Synergies and conflicts of energy development and water security in Africa

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Key Messages

- Energy decarbonization pathways reduce water withdrawals and water consumption relative to business-as-usual (Reference case).
- However, the more aggressive decarbonization (2.0°C relative to 1.5°C) can lead to additional water consumption savings but may lead to increased withdrawals.
- Energy trade could reduce overall costs and emissions for the African continent.
- Integrated planning is required within NDCs, including the interdependencies between energy, water, and carbon emissions

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Introduction

Africa is facing severe water and energy challenges [1]. Population increase [2], together with rapid urbanization [3] and economic growth [4], are expected to increase water and energy needs in Africa. The interdependency of these two resources is important for Africa, which is vulnerable to climate change [5]. The continent hosts economically diverse countries with unevenly distributed energy and water resources.

Northern and Southern Africa are two of the most water-stressed regions in the continent. Overall, more than 300 million (~25%) people in Africa live in water-scarce regions [3]. Also, the reliable supply of water is prone to disruptions in countries with low energy access as countries need energy to supply water [6]. The Central and Western regions contain the highest share of Total Renewable Water Resources (TRWR) [7], 53% and 25%, respectively, and Northern Africa the lowest (1%). This widespread distribution of TRWR across Africa makes an integrated energy–water approach fundamental to mitigate future challenges [8].

Fuel processing and power plant operation require different amounts of water, indicated as water withdrawal (WW) and water consumption (WC) [9]. The reliable operation of thermal power plants depends on water availability [10] and water temperature for cooling purposes. They comprise a high share (81%) of installed electricity production capacity in Africa in 2016, showing an increasing trend in the future [11]. Water is also required for household use and agricultural purposes [12]. Therefore, water availability is a crucial component of a nation's energy security together with energy resources [3], geopolitical stance, and energy strategy.

Methodology

A model was developed to evaluate energy supply and water requirements to cover the energy needs of the African continent during the period 2015–2065. The energy system of 48 African countries, with a focus on the power sector, was modelled individually and linked via trade links, using an open source cost optimization modelling tool for long-term energy planning, OSeMOSYS [13], to identify the least-cost energy system pathway. Also, the annual water withdrawal and consumption of the energy system on a national and continental scale was examined by considering different cooling types by technology. The objective of the modelling is to minimize total energy system costs, rather than, co-optimize the energy and water sectors. The latest available data on the energy system of Africa are considered, including national energy policies.

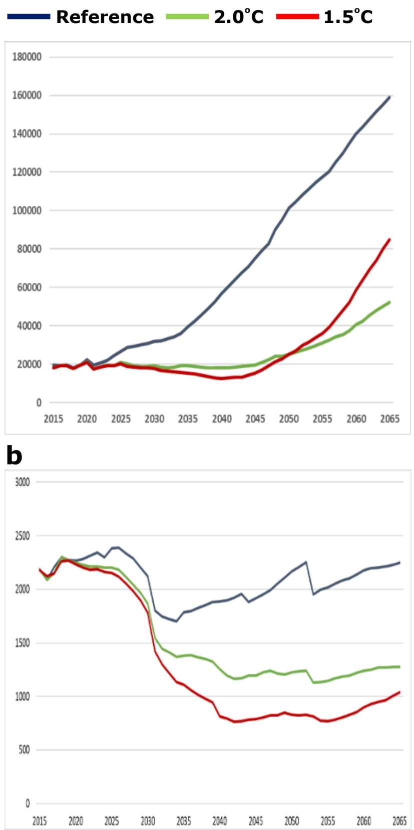
Problem definition and scenario development

Three different main scenarios for the period 2015–2065 are modelled. The Reference scenario assumes no change from national renewable energy policies after 2017. In two mitigation scenarios (2.0°C, 1.5°C), the final energy demands are lower due to energy efficiency measures and the annual emission levels are constrained to the emission pathways compatible with the 2.0°C, 1.5°C scenarios [14]. For each one of the scenarios, the influence of water availability in the energy system is examined.

Results

Our results show that fossil fuels remain the least-cost option in countries currently under high-risk of water scarcity, further increasing their water use in the future. Under mitigation scenarios (2.0°C, 1.5°C), a reduction in demand in comparison to the Reference scenario, coupled with the use of low carbon technologies, leads to a decrease but then an increase in water withdrawal (**Figure 1**). This transformation highlights the role of nuclear, solar PV, hydropower, and carbon capture with storage technologies (CCS) in Africa's energy future. Higher levels of electricity and gas trade are required to achieve lower emission limits affordably, highlighting the role of transit countries and key net exporters. Nevertheless, it needs to be noted that higher electricity exports in specific countries lead to higher levels of water withdrawal and consumption.

Figure 1. Water withdrawal[a] and consumption[b] in Africa across the scenarios (in million cubic meters)



Limitations

Our model is a high level representation of the energy supply system and its associated water withdrawals and consumptions for cooling purposes, connected with electricity and gas trade among African countries. The future capacity of technologies and consequently water withdrawal and consumption depend on the modelling assumptions and their projections. It does not account for detailed spatial disaggregation of these systems within countries. Combining agricultural and municipal water withdrawals for each African nation with our results would show the impact of the scenarios upon levels of water-stress. Hydrological modelling of each of the planned dams would provide more accurate quantification of dam productivity and impacts. Broader social and environmental effects of hydropower and nuclear, should be further examined to understand the implications of those technologies better. Battery storage for solar PV and pumped hydropower storage are only implicitly modelled. Better data and spatial techniques could help identify and allocate the different cooling technologies to future thermal power plants. Linking a spatial database of power plants with precipitation patterns and cooling technologies would improve estimation of water factors. Also, incorporating country-specific reserve margins rather than using an average, the power sector projections would be improved.

Policy implications and recommendations

- To meet the 1.5°C pathway, the African energy sector would require higher water withdrawals overall and per unit of final energy than the 2.0°C pathway, so proper water resource management is essential. However, energy pathways that are not compatible with climate targets are likely to require even higher levels of water demand.
- Co-operation between neighbouring countries via energy trade could reduce overall costs and greenhouse gas emissions at the whole-Africa level.
- This policy briefing highlights the future role of some countries as key net exporters and transit hubs.
- As nations invest in new power plants to increase electricity exports, this could come at the cost of their available water resources and increase geopolitical tensions.
- Implications for water resources should be considered within National Determined Contribution targets [15].
- Governmental institutions and universities could build on the results of this research. The datasets that have been produced could strengthen the capacity for further studies and extending existing energy systems models.

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Notes

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