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The Performance Assessment of Solar & Wind Hybrid System in Iraqi Climatic Conditions

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Abstract— *Hybrid energy systems combine two or more renewable sources to provide a high level of reliability and safety in energy supply. For example, geothermal energy + solar photovoltaic, biomass + solar concentrated power stations, solar fuel cells + solar energy, wind + solar PV, wind + hydroelectricity pumped + solar photovoltaic. The use of fossil fuels, as well as renewable energy sources, is sometimes used to ensure the safety and continuity of energy supply, such as: biodiesel + wind, natural gas + solar CSP, coal + solar CSP.*

This paper addresses many of the advantages of the hybrid electric system when combining wind and solar (PV) technologies. The experimental work was done in Al-Muthana Governorate. This area was chosen because wind speed is high compared to the rest of Iraq, which enables the generation of electricity acceptable for use and has been linked to the system for the production of photovoltaic electricity. The hybrid wind/solar system were tested in the area climatic conditions in March 2019. The results revealed good and acceptable performance for the proposed system especially if it is connected to the grid.

Keywords— *Solar Energy; Wind energy, PV module, wind turbine, generated electricity.*

I. INTRODUCTION

The rapid increase in population around the world, which exceeded seven billion today, is causing an increase in demand for energy to equip electricity for housing and work in addition to the operation of engines of cars, vehicles, aircraft, ships and others. All this has caused an unprecedented increase in fossil fuel combustion [1, 2]. This fuel is now an unsafe source of dependence on energy saving for two important reasons. The first is the near-exhaustion and great fluctuation in price, which has caused several shocks to the global economy. [3] The second reason is that the effects of severe environmental pollution have been reflected in environmental phenomena such as global warming and climate change that could cause future human genocide if pollutant emissions from fossil fuels remain at or above their current levels [4, 5]. Switching to renewable power supply systems is the best choice for the world to reduce pollution and eliminate its consequences [6]. These energies include solar energy, wind, geothermal, bioenergy, etc.

About 16% of global final energy consumption at present is from renewable sources, 10% of the total energy from conventional biomass is used for heating, 3.4% of hydroelectric power. New renewable energy sources (modern biomass [7, 8], small hydropower, biofuels, wind power, solar energy). Renewable technologies are also growing rapidly and are also suitable for rural, remote and developing countries. [9] Renewable energy sources are expected to contribute 20% of the world's energy by 2030.

Renewable energy is derived from natural processes that are constantly renewed. In various forms derived directly from the sun, or from the heat generated in the depth of the earth. Renewable energies: ocean energy [10], hydroelectric heat [11, 12], wind [13, 14], biomass [15, 16] and hydrogen energy [17, 18]. Wind power is growing 30% per year, and photovoltaic power plants are popular in Germany and Italy. Ethanol now provides 18% of the country's automotive fuel. Ethanol fuel is widely available in the United States and Brazil [19, 20].

Solar energy is the conversion of energy stored in sunlight into electricity, either directly using photovoltaic cells (PV) [21] or indirectly using concentrated solar energy (CSP) [22]. Concentrated solar systems use lenses or mirrors and tracking systems to focus a large area of sunlight on a small beam [23]. Photovoltaic cells are a very important and relatively inexpensive source of electrical power where network power is inconvenient, unreasonably expensive, or simply unavailable [24]. Photovoltaic cells convert light into an electric current to use the photoelectric effect, and solar energy is increasingly used even in grid positions as a means of feeding low-carbon energy in the grid [25, 26]. The cost of solar electricity is also falling.

Solar energy is used in many important applications such as: heating water for housing and industry [27], heating the air for comfort purposes [28], heating rooms by Trombe walls for ventilation and heating [29], solar distillation [30] and electricity production [31]. The heating processes are carried out using salt gradient solar ponds [32, 33], solar water heaters [34], solar air heaters [35] and Trombe walls [36]. The production of solar electricity varied from the confiscation of solar chimney [37, 38], solar concentrated power stations [39, 40], and photovoltaic cells [41]. The most important environmental factors that affect the productivity of solar applications and cause degradation of efficiency and performance are the dust [42, 43]. Unfortunately, Iraq has been a dust-producing basin in recent years after suffering more than two decades of continuous drought. The efficiency of the solar chimney, concentrated power plants, and photovoltaic cells is reduced by the accumulation of dust [45, 46, 47]. Therefore, researchers stressed the need for periodic cleaning and sometimes rapid (after dust storms) to reduce the damage [48, 49].

The intensity of solar radiation in Iraq is high because of its neighbor to the countries of the solar belt and the intensity of solar radiation in August about 876 W/m^2 and the lowest radiation intensity registered in January is about 265 W/m^2 [50]. This high solar radiation makes the use of solar energy in Iraq an ideal solution to reduce dependence on fossil fuels and reduce the pollution caused by the fires. But at the same time causing high temperatures of photovoltaic cells, which reduces their productivity [51, 52]. This effect has been studied extensively by researchers around the world. There are many solutions to this dilemma, such as switching to the use of air-cooled PVT systems [53, 54], water [55, 56], nanoparticles [57, 58], PCM [59, 60], and nano-PCM [61, 62]. The results achieved by researchers in this field of research are impressive results and confirm that the future of this technology, but researchers have not agreed today to a specific technology because of the wide and wide range of materials that can be used in the process of cooling the photovoltaic cell. The Iraqi government has agreed with Germany's Siemens and General Electric to set up stations of this type and yield more than 500 MW.

Wind power is a reasonable and acceptable alternative to fossil fuels in most countries of the world. It is abundant, widely distributed, renewable, clean and emits greenhouse gas emissions during operation and requires little land. Effects on the environment are generally less problematic than those found in other energy sources. Wind power is a reliable and used source. Denmark and Germany generate more than a quarter of the electricity from wind, and 83 countries around the world use wind energy to supply power.

Wind is the movement of the air due to natural factors resulting from unequal solar heating of different areas of the earth's surface, and the rotation of the earth, as well as the topography of the earth plays a role in the formation of wind and speed of air movement. Wind energy has been used in windmills, which are widely used to pump water and generate electricity across the Great Plains [63]. Wind energy can be converted into a useful form of energy, such as mechanical energy in windmills [64], or electric power, as in the case of wind turbines [65]. Hundreds of individual wind turbines can be assembled in one place by speeding up acceptable winds to build large wind farms where the electricity produced is processed into the electrical grid. The production of electricity using wind energy can be considered a cheap source of electricity. In some places (these areas are multiple and many around the world), electricity is produced in a competitive manner with fossil fuel power plants and sometimes overcome such stations [66]. The establishment of small wind farms in isolated sites can provide electricity for such sites. The use of offshore wind stations results in more electrical power than those produced on land, and these farms have a low visual impact. However, the maintenance costs of these systems are much higher than the stations above the land [67, 68, 69].

Given the fluctuation of wind velocity in different regions, solar energy is unstable and sometimes causes a significant reduction in the intensity of solar radiation due to shadow [70], clouds, and dust storms [71, 72]. Therefore, the meeting of the two systems together in one system is ideal for the continuity of electricity supply and non-interruption. The hybrids of photovoltaic cells and wind turbines systems provide many higher benefits than any single system, according to many renewable energy experts [73]. Studies of the wind speeds across Iraq have shown that wind speeds are very low in the summer when the sun rises. The speed of wind in the winter increases somewhat as the intensity of solar radiation decreases. The peak operating times for wind and solar systems occur at different times of day and year, and hybrid systems are likely to produce energy better than each system alone. Many hybrid systems are stand-alone "off-grid" systems that are not connected to the power distribution system. At times when the wind or solar system is not produced, most hybrid systems provide energy through batteries and / or a conventional fuel generator, such as diesel. When a motor generator is added, modern electronic controls can automatically operate these systems. The engine generator can also be used to reduce the size of other components needed for the system. The size of the battery banks is usually to supply the electric load for one to three days. Here, it must be borne in mind that storage capacity must be large enough to provide electrical needs [75].

It is difficult for hybrid systems to determine exact recovery periods. Solar wind hybrid systems work best in commercial and industrial situations where grid power is not available or where after terrain the energy is made a military source or rail application, or where power is expected to be continuous At all times [76-79]. These small size systems can also be used in small rural offices, rural health care centers, and government office offices [80]. Because such small rural offices operate with a few residents, lights, one or two computers, and a laser scanner. Offices with this load will typically consume 3 to 4 units of energy per day.

The study aims to shed light on the use of a hybrid system consisting of a photovoltaic cell and a wind turbine operating in an area outside the city of Samawah, Muthanna province in southern Iraq. The successful operation of such a system in severe desert weather conditions will make the use of these systems encouraging to be used in border posts and remote medical clinics away from the network.

II. STUDY METHODOLOGY

A. *Study Area*

The Iraqi province of Muthanna is the second largest province in the Republic of Iraq in terms of area, but the population (which according to the estimates of the Iraqi Ministry of planning population in 2014 by 775 thousand people), which is considered the least [81, 82]. After nearly two decades of drought and lack of rainfall, the water level in the Euphrates River has decreased, agricultural production has been reduced to a large extent, land has increased at the expense of agricultural land, and the Euphrates River has been salted in the region [83].

B. *Electricity Conditions in the Province*

The study area suffers from the deterioration of electricity services as the vast area of the province makes the transmission lines of electricity very long [84]. Iraq over the past 40 years has been subjected to several wars and extensive destruction in the infrastructure [85]. Among these sectors is the destructive electricity sector in this province [86]. The residents of the province to use diesel generators to distribute electricity to the neighborhoods of the city and districts of Muthanna, but these generators, ranging from 150 kilowatts to 1 megawatt consume large amounts of fuel, in addition to the emission of millions of tons of pollutants into the atmosphere [87]. To date, the power cut has not been dealt with decisively and people continue to suffer.

C. Experimental Setup

This study aims at making sure that a hybrid system consisting of photovoltaic cells and wind turbine can be used with storage of electricity using batteries in the city of Samawah in Muthanna. The system performance analysis was based on analysis of the performance of PV panel, inverter, wind turbine, and battery. During the study, the wind speed was measured using the system. The voltage of the wind system was measured as well as the voltages generated in the photoelectric panel. It also took into account wind energy, solar radiation, and the current generated from both systems when charging the battery through the FSNW0.8KD inverter using Fluke 345 and electronic noise. Data on solar radiation and wind speed are taken from the UniMAP Weather Station and Weather Link Program.

Inverter Data

FSNW0.8KD is a combination of the controller and the inverter technology used in this system depends on microchip control and protection system. The main circuit is USA FC MOSFET and the most advanced intelligent power unit IGBT, which has good transient response and high conversion efficiency.

The main equipment of the PV module, battery, wind and AC/DC FSNW0.8KD hybrid load of inverter, control unit and instrumentation consists of Electrocorder (Electrosoft), Fluke 345 clamp meter (Data Logger).

For solar radiation and wind speed in Samawah-Muthanna the weather station was used. This station uses the weather link program, which can record changes in solar radiation and wind speed every minute of the day, and solar radiation and wind speed data can be downloaded using the Weather Link Program. Four photovoltaic solar modules were used to generate continuous current power in this study. Each panel of PV has the following: Maximum power of 62W, maximum current generated 4.13A and maximum voltage generated 15V. The photovoltaic panels are connected to each other in parallel. The maximum output capacity of the PV panel is 248W, and the 24V battery is used with the system with reflector to convert DC to AC. As for the specifications of the wind turbines, it has a diameter of 2.2 m, the highest wind speed can be measured: 10 m/s, estimated power: 450W, rated voltage: DC24V, generators: permanent three phase magnet, blade material: Nylon, number of blades: three, Estimated rotational speed (rpm): 450, tower height: 8m. An Electrosoft program was used to record the voltage and current generated in each minute and the download of recorded data can be saved using the program. Fluke 345 acts as a clamp counter, data logger and digital power meter. Fluke 345 works as a clamp counter, data logger and digital power meter. The instrument design makes the impact of the clamp from the DC measurement possible without the need to break the circuit. The PM300 power analyzer is used to measure average AC power. It is set using VPAS lite, so the measurement can be recorded every minute and downloaded by the program.

III. Results and Discussions

Figure 1 shows the solar radiation intensity for the study area in summer and winter. The intensity of solar radiation increases in summer to reach 860 W/m^2 during the afternoon. The increase in solar radiation rates is appropriate from the outset because it increases the productivity of the PV cell, but in fact causes a high increase in temperature gradation, which reduces its productivity while the intensity of solar radiation in winter is more suitable for cell work in this region.

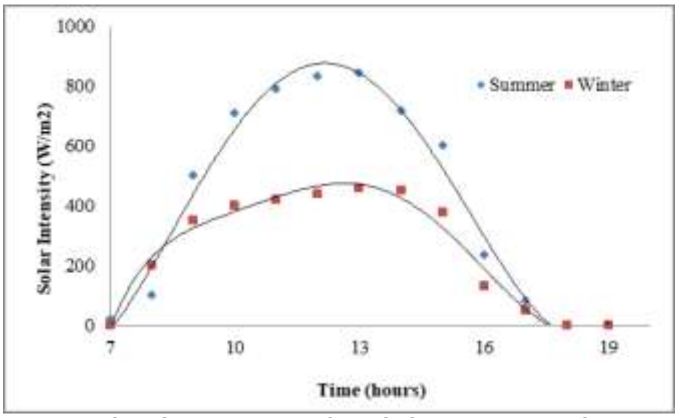

Fig. 1. Solar radiation intensity in the studied area in summer and winter

Figure 2 shows the tested PV module generated power during summer and winter for the studied area. The power generated in winter is higher than that of summer because the PV panel temperature is near the standard test conditions where the PV temperature must be not more than 25°C. The sun in summer stay for rises at 5.5 AM while in winter it rises at 6.5 AM; and the sun set time is at 5.5 PM and 7.15 PM for and summer, respectively. This means longer operation time at summer than at winter. The maximum energy generated is at its peak in the middle of the day as the demand for electricity peaks. This is a good characteristic and advantage of solar energy that all the daytime it generate electricity and it rise its generated power at peak period.

Figure 3 shows wind speed over time for the study area in summer and winter. The wind speed in this area is moderate and does not exceed the best conditions of 5.5 m/s for both seasons. Wind speed is volatile and unstable, which means unstable energy productivity. Note that there is speed of wind at night, which leads to the production of energy at night, unlike solar energy, which cannot produce electricity at night. Wind speed is more pronounced in the summer, as in this season the temperature rises in this desert region extended and connected to the Desert of the Najed, which generates a movement of hot air.

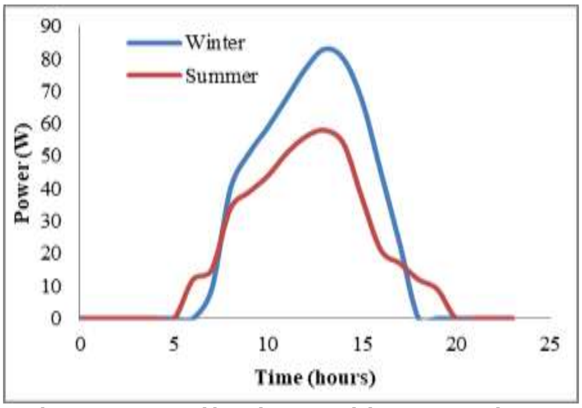

Fig. 2. The power generated by solar PV module in winter and summer

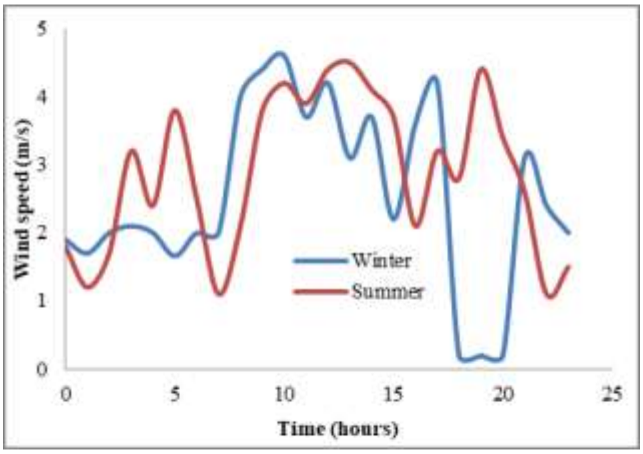

Fig. 3. Wind speed in the tested area in summer and winter

Figure 4 represents the generated power using the wind turbine during winter and summer. In general, the power generated in fluctuating and not stable in both seasons. The work with wind turbine necessitates the use of electricity storage system (batteries) to store part of the generated power for using it when the power generated reduces due lower wind movements.

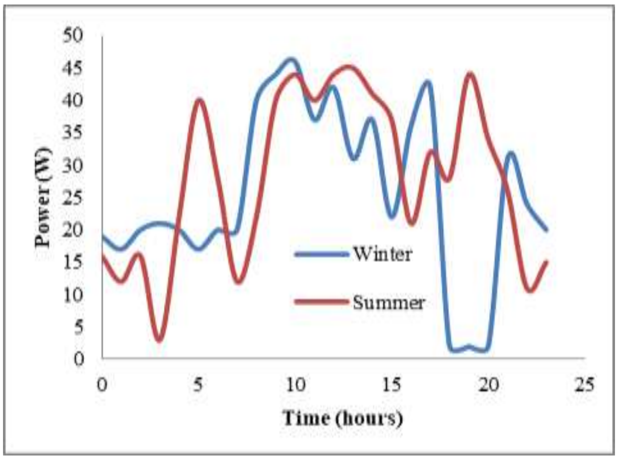

Fig. 4. The power generated by wind turbine in winter and summer

IV. Conclusion

Renewable wind and solar energy that comes from natural resources does not cause any emission of greenhouse gases or any air pollution when it generates electricity or any other energy. The hybrid solar and wind system revolves around the power plant range to increase power. High capacity wind turbines, PV panels and battery can be used for this purpose. Hybrid combinations of wind power, solar hydroelectric power, tidal energy, geothermal energy, biomass generated energy, can be considered energy from solid waste incineration, and many other technologies can be considered to be dependent on local resources or two renewable sources of energy connected to the electricity grid. The photovoltaic array consists of multiple light units, which convert sunlight into electricity.

The results of the study showed clearly that the electricity generated in the photovoltaic cell is directly proportional to the intensity of the solar radiation. When the intensity of solar radiation is high, the energy generated by the photovoltaic cell is high when compared to that generated at low solar radiation intensity. The voltage difference for the wind turbine is also created directly with the wind speed. The highest power generation was 83 watts of photovoltaic power, and the highest generating voltage of the wind was 45 watts. The performance of PV is good and the wind performance is average in Samawah-Muthanna. The use of both systems necessitates storage batteries to store the excess electricity for use at night or when the wind movement is low.

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