



# Design of isolated hybrid systems minimizing costs and pollutant emissions

Abdel-Karim Daud<sup>a,\*</sup>, Mahmoud S. Ismail<sup>b,c</sup>

<sup>a</sup> Palestine Polytechnic University, P.O. Box 198, Hebron-West Bank, Palestine

<sup>b</sup> Palestine Technical University, P.O. Box 7, Tulkarm-West Bank, Palestine

<sup>c</sup> Department of Electrical Engineering, University of Malaya, 50603 Kuala Lumpur, Malaysia

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## ABSTRACT

Hybrid power systems based on renewable energy sources, especially photovoltaic and wind energy are an effective option to solve the power-supply problem for remote and isolated areas far from the grids. This paper presents a study and design of a complete hybrid system for providing the electrical loads in a family house in Palestine according to their energy requirements.

A computer program is developed to achieve this and to determine the specifications of the whole system components. It uses the data of wind and solar radiation measurements of the selected rural zone and all the required information about the electrical loads. Also, the hybrid systems minimizing, simultaneously, the total cost throughout the useful life of the installation, pollutant emissions (CO<sub>2</sub>) and dump load are taken into consideration.

It is found that providing electricity to a family house in a rural zone using hybrid systems is very beneficial and competitive with the other types of conventional energy sources, especially considering the decreasing prices of these systems and their increasing efficiencies and reliability. They have also the advantage of maintaining a clean environment.

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## 1. Introduction

Nowadays many applications in rural and urban areas use hybrid systems. Managers of isolated loads try to adopt this kind of technology due to the benefits which can be received in comparison with a single renewable system [1–3].

For the Palestinian case, the daily average of solar radiation intensity on horizontal surface is about 5.6 kWh/m<sup>2</sup> and day, while the total annual sunshine hours amounts to about 3000 [4,5]. These figures are relatively high and very encouraging to use PV generators for electrification of certain loads as it has been worldwide successfully used. For tilted surface it is about 6.1 kWh/m<sup>2</sup> and day. The annual average of wind velocity at different places in Palestine is about 3 m/s. In some places it exceeds this number and reaches up to 5.5 m/s. One is called Al-Mazra'a Al-sharqiyah which is located in Ramallah and considered as case study in this paper [5].

This paper shows the design of a hybrid PV–wind–diesel–battery installation for the generation of electric energy for a house in the region mentioned above as shown in Fig. 1.

The high capital cost of hybrid systems is affected by technical factors such as efficiency, technology, reliability, location, as well as

some non-technical factors, so the effect of each of these factors shall be considered in the performance study of the hybrid system [4].

In the specialized technical literature [1–4,6], the design of these systems is usually done by searching the configuration and/or control that renders the lowest total cost throughout the useful life of the installation, considering a fixed value for the unmet load, previously decided by the designer, and in some cases, the pollutant emissions are also limited or economically evaluated. Therefore, the result obtained will depend on the unmet load value selected, on the limitation of the pollutant emissions and/or on the subjective assignment of costs to the pollutant emissions.

In our study, different components constructing the hybrid system shall be studied, modeled, identified, specified, and chosen appropriately. Different issues concerning operation, technology, types, specifications and data analysis of both wind and solar radiation measurements are reviewed and studied. This study is applied considering uninterrupted of electricity supplying the load.

## 2. Mathematical model of the components

A more detailed mathematical model of the components of the hybrid system (PV panels, wind turbines, diesel generator, and batteries) and the control strategy can be found in previous works [1–4,6–9]. A brief description of such mathematical models is shown in forthcoming subsections.

\* Corresponding author.

E-mail address: [daud@ppu.edu](mailto:daud@ppu.edu) (A.-K. Daud).