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Spatial Suitability Assessment of Onshore Wind Systems Using the Analytic Hierarchy Process

Authors : Ayat-Allah Bouramdane

Abstract : Since 2010, there have been sustained decreases in the unit costs of onshore wind energy and large increases in its deployment, varying widely across regions. In fact, the onshore wind production is affected by air density— because cold air is more dense and therefore more effective at producing wind power— and by wind speed—as wind turbines cannot operate in very low or extreme stormy winds. The wind speed is essentially affected by the surface friction or the roughness and other topographic features of the land, which slow down winds significantly over the continent. Hence, the identification of the most appropriate locations of onshore wind systems is crucial to maximize their energy output and therefore minimize their Levelized Cost of Electricity (LCOE). This study focuses on the preliminary assessment of onshore wind energy potential, in several areas in Morocco with a particular focus on the Dakhla city, by analyzing the diurnal and seasonal variability of wind speed for different hub heights, the frequency distribution of wind speed, the wind rose and the wind performance indicators such as wind power density, capacity factor, and LCOE. In addition to climate criterion, other criteria (i.e., topography, location, environment) were selected fromGeographic Referenced Information (GRI), reflecting different considerations. The impact of each criterion on the suitability map of onshore wind farms was identified using the Analytic Hierarchy Process (AHP). We find that the majority of suitable zones are located along the Atlantic Ocean and the Mediterranean Sea. We discuss the sensitivity of the onshore wind site suitability to different aspects such as the methodology—by comparing the Multi-Criteria Decision-Making (MCDM)-AHP results to the Mean-Variance Portfolio optimization framework—and the potential impact of climate change on this suitability map, and provide the final recommendations to the Moroccan energy strategy by analyzing if the actual Morocco's onshore wind installations are located within areas deemed suitable. This analysis may serve as a decision-making framework for cost-effective investment in onshore wind power in Morocco and to shape the future sustainable development of the Dakhla city.

Keywords : analytic hierarchy process (ahp), dakhla, geographic referenced information, morocco, multi-criteria decision-making, onshore wind, site suitability.
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