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Modelling the Water-Energy Nexus: Should regional variability in water supply impact on decision making for future energy supply options?

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Many countries, like South Africa, Australia, India, China and the United States, are highly dependent on coal fired power stations for energy generation. These power stations, however often require significant amounts of water, particularly when fitted with technologies to reduce pollution and climate change impacts. As water resources come under ever increasing stress it is important that spatial variability in water availability is taken into consideration for future energy planning particularly with regards to motivating for a switch from coal fired power stations to renewable technologies which are likely to be located in different places with different levels of relative water availability and associated costs of supply. This is particularly true in developing countries where there is a huge need for increased power production and associated increasing water demands for energy. Typically future energy supply options are modeled using an optimization model such as TIMES that considers water supply as an input costs, but is generally constant for all technologies. It is however important to note that different technologies are likely to be located in different regions of the country with different levels of water availability and associated infrastructure development and supply costs. In this study we develop regional marginal cost curves for future water supply options in different parts of a country where different energy technologies are planned for development using South Africa as a case study. These regional water supply cost curves are then used in an expanded version of the South Africa TIMES model called SATIM-W that explicitly models the water-energy nexus by taking into account the regional nature of future energy supply technologies and related differences in the water supply availability and supply costs. The model also allows for additional water supply constraints such as variability in the distribution costs, water quality, non-energy water demands, and climate change risks. The results show a significant difference in the optimal future energy mix using the SATIM=W model.In particular there is an increase in renewables and a demand for dry-cooling technologies that would not have been the case if the regional variability of water availability had not been taken into account. The results also show how choices in energy policy, such as the introduction of a carbon tax, will also significantly impact on future water resources planning as the alternative technologies are often located in different regions of the country placing additional water demands in these regions but making water available for other users in other regions with a declining future energy demand. This study presents and example of an integrated water-energy nexus model that could be used to inform sustainable development for both water and energy planning in both developed and developing countries.