ENERGY STORAGE ECONOMICS AND FUTURE MARKET POTENTIAL IN SAUDI ARABIA:

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Overview

In Carbon constrained world , decarbonization is imperative to reach carbon neutrality targets by many countries between 2050 and 2060 and large adoption of renewable energy is a key measure to decarbonize the electric grid. Saudi Arabia is planning to expand the renewable energy generation to reach 50% of total energy mix by 2030 where the rest planned from natural gas. This target is largely to realize Saudi Arabia's Nationally Determined Contributions (NDCs) commitments by removing greenhouse gases (GHG) emissions of 278 million tons of carbon dioxide equivalent (CO2eq) annually by 2030. According to Saudi National Renewable Program (NREP) recent targets , 58.7 gigawatts (GW) of renewable power capacity is planned by 2030 which constitute of 40 GW of Photovoltaics (PV) power , 16 GW of wind power and 2.7 GW of Concentrated Solar Power (CSP). These future Variable Renewable Energy (VRE) generation by 2030 will help to decarbonize the electric gird however they are intermitted energy sources and cannot be used as base load electricity generation similar to dispatchable power generation sources such as fossil fuels. Therefore, Energy Storage Systems (ESS) is an important enabler to store excess VRE electricity from the gird for later use to further decarbonize the gird to reach carbon neutrality by Saudi Arabia in 2060. Although Saudi National Renewable Program has put targets for future renewable power capacities , there are not enough studies or assessments regarding energy storage future demand in order to have resilient Saudi Arabia grid and to project future potential new ESS electricity market.

The objectives of this paper are to quantify and evaluate holistically the impact of VRE generation supply in Saudi Arabia's future electric gird and the potential opportunities of seasonal and long duration energy storage. Moreover, the paper will evaluate the ESS applications and technologies selection to reach optimum system investment costs for ESS deployment in Saudi Arabia and forecasted Levelized Cost of Storage (LCOS). Finally, the paper will shed some lights on recommended policies and regulations to enable Saudi Arabia EES market to be competitive with dispatchable fossil fuel sources and support national net zero carbon objectives by 2060.

Methods

Data collection was completed to quantity future VRE generation from the planned 35 projects locations scattered in Saudi Arabia based on publicly announced power capacity targets by NREP and capacity factors (CF) for each VRE technology type were assessed. In addition, the forecasted power demand and total energy generation from fossil fuels were calculated based on Saudi Electric Company (SEC) announced numbers in 2020 and existing power generation fleet breakdown by sources and technologies were analysed. It was assumed a retirement plan of old gas turbines power generators and there will be base load electricity generation from natural gas and also future low carbon dispatchable from nuclear energy , waste to energy and geothermal resources. An optimization model was formulated to calculate the projected excess electricity from VRE and the ESS potential future market were sized in 2030 and 2040. The model included mixed integer liner algebra programming to quantify future EES applications demand and hence technology selection to provide the optimum EES system cost while meeting NDCs targets. Finally, projected different LCOS technologies type were calculated to understand the competitiveness of EES future market in Saudi Arabia.

Results

The results shows high seasonality power demand and hence large potential EES market size in GWh in the segments of seasonal energy storage and Long Duration Energy Storage (LDES) to avoid large electricity curtailments. This EES market size is forecasted to increase when VRE reach more than 60% of total power capacity penetration in the grid. In addition, Intra-energy storage applications segment shall be first EES market adaptor to provide daily localized electricity from EES to reduce additional power transmission investment in remote areas from the grid . The optimization model shows Power to X technologies such as hydrogen storage in salt caverns and other LDES technologies such as thermal energy storage and flow batteries will achieve LCOS between 0.082 and 0.045 $/KWh in 2040 based on future cost learning curves reductions in renewable energy and EES technologies.

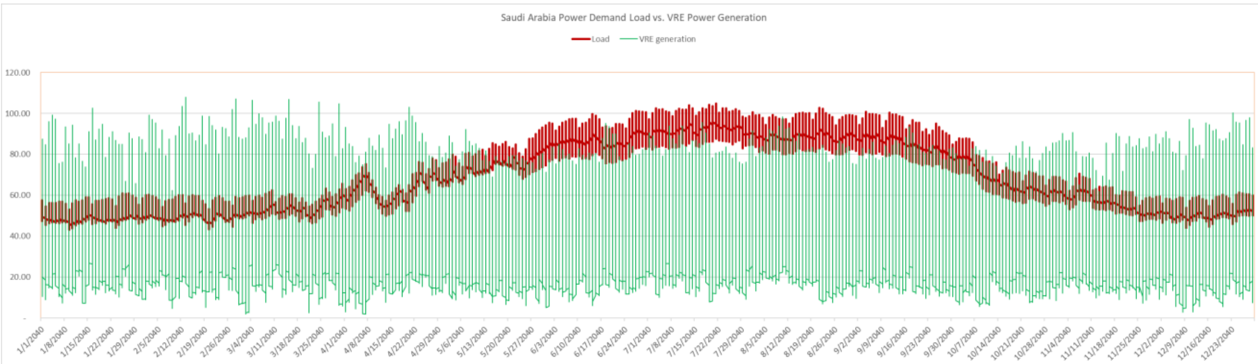

Figure 1. Saudi Arabia Projected Power Demand in 2040 vs. VRE Power Generation Forecast (GW)

Conclusions

EES deployment in Saudi Arabia is imperative to decarbonize future electric grid and an important bridge to energy transitions and carbon neutrality targets. Although there are economics benefits and technical requirements to expand and create new market for EES , the economics is more favourable to fossil fuels dispatchable power generation resources in the near future and energy policy instruments are needed to incentivize ESS.This is largely due to the lack of carbon pricing , price arbitrage and electricity dynamics pricing opportunity that is required for ESS business models for market entry and growth. Although the reductions of EES capital costs and technology performance improvement will improve the economics of EES market , incentives and market regulations are required from government agencies to promote EES market establishment and growth to meet Saudi Arabia climate targets.

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