Overview of Renewable Energy System Architecture and Performance

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Abstract: Global interest in solar energy has peaked as governments and organizations continue to take a stand against the dependence on fossil fuels and the high carbon footprint of the industrialized world. Using renewable energy technologies such as solar energy appears to be a good option, especially for third world countries that receive large amounts of solar radiation all year round. This article provides an overview of the architecture of renewable energy systems and the solar and photovoltaic (PV) energy system. It also provides a description of the system connected to the grid and the autonomous PV production system.

Keywords: PV system, Renewable energy, hybrid system, Stand-alone system

I. Introduction

The level of development of renewable energies is higher than ever. Many organizations and countries around the world support the use of renewable energy to reduce CO_2 emissions and dependence on fossil fuels. The continued volatility of the fossil fuel industry is a clear indication that fossil fuels may not be the only source, as is the proven study of its impact on global warming. Countries like the Sultanate of Oman are heavily dependent on fossil fuels, where the Sultanate was the world's 24th oil exporter in 2012 and 64% of its revenue came from oil. With approximately 29 billion cubic meters of gas sold annually, natural gas is the largest viable sector in Oman [1]. The development of a renewable energy market in Oman is important and fundamental to improve the country and allow citizens to take advantage of the diversity of energy resources. However, the replacement of oil and gas appears to be a difficult goal. The first steps must be taken to achieve this goal. The solar cell is one of the most popular technologies in the world due to its advantages. Thanks to its low weight, dependent on the sun that is everywhere, it is easy to install, silent as no mechanical or combustion process has to take place and can be easily purchased by users in the markets, especially when prices drop.

The area of Oman is 309,500 km2 and is located in the south-eastern part of the Arabian Peninsula between latitudes 16 ° 40 'and 26 ° 20' north and between longitudes 51 ° 50 'and 59 ° 40' east. Solar radiation in Oman and the Arabian Peninsula shows enormous potential for solar cell technology or what is called photovoltaics. The concept of photovoltaic technology revolves around the conversion of light into electricity using a semiconductor device. There are different systems and configurations for photovoltaic (PV) depending on the use of photovoltaic and the load you intend to supply [2, 3].

II. Literature review

Mohammed Alghassab et al. [4] This paper presented the study of the I-V and P-V properties of the photovoltaic (PV) field with different loads using MATLAB Simulink tools. Therefore, the steps and components required for the planning of photovoltaic (PV) panels under different solar radiations were identified. The optimal operation of stand-alone photovoltaic systems with direct and AC loads is discussed. The components of the proposed system were a PV power panel, a DC / DC converter, a battery, one phase inverter and DC / AC loads.

E. T. El Shenawy et al. [5] this article presents the utilization of solar (photovoltaic) energy to supply electricity to a family of roughly 50 m2 during a country of Shalateen, Egypt. The planning and installation of the autonomous photovoltaic system consistent with the daily electrical load of the house and therefore the irradiation data concerning the situation are described intimately. The sizing of the varied system components was examined (photovoltaic, mechanical structure, battery, inverter and charge controller). The paper also examines the economic analysis of the system in terms of life cycle costs and unit costs of electricity. The cost of electricity with the photovoltaic system installed was $ 0.201

/ kWh. This encourages the utilization of this efficient and clean energy system in rural community development plans.

LaurentiuFara et al. [6] an autonomous photovoltaic system was studied, designed and simulated for an isolated mountainous area in Romania. This photovoltaic system was developed for energy production and guarantees the energy independence (electricity for lighting and provide of low consumption appliances for a period of 70% from one year) of a house / chalet in a neighborhood with local power system. Connection is impossible or would require very high costs to increase the facility grid. A library of straightforward mathematical models was created for every element of such an autonomous PV system, namely the PV generator, battery, controller and cargo.

Laith M. Kadhom et al. [7] this text presented variety of mechanisms necessary to extend the economic benefits and therefore the level of scientific services supported by this technique. The results described during this paper confirmed that the planning of the system parameters (solar size, charge controller, battery bank, inverter characteristics, wiring size, and vertically movable base plate to live the lean angle) is more efficient using solar panels.

III. OVERVIEW OF RENEWABLE ENERGY SYSTEM ARCHITECTURE

A typical structure of the RE system is shown in Fig.1. The whole system is called a hybrid energy system.

The system consists of two or more RE sources that supply energy to the electrical load. Hybrid systems fall into two categories, namely: stand-alone and grid-connected systems.

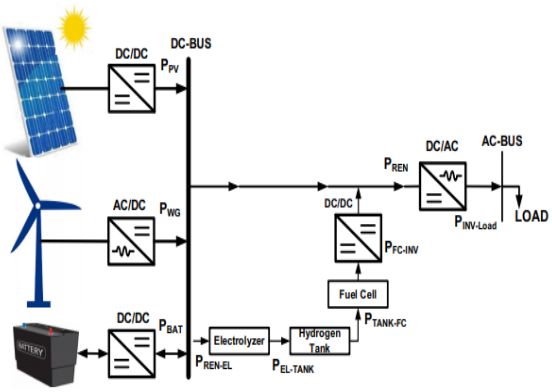

Fig. 1. Schematic of hybrid stand-alone PV-WT-BT integrated with fuel cell.

IV. STAND-ALONE SYSTEM

Autonomous system is also called autonomous system. The system is disconnected from the network and is responsible for meeting the demand at all times. This type of system presents reliability problems due to the nature of the resources used. For this reason, the system is economically and technically profitable only in off-grid applications when it is difficult to expand the network in one place. A flowchart of planning and designing an autonomous energy system is shown in Fig. 2.

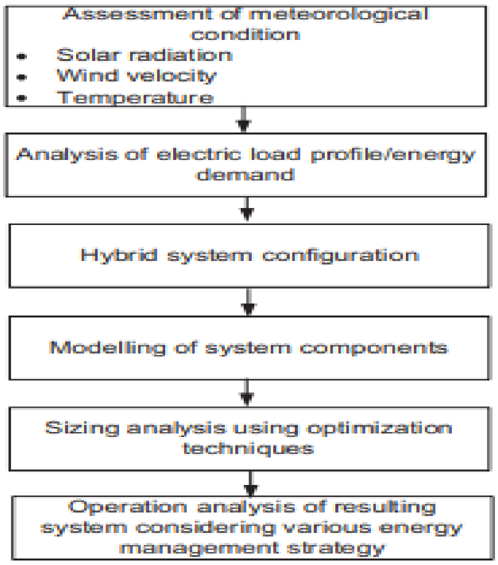

Fig. 2. Basic steps for standalone energy system planning and design.

A. *Grid-connected system*

An autonomous RE system connected to a large independent network. The public supply network is generally referred to as the Grid Connected System (GCS). In GCS, the excess energy generated by the independent ER system is fed into the grid. Similarly, during a production deficit, the grid serves to make up for the deficit.

B. *Standalone PV Generation System*

The configuration of an independent PV production system is shown in Fig. 3. The system mainly consists of PV module (including PV cell array), high DC boost converter, full-bridge PWM inverter, system controller and non-linear output load.

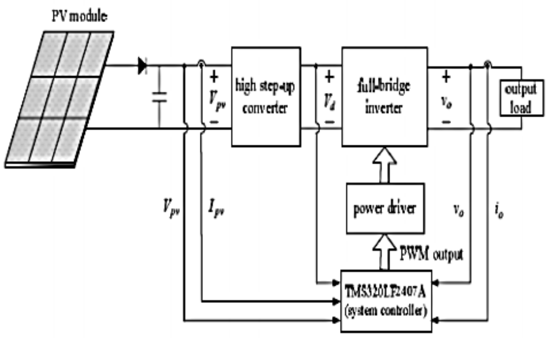

Fig. 3 A standalone PV generation System

V. Solar Energy and Photovoltaic (PV) System

The photovoltaic system has played a very important and crucial role in the electrification of rural areas, especially in developing countries [8]. Figure 4 shows the configuration of the autonomous solar system proposed in this work, which consists of five main elements, including a photovoltaic system (solar modules), a solar charge controller, a battery bank, an inverter and electronic circuits. A photovoltaic cell is a non-mechanical device typically made up of silicon alloys. Sunlight is made up of photons or particles of solar energy. These photons contain different amounts of energy that correspond to different wavelengths of the solar spectrum. When a photon hits a photovoltaic cell,
Depending on the amount of energy it contains, it can be reflected, transmitted or absorbed. Only the absorbed photons provide energy to produce electricity [9].

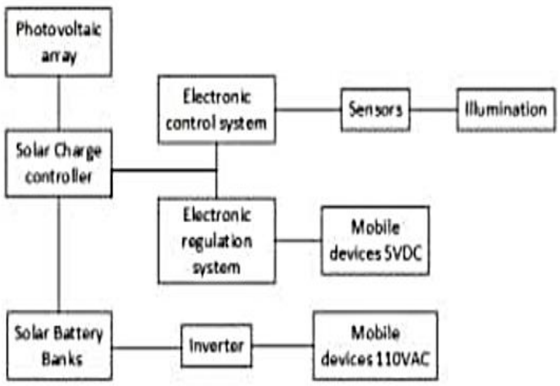

Figure 4 Configuration of the Stand- alone PV system under study

A. The Photovoltaic Cell

The following factors are generally taken into account in determining the performance of a solar PV module: characterize the performance of the solar cells, determine the deterioration factors related to the design and assembly of the PV module, given the environmental conditions and their effects on temperature operating conditions of solar cells and calculation of the output power of the solar module. A photovoltaic solar cell is a P-N junction semiconductor device that generates an electric current when photons with energy greater than the energy band gap of semiconductor materials fall on it. These cells are arranged in series and in parallel combinations to form a photovoltaic module [10]. Several types of photovoltaic materials for solar cells are currently available on the market [8]. Namely crystalline semiconductors. Si and GaAs have the highest performance compared to other options available on the market. Although solar cells are based on less pure materials, viz. polycrystalline or amorphous inorganic or organic materials, or a combination of them, have lower performance but their cost is lower [12].

B. Solar Charge Controller

Variation of voltage and frequency with variations in energy demand [11]. The basic function of this device is to prevent battery discharge and overcharging. It is also used to protect loads under extreme operating conditions and to provide information to the user. The charge regulation function should ideally depend directly on the state of charge of the battery. A charge controller adjusts the output of a photovoltaic module to avoid battery overload and unacceptable voltage levels. It also acts as a low voltage disconnect switch to stop the DC charging of the battery and prevent overcharging [13], [14].

C. Batteries Bank

To have energy available in the absence of solar radiation, a relative balance between the solar cells is necessary; they are the heart of the system and constitute the energy storage system. In this situation, a battery system is required to store the energy supplied by the photovoltaic system. The most commonly used energy storage devices are VRLAs. For a battery to be used in a self-contained solar system, it must be charged during sunny hours and withstand a deep discharge during sunny hours. Batteries are called deep cycle batteries.

D. Invert

Since photovoltaic modules only provide direct or unidirectional current when illuminated by sunlight, it is necessary to convert this direct electrical current into alternating current. An inverter is used for this purpose; it acts as a coupling element between the direct current generated by the photovoltaic solar module and the load that requires an alternating current. Its function is to adapt the properties of the energy produced to the needs deriving from the plant applications. Some of the main characteristics of an inverter are: input power or voltage, maximum output power and efficiency.

VI. Conclusion

The paper concludes that the high DC boost converter system is responsible for monitoring the maximum power point, the battery converter is responsible for the constant voltage of the DC bus, and the inverter is responsible for the stable and high quality output. In the absence of linear load. The controller checks that the three converters can work together and must remain coordinated for perfect performance. The efficient performance of renewable energy sources can be achieved by efficient converter control techniques.

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