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An Analysis of Solar and Wind Resources for Building a Hybrid PV and Wind Power Plant

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Renewable energy technologies, such as solar PV and wind turbines, have become widely implemented to meet the increasing energy consumption and reduce carbon emissions. It is well known that solar and wind power generation are strongly related to weather characteristics such as Global Horizontal Irradiance (GHI) and wind speed. Therefore, we investigated the GHI and wind speed in a specific location to assess the potential for building a hybrid PV and wind power plant.

There are a range of advantages to building hybrid PV and wind power plants rather than individual solar or wind farms. For example, investment costs and time required to construct an individual farm can be reduced by retrofitting an existing solar/wind farm to create a hybrid plant. Moreover, the complementary characteristics of solar and wind resources can improve the capacity factor of the hybrid power plant, due to solar and wind being separately dominant during the day and night [1].

Hence, it is important to quantify the complementary features between solar and wind resources. There are three approaches used for evaluating both solar and wind resources. Firstly, the complementary characteristics of GHI and wind speed data are examined by using an approach from [2], to estimate the probability that solar complements wind (SCW), wind complements solar (WCS), and wind and solar synergy (WSS). The results in Figure 1 show that there is a higher chance for wind resources to complement solar resources. Overall, there is nearly 35% probability that wind and solar can complement each other.

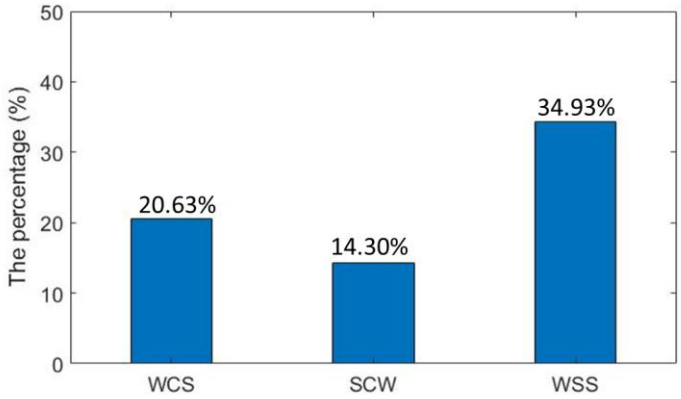

Figure 1. The proportion of the three scenarios

Furthermore, the ramping rates of both solar and wind resources have been assessed. The complementary nature of the ramping rates is shown when the ramping rate increase for one resource coincides with a decrease in the other resource. Thus, we can evaluate the occurrence probability of four different scenarios. The scenarios are: Solar Increase Wind Decrease (SIWD), Solar Decrease Wind Increase (SDWI), Solar Increase Wind Increase (SIWI) and Solar Decrease Wind Decrease (SDWD). From Table I, it can be observed that there is a higher chance that a wind increase will

complement solar decrease. However, the chance that both resources will increase/decrease at the same time is still quite high when compared to the chance that the resources will compensate for each other. In addition, the increases/decreases were classified into sudden changes (top 5% in magnitude) and extreme changes (top 1%). The investigation results show that there is a significantly low chance that extreme changes of solar and wind will coincide.

Table I. The probability of the four scenarios for ramping rates

SIWD (%)	SDWI (%)	SIWI (%)	SDWD(%)
7.87%	10.44%	14.55%	14.05%

Another aspect is to investigate the duration of prolonged lulls, which are consecutive hours of low solar or wind resources. The results show that there is also a significantly low chance that the prolonged lulls will occur for solar and wind resources at the same time.

Based on the analysis above, we further evaluated the requirement for using a battery energy storage system in the hybrid PV and wind power plant. Therefore, the battery in the hybrid PV and wind power plant can be used to ride through the weather lulls and extreme conditions.

References

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