Simulation of a Hybrid Power System Consisting of Wind Turbine, PV, Storage Battery and Diesel Generator: Design, Optimization and Economical Evaluation

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Abstract—**Hybrid power systems are based on renewable energy sources and especially on photovoltaic and wind energy systems. Software package is used to analyze measuring data for wind speed and solar radiation of two locations in Palestine (Ramallah and Nablus). Results of analysis illustrate that energy density available in wind for Ramallah site is about 2008 kWh/m^2.year, while it is 927 kWh/m^2.year for Nablus site. The daily average of solar radiation intensity on horizontal surface is about 5.4 kWh/m2 .day. A Matlab software package is used to simulate different scenarios of operation of the hybrid system by making energy balance calculations on an hourly basis for each of the 8760 hours in a year. This enable to choose the appropriate sizes of the different components for the most optimum scenario. The optimization is based on cost of generation. Results of the simulation illustrate that the most economic scenario is the scenario that uses a hybrid system mainly dependent on wind. Cost of energy (COE) in this scenario is 1.28 NIS/kWh(0.35 $/kWh). Other scenarios dependent on wind-diesel hybrid system, PV-diesel hybrid system, wind stand-alone system, PV stand-alone system, or diesel only, give results of COE greater than this value. It was concluded that none of the hybrid system scenarios analyzed could be justified to replace purchasing of electricity from the grid where the COE is 0.70 NIS/kWh(0.19 $/kWh).**

Keywords— **Hybrid Power System; Matlab; Wind Power; Photovoltaic; Energy Cost; CO2 Production ; Weibull Distribution; Diesel Generator**

I. INTRODUCTION

Hybrid power systems, which combine conventional and renewable power conversion systems, are the best solution for feeding the mini-grids and isolated loads in remote areas. Nowadays many applications in rural and urban areas use hybrid systems. Many managers of isolated loads try to adopt this kind of technology because of the benefits which can be received in comparison with a single renewable system.

For the Palestinian case, the daily average of solar radiation intensity on horizontal surface is about 5.4 kWh/m^2.day, while the total annual sunshine hours amounts to about 3000 [1]. These figures are relatively high and very encouraging to use PV generators for electrification of certain loads as it has been worldwide successfully used.

The annual average of wind velocity at different places in Palestine is about 3 m/s which makes the utilization of wind energy converters surely un feasible in such places . In other places it exceeds this number and reaches up to 5.5 m/s (Al-Mazra'a Al-sharqiyah/Ramallah is an example and it is the case under study in this paper) which makes it feasible to be used to operate a wind turbine. At Nablus, the annual average of wind velocity is about 4.5 m/s. Nablus site is also considered in this study for comparison with Ramallah site [2].

II. BLOCK DIAGRAM OF A HYBRID SYSTEM