2005* (No. 1344). US Geological Survey.

Contact Information:
diego.sesma@unavarra.es