OVERCOMING WEATHER DATA SCARCITY TO AID POLICYMAKERS IN EFFECTIVE RENEWABLES DEPLOYMENT FOR SAUDI ARABIA

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Overview

In many countries, the power generation sector is undergoing a transformation through the deployment of renewable energy (RE) to address climate change issues. Given that weather data is crucial for effective RE deployment, we observe that several countries have already started collecting this data specifically tailored for RE deployment purposes. In many cases, however, such as the Middle East and North Africa region, not enough historic data has been compiled yet. Despite the inadequate data available, many countries have already started planning their energy future RE targets, and others have actually started executing these plans.

In light of the above, we investigate herein the extent to which long-term plans, stemming from capacity expansion models, are impacted by weather-dependent RE assumptions. Explicitly, the assumptions assessed are the firm capacity (FC) and forced outage rate (FOR) of renewables. The analysis was conducted in the context of Saudi Arabia, where a 50% renewable energy target is set to be met by 2030 ("Renewable Energy Sector in the Kingdom" 2022). Beyond the modeling efforts, we quantify the sensitivity of long-term plans to FC and FOR assumptions. In our Saudi Arabian case study, values assumed for FC and FOR resulted in a 10% variation in power system costs, and 14% and 26% variations in RE and storage deployment respectively.

Methods

First, we review available RE-specific weather data for Saudi Arabia and highlight that very few data sets are available. When available, these data sets are single-year data sets. The FC and FOR are the two parameters describing RE that would be influenced most by lack of weather data. The firm capacity is defined as capacity that is guaranteed to be available when required, and thus available to meet the resource adequacy requirement, whereas forced outage rate refers to the percentage of time when the power plant is not able to generate electricity, due to mechanical failures or weather conditions. To overcome the lack of data available for Saudi Arabia, we deduce a range for the FC and FOR particularly for solar photovoltaics (PV) and wind technologies based on a literature review for several countries. We arrive at the two following sets of assumptions regarding RE:

- An optimistic case where the FC is 30% for solar PV and 25% for wind, and the FOR is 10% for solar PV and 50% for wind.
- A pessimistic case where the FC is 10% for solar PV and 5% for wind, and the FOR is 30% for PV and 80% for wind.

The FC is used for long-term planning purposes, i.e., to arrive at installed capacities that would meet a reserve margin target. On the other hand, the FOR is used for dispatch purposes to assess resource adequacy in 2030 through the loss of load probability metric. We combine these two sets of assumptions with two 2030 RE energy targets. Thus, we consider four scenarios that differ by varying two main assumptions: being optimistic or pessimistic regarding RE in terms of FC and FOR, and the share of RE in total consumption by 2030. Table 1 names and summarizes the considered scenarios.

Table 1: Summary of scenarios simulated

Scenario Name	Share of RE by 2030	RE assumptions
25-Opt	25%	Optimistic
25-Pes	25%	Pessimistic
50-Opt	50%	Optimistic
50-Pes	50%	Pessimistic

Second, we run a long-term capacity expansion plan of the four scenarios for Saudi Arabia over the 2018-2030 horizon. The simulations were conducted using the KAPSARC Power Model (Elshurafa et al. 2021; Elshurafa and Peerbocus 2020; Soummane et al. 2022), which was built using the commercially available software PLEXOS. The model describes six Saudi regions along with the existing transmission interconnections between them and solves the problem via mixed-integer linear programming.

Third, we analyze the different simulated scenarios in terms of capacity expansion, system costs, and resource adequacy level. We also assess the additional cost that would be borne by considering a long-term plan with a set of assumptions that turns out to be inaccurate with respect to RE weather data, i.e., the additional cost born in case of policymaking based on inaccurate RE assumptions.

Results

First, our results highlight that long-term plan significantly varies depending on RE assumptions. Indeed, by 2030, RE and storage installed capacities increase by up to 14% and 26% respectively in Pes-RE scenarios with respect to Opt-RE ones. This turns to an increase in power sector cost by up to 10% in Pes-RE scenarios over the period 2018-2030. However, as more RE and storage are developed in Pes-RE scenarios, carbon emissions observed in 2030 are slightly decreased (0.1-2.9%) compared to the Opt-RE counterparts.

Second, solar PV is a more economical choice than wind power in Saudi Arabia given our cost assumptions. In 2030, the 50% RE target is achieved by installing 140-160GW of solar PV and only 2GW of wind. Given that this large amount of solar PV would be challenging to be installed in a few years, we rerun the simulations with a cap on the new annual solar PV and wind builds, but still reached the 2030 renewable target, which result in a share of wind and solar capacities of roughly 50%-50%.

Third, storage and transmission network developments play a significant role in our long-term plans to help in managing RE intermittency and variability. When considering different RE assumptions for their FC and FOR, the balance between storage and transmission development varies, with a trend to develop more storage and less transmission in Pes-RE with respect to Opt-RE.

Conclusions

RE development will challenge the resource adequacy of power systems worldwide. In the Middle East and North Africa, the first RE projects have been developed but few RE-specific weather data sets that span several years are available, if any. This paper quantified the extent to which FC and FOR would impact the modeling results of a capacity expansion modeling exercise within the context of Saudi Arabia.

Variations observed in the results are significant, with up to 10% in additional system costs and 26% in additional storage capacity when considering pessimistic FC and FOR assumptions with respect to optimistic ones. These findings support the significance of country- and technology-specific data collection tailored to RE to minimize, to the extent possible, additional (but avoidable) costs that would be born during the transition to the sought future.

References

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