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IMPLEMENTING WATER ALLOCATION IN THE TIAM ENERGY MODEL

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OVERVIEW

Over the past ten years, a conscious concerning the energy sector has increased: we must face a depletion of fossil resources, increase the efficiency of current technologies, and develop new technologies to reduce environmental impacts. The energy sector is increasingly constrained and faces numerous challenges. The same applies to water supply, with growing concern about the availability and the sustainability of water resources.
Water and energy are both considered as strategic issues in our societies. Even though policies related to these resources generally dealt with separately, they are highly interconnected. Indeed, energy is required to maintain water supplies and water is essential to produce energy.
Although water use in the industry sector only represents 10% of the total use in low and middle-income countries, water use for energy can be close to 60% of the total use of water in high-income countries like France (57%) and the United States (40%). For upstream chain energy activities or cooling systems necessary for the production of electricity, huge quantities of water may be used: one part is consumed, the other is returned to the source.

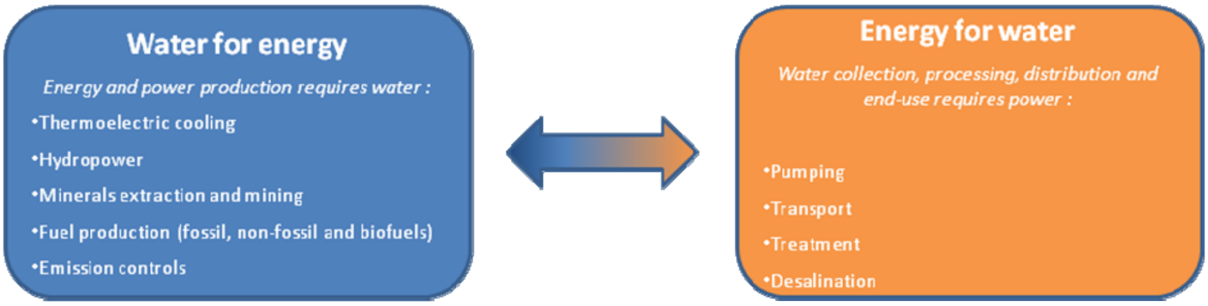

Fig 1. Water for energy and energy for water

The selection of technologies used in the energy sector may have a large impact on water. So, in the context of a growing world population, leading to increasing demands and competition for water and energy, it is vital to develop long-term strategic policies that consider the interconnections between the water and energy sectors. The current environmental approach in energy issues mainly focuses on the reduction of greenhouse gases emissions and seldom considers the impact on water. Issues such as the amount of water dedicated to the production of energy and the alteration of its quality are rarely considered. For example, carbon capture and storage systems (CCS) or flue gas desulfurization (FGD) are, on the one hand, answers to air pollution issues but, on the other hand, worsen the water stress as they require large inputs of water; a trade-off between those two issues has to be made.
The main aim of this study is to show how issues concerning water consumption and water withdrawal can be incorporated into energy system models, thereby facilitating discussions about possible futures concerning both aspects.

METHODS

Analyses carried out in this paper are based on the ETSAP-TIAM model which offers a technology-rich representation of the energy systems in 15 regions of the world. The model considers the long-term development of the energy system and is based on a partial equilibrium framework. Water issues are incorporate in the model in terms of water withdrawal (water removed from any sources, either permanently or temporarily) and water consumption (water abstracted which is no longer available for use because it has evaporated, transpired, been incorporated into products and crops, consumed by man or livestock, ejected directly into sea, or otherwise removed from freshwater resources)[3]. The water withdrawal and water consumption are specified for each technology, giving a clear link between the energy and water sectors.

A number of scenarios with different policy measurements concerning water were developed and evaluated. These scenarios were compared to a reference scenario without any explicit policy concerning water. Furthermore, impacts of different cooling systems utilizing large amounts of water were considered through scenario specifications. Different types of cooling systems were evaluated; open loop systems, closed loop systems and dry systems.

RESULTS

Policies on water consumption concern both the upstream and downstream of the energy chain. The introduction of new legislations concerning cooling systems was found to lead to decreased water withdrawals and increased water consumption. Technological choices (CCS or FGD) were found to have a large impact on water consumption, consolidating the importance of considering the interconnection between the water and energy sectors.

CONCLUSION

This first study gives us the opportunity to show how water question is crucial in energy production and which sectors are the main users. It can constitute a tool to observe if future energy mixes could be plausible. If we want to perform a comprehensive analysis of the future energy mixes with decreased greenhouse gases emissions, the approach has to take into account all these considerations in one and global model. Further analysis are considered, for instance with the introduction of additional constraints on water availability or water pricing.

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