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Downscaling Sub-Saharan Africa energy projections for power system planning: impacts, inconsistencies, and potential improvements

Arianna Leoni, Angelo Carlino, Wyatt Arnold, and Andrea Castelletti
Politecnico di Milano, Electronics, Information, and Bioengineering, Milano, Italy

Development pathways for Sub-Saharan Africa project a substantial increase in population and living standards. To accommodate the future energy demand, the power and the energy system community have been developing least-cost optimization models to support long-term planning. Given the rise of climate change impacts and the necessity to mitigate them in the future, investments in new energy infrastructure should contemplate carbon neutral alternatives wherever economically viable.

However, integrated assessment and long-term energy planning models usually focus on annual or seasonal energy balances neglecting higher time resolution dynamics that can actually lead to short but high impact events. Indeed, the variability of renewable generation and power demand can lead to significant risks of high electricity prices, transmission lines overload, and power generation deficits.

To quantify these impacts, we inform a power system simulation model, PowNet, with energy development pathways from the long-term energy system planning model, OSeMOSYS-TEMBA. While the latter models the development of all the countries in continental Africa with a seasonal resolution from 2015 to 2070, the first has an annual horizon with hourly resolution and focuses on countries included in the Southern African Power Pool. In particular, PowNet is used to optimize the dispatch of power from each source as well as the usage of transmission lines, and it is constrained to the power capacity available according to the long-term energy planning provided by the OSeMOSYS-TEMBA model. We assess these impacts in 2025 and 2030 under three climate policy scenarios: no climate policy, and constrained to 2.0°C and 1.5°C warming constraining emissions to a consistent pathway. We study the difference in generation mix, the impact on transmission lines overloading, power generation deficits, and electricity prices.

Preliminary results show an increase of the generation during the years, in particular of the renewable resources, that varies depending on the selected scenario. Moreover, power generation deficits and transmission lines overloading are observed in many countries, especially during the night. These impacts are to be associated with insufficient total power system capacity to meet power demand due to the low time and spatial resolution of the energy system model. Indeed, the increased dependency on variable renewable resources, and a higher resolution demand profile

prove the need to further expand total capacity, the importance of flexible generation adopting a diverse energy portfolio, and the potential benefits of increasing transmission lines' capacity. Finally, the lack ofpower storage technologies in the energy system model might also significantly affect capacity expansion plans and consequent impacts. These results show the importance of the assumptions embedded in energy system model and motivate methodological improvements to design coupled energy and power system pathways that remain reliable at high spatial and time resolution.