Long-term assessment of CSP entry into Saudi Arabia's power system using PLEXOS

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Overview

Recently, renewables are being developed in the context of reducing CO2 emissions and climate change. Most renewable energy resources are intermittent due to their weather dependency. They need energy storage to be dispatchable. Concentrated solar power (CSP) has thermal storage inherent in the system that makes it dispatchable. CSP is a technology that generates power by concentrating solar energy onto a receiver and then using the heat in a power generation cycle. CSP has potential in regions with high direct nominal irradiance, but its capacity deployment is still limited due to its high capital expenditure (CAPEX). However, future energy mixes will likely include different types of renewable energy resources including CSP to replace fossil fuels and reduce emissions. The inherent thermal storage in CSP systems make their valuation a bit more challenging in energy expansion models. This study will model and analyze the CSP in long term expansion modeling of the Saudi power system to assess its potential role in the energy mix to achieve Saudi Arabia's 50% renewable energy target by 2030.

Methods

Energy system analysis is conducted using the Energy Exemplar power systems software, PLEXOS, to simulate the long-term energy expansion. CSP yield analysis were done using the System Advisor Model (SAM). The output of SAM estimates for CSP plant productivity using hourly historical weather data for Saudi Arabia are then fed as an input data in PLEXOS (Narimani et al, 2017; and Denholm et al, 2014). The performance data in addition to financial assumptions form the CSP candidates' inputs in PLEXOS. The Saudi power system is modeled by dividing the kingdom load into six regions and taking the base year as 2018 (Elshurafa et al, 2021). We conduct a long-term study for the entry of CSP into Saudi Arabia's power system until 2030. The renewable energy options in our analysis are PV solar, CSP, and wind power. Also, we included battery energy storage candidates as options. Two scenarios were considered on the modelling, one with CSP candidates, and another one without. Then we analyzed what the generation mix would be in 2030 in the case of 50% renewable energy and 50% natural gas with the retirement of fossil fuels generators.

Results

The results are focusing on the comparison between two scenarios; one is the Saudi power system with CSP candidates and another scenario without CSP candidates. The resulting two different technology mix scenarios for the 50% target by 2030 and the findings are compared and contrasted based on different criterias. First, the cost differences for both scenarios to measure the effect of the CSP entry on the long term planning cost. We compare the Levelized cost of energy (LCOE) between both scenarios in terms of the mix of technologies used in each one (e.g., the number of installed batteries in each scenario and the other technologies). Given the high Capital costs of CSP, the economic optimization of the system did not build any units of it. Therefore, a constraint was added to include at least 10% of CSP in the total installed capacity by 2030 as shown in Figure 1. This percentage will allow us to study the effect of the presence of CSPs on the acceleration of reaching the 50% renewables goal by 2030 and the effect of CSPs on accelerating the retirement of fossil fuel-based generators.

Finally, based on the technologies mix, we compare the Loss of Load Probability (LOLP) to evaluate the system reliability for the scenarios by including the forced outage rate for each renewable energy technology. The goal here

is to measure the impact of CSP's entry into the Saudi power system and its contribution to reaching 50% renewable energy and 50% natural gas generation mix by 2030.

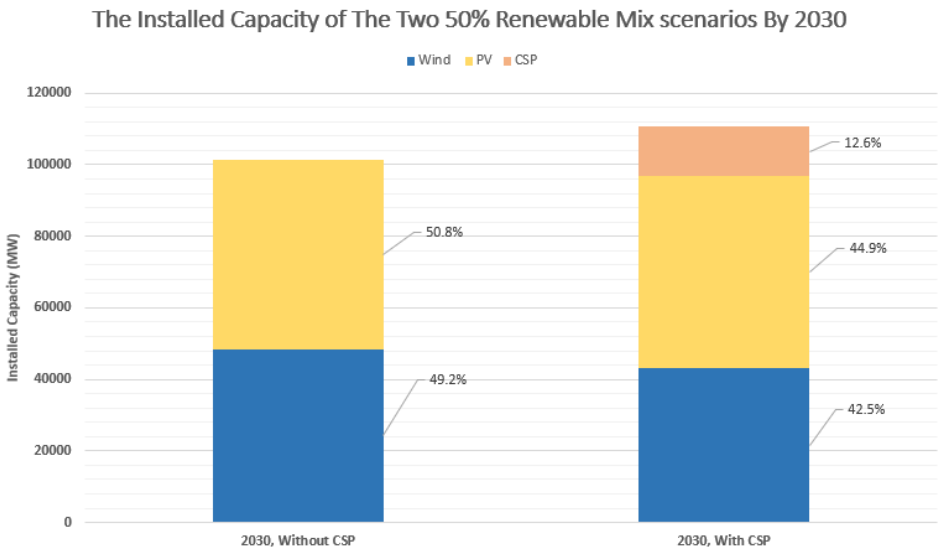

Figure 1: The installed capacity results for the two 50% renewables mix scenarios by 2030

Conclusions

The entry of new renewable energy technologies into the power system is expected in the coming years, and studying the impact of these technologies can make reaching the Kingdom's power sector goals faster and more reliably. Through our study, we measured the impact of the CSP entry into the power system to have a better understanding of its contribution to the system cost, reliability, and acceleration of reaching the 50% renewables goal by 2030.

In addition to measuring the impact of the CSP's entry into Saudi Arabia's power system, the costs of the technology are still high compared to other renewable energy resources. A significant cost reductions and increased deployment is needed to bring the cost down. Alternatively, the power system benefits that CSP can bring may offset its costs and make a valuable resource in the energy mix. The findings of this study can be used to compare CSP with other technologies in the future to assess how they may affect the renewable energy generation mix in Saudi Arabia.

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