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Using Artificial Intelligence Techniques for Solar Irradiation Forecasting: The Case of Saudi Arabia

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Abstract

The Middle East and North Africa (MENA) region is considered as one of the best areas, for solar radiation, in the world as seen in Figure 1 [1-2]. Sustainable Development Goals (SDGs), adopted by 193 nations in 2015, include, for the first time, a target to ensure access to affordable, reliable, and modern energy for all by 2030 [3]. In an analysis by IRENA [4] on the investment opportunities in the GCC, it is reported that close to 60% of the GCC's surface is hit by the sun and has significant potential for solar PV power systems. The European Photovoltaic Industry Association (EPIA) and Greenpeace expect that PV could provide up to 12% of electricity demand in European countries by 2020 [5]. Developing just 1% of this technology could eventually result in 470 GW of solar PV capacity.

In its vision 2030 [ref], Saudi Arabia identified renewable energy as one of the pillars of economic diversification, away from oil, with an initial target set to 9.5 GW. The abundance of solar resource potential in KSA combined with the falling cost of associated technologies, including photovoltaic (PV) modules, represent the major factor behind the increased use of this source of energy. Recently, Saudi Arabia launched one of the Kingdom's largest project to build $500 billion mega-city business and industrial zone "NEOM" with a high ambition to make this new area running on 100% renewable energy. However, despite its abundance and the many advantages over other sources of energy, this technology is related to the challenging whether predictions and modeling accuracy. The integration of solar energy into the electrical network would be more efficient if the fluctuation of the Global Horizontal Irradiation/Irradiance (GHI) is more reliable and hence the PV energy output well predicted more accurately. Although a solar PV system relies on many components such as inverter, charge controller, batteries, and panels, forecasting the solar irradiation represents the main step in ensuring and designing an efficient solar PV system since it depends on several parameters namely, PV system location and orientation, daytime, and sunshine period.

This paper attempts to develop a prediction model using the artificial neural network (ANN) [6, 7] for estimating the monthly average daily solar irradiation in the city of Jeddah, Kingdom of Saudi Arabia but, may be extended to other cities of the Kingdom. An in-depth ANN forecast method for solar irradiation is presented along with the statistical

approach and techniques for predicting the Global Horizontal Irradiation (GHI). By using case examples, it is possible to build models capable of predicting and generating rules that can be translated into natural query language and provide a measure of the confidence of the classification on the basis of its attributes. The data used in this study uses attributes such as variable weather and solar irradiation data of 10 cities provided by KACARE [8] as part of the Renewable Resource Monitoring and Mapping (RRMM) Program. The simulation is performed at Jeddah in an attempt to compare with the experimental measurements by KACARE and measurements done at Effat Solar PV system installed at the roof of the Deanship for Graduate Studies and Research (DGSR). An example of solar radiation and air temperature distributions computed using RETScreen [9], an energy management software created by the Government of Canada, to help predicting the viability and feasibility of energy project including renewable energy sources, is given in Figure 2. ANN method may use up to 12 attributes with MATLAB and/or WEKA [10]. The set of attributes being used for training are namely the time of the day, the year, the latitude and longitude, the air temperature, the wind speed and its direction, the azimuth angle, the diffuse horizontal irradiance, the direct horizontal irradiance, the global horizontal irradiance, the humidity, the pressure, and the zenith angle.

The significance of this study relies on its capability of predicting the solar irradiation to quantify and improve the PV system design, to ensure a secure and reliable electrical output, and to help electrical grid operators to manage the entire grid system. Another key element of this study is the outreach and dissemination of renewable energy technologies on Effat University campus, in addition to providing students with opportunities to perform experiments on the installed PV systems and to help Effat University becoming a leader in best practice campus sustainability.

Keywords
Solar Energy, GHI, Artificial Intelligence, PV Systems, and Machine Learning