Sustainable hybrid energy production system

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Abstract: *Solar energy has a drawback when it works individually, because it could not produce electrical energy in rainy and cloudy seasons, and during the night time. Wind energy is not constant and it varies from zero to storm force. This means that wind turbines do not produce the same amount of electricity all the time. Therefore, the need to overcome these drawbacks could be by combining two energy resources so that any one source fails the other source will keep generating electricity. In this study, a designed prototype that combines two energy resources wind and solar energy will be constructed and tested. The design will supply the sustainable energy resources without damaging the nature and gives uninterrupted power. Also it works during day time and produce DC power by the solar PV cell which is stored in the battery bank through a hybrid controller, which maximizes charging current and prevents excessive discharge/overcharge. The Wind turbine generator will generate power when wind speed exceeds cut-in speed; wind power is also stored in the battery bank through hybrid controller. Energy stored in the battery is drawn by electrical loads through the inverter, which converts DC into AC power. The inverter has in-built protection for short-circuit, reverse polarity, low battery voltage and over load. The battery bank is sizing to feed loads up to five hours, during non-sun/wind days. The designed prototype has proved to work efficiently for a sustainable electricity supply for 24 hours, the results of this work give an incentive to proceed with building and using such sustainable power generation systems (hybrid) that have proven to be efficient and economically feasible to use for continuous energy generation which is suitable for urban, rural and isolated areas.*

KEYWORDS: *SOLAR ENERGY, WIND ENERGY, BATTERY BANK AND CONVERTER*

Introduction:
Humans have an insatiable thirst for energy, but the population will increase rapidly with the continuous increasing in energy demand. Global electric power has now reached 15 terawatts (the equivalent of 150 billion 100W light bulbs) and assuming an increase in population to 9 billion and continuation of the current growth rate in energy demand, this would increase to 100 terawatts by 2050 [1 and 2]. Even if we take on more sustainable approaches in the future and conserve energy to the best of our ability, we would still require 30-40 terawatts of electrical power capacity by 2050. Since the industrial revolution, our entire infrastructure and economy has been built upon cheap and easily available fossil fuels, such as coal, natural gas and oil, so that these are now the most essential resources for humankind. These fossil fuels are being rapidly consumed – an approximate 2 trillion barrels of oil were consumed over the last 100 years and another trillion is likely to be consumed in the next 30 years, nature took millions of years to produce this amount of oil. Current predictions state that coal reserves will be depleted in 250 years, oil in 40 years and gas in 70 [3 and 4]. This means that we are in an energy crisis, and the implementation of renewable energy solutions can help solve this predicament. Renewable energies refer to energies derived from sources that are a constant factor for humans on earth, and these sources include the sun, wind, biomass, the ocean, hydro power and geothermal. However, the move towards renewable energies needs to be done quickly. Although the depleting fossil fuels will not affect us for a few decades at least, governments of countries have an increasing incentive to diversify their energy sources [5 and 6]. Investing in renewable energy on the national and global scale is advisable for the following reasons [7].

- Energy security
- Escalating costs of conventional energies
- Less price volatility and competitive market
- Stimulation of economy and creation of jobs – investing in renewable energies will create a renewable energy industry which will stimulate the economy [8]
- Environmental concerns –burning of fossil fuels leads to the release of carbon dioxide gas into the acreage havoc in many parts of the world [9]
- Depleting resources

Motivation of the Study: Jordan is a non-oil-producing country and imports 96% of the energy used. As a consequence, energy imports accounts for roughly 22% of the GDP (Gross domestic product). The population's growth rate is high; about 2.3% per year. This causes the demand on energy sources, mainly oil products to increase rapidly. Implementation of renewable energy resources such as solar and wind energy, will lead to economic, social and environmental benefits [9].

Objectives: The main aim of this study is to design and implement a prototype of a solar-wind hybrid energy system. While the sub-objectives are:-

-Calculate the wind power generation for the case study
- Calculate the solar power generation for the case study
-Calculate the total storage of combined power that generated from the system
- Design a suitable combined system to give a sustainable energy for 24 hour

Methodology: In order to achieve the overall objectives of the research, the following approach is adopted in the current research.

- Literature survey: Reviewing the collection of research publications related to the present research problem, in order to understand and evaluate of the current state of the research
- Theoretical analysis of the proposed designed system
-Analysis the data that will be collected
-Modeling and simulation of the designed controller for hybrid energy system

The Proposed Hybrid System in Present Work: In recent years, hybrid technology has been developed and upgraded its role in renewable energy sources due to its benefits [10]. It produces autonomous power production which is un-challenged, and now days many houses in rural and urban areas use hybrid systems. Many isolated islands try to adopt this kind of technology because of the benefits which can be obtained in comparison with a single renewable system. In present work this system will be designed based upon a wind ducted turbine and photovoltaic (PV) panels, as shown in figure (1). This specific hybrid system presents many benefits; specifically, the assessment for a wind/solar hybrid system which is focused on the wind and solar potential of the region.

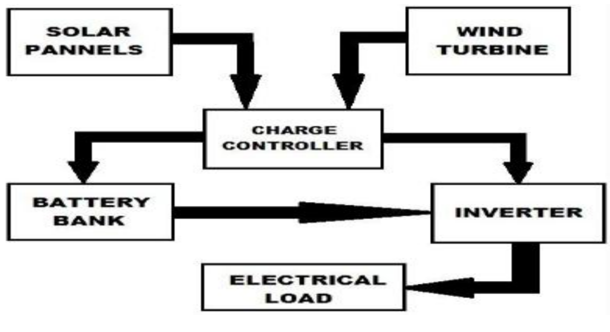

Figure -1: *Operation Diagram of a Hybrid System for PV and Wind Turbine*

The system can be operated during the day using the energy from the sun and after the sun has set it can utilize the potential wind energy to continue its function. For this reason, wind and solar systems work well together in a hybrid system and they provide a more consistent year-round output than either wind-only or PV-only systems. Moreover with the use of the appropriate auxiliary systems like batteries can store energy which will be useful in compensating electrical demands used by the building for periods where there is no sun or wind. Finally, it is economically sound and advantageous to use non finite resources, i.e. solar and wind (hybrid). The investment financially and environmentally in modern technologies will win through the generations to come in the fight for energy efficiency and effectiveness.

Wind Turbine Power Generation: Wind turbine (WT) power is used to convert kinetic energy into electrical energy through the use of a generator. As wind conditions vary, the electrical energy created from the generator needs to be converted for usability. A rectifier, inverter, transformer and filter are needed within the wind turbine for utility-grade AC power to be transmitted over long distances. A transformer is usually installed at the bottom of the tower to provide voltage conversion from the low voltage generated by the wind turbine, to medium/high voltage for transmission [11].

Rectifier and Inverter: The rectifier and inverter are key components in the wind turbine system. The rectifier converts noisy AC power to DC power, while the inverter converts DC power to clean and reliable AC power. The switching of these devices is usually controlled by a DSP-embedded controller via a fiber optic link, to provide efficient and reliable switching control with high galvanic isolation capability

Power Outputs: The mechanical power extracted from the wind can be calculated by the following equation [11]:-

$$\mathbf{P_{mec}} = \frac{1}{2} \rho_{air} \mathbf{A_r C_p} V^3 \, \eta \quad \text{…………... (3)}$$

Where

$\mathbf{P_{mec}}$: Mechanical power on the shaft of the turbine,

ρ_{air}: Air density,

$\mathbf{C_p}$: Power coefficient,

$\mathbf{A_r}$: Area swept by the rotor,

V: wind speed.

η : Mechanical efficiency of wind turbine.

Wind turbines are also classified by the amount of power that they can generate, and are directly correlated to the physical size of the turbine (larger wind turbines produce more energy). The three types of turbines in terms of power output levels are: utility, industrial, and residential- scaled wind turbines. Table-1 displays the average size range and uses for each of the three scales of turbine [12].

***Table -1:** Wind Turbine Classifications [12]*

Scale	Average Output Range	Uses
Utility	900 kW - 2 MW	•Generate bulk energy for sale in power markets •Commonly used in "wind farms"
Industrial	50 kW - 250 kW	•Remote grid production •Reduce consumption of higher cost grid power •May be sold if permitted by state regulations
Residential	400 W to 50 kW	•Remote power •Battery charging •Net-metering type generation

Wind Speed and Effect of Height: Wind speed varies with height at ground level (zero meters) the speed is low and turbulent and at some higher altitude (say, 100 m) it is faster and smoother, this is due to friction as wind passes across the earth's surface. Whilst the nature of surface varies, it is common practice to use an empirical relationship between height and speed. The standard height for meteorological observation wind speed data is 10 m. This type of data is the most readily available, as the power generated is proportional to the velocity cubed, there is an advantage to be gained by locating the turbine on some form of tower, typically in the range 10 to 120 m high. The effect of height is shown in the figure (2)

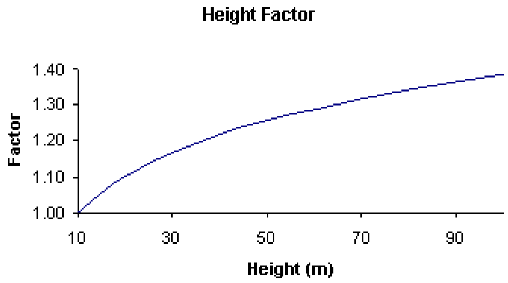

***Figure -2:** The effect of height and speed factor [13]*

While, figure (3) illustrates the increase in wind speed with height in the context of rated output.

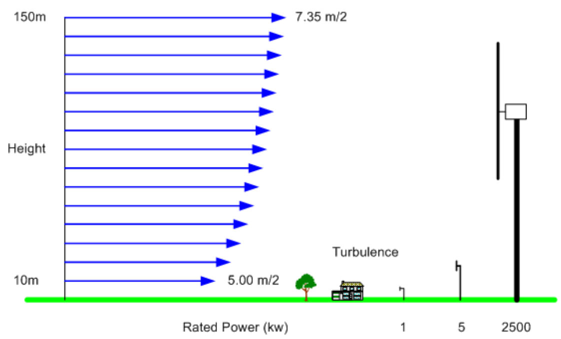

***Figure -3:** Wind Speed with Height [13]*

The sample calculation assumes that the turbine is mounted on a 30-meter tower, thus if the Rayleigh wind speed is 5 m/sec at 10 m, this can be expected to increase by a factor of 1.17, allowing a value of 5.85 to be used for the estimate, giving a 60% increase in output [13]

Wind Speed - Operating Range: At very low speeds (say less than 2 m/sec) the turbine will not rotate at all whilst at high speeds (say greater than 25 m/s) it is necessary to limit or stop the turbine to prevent damage from over-speeding [14]

Pitch Regulated and Stalls Regulated Wind Energy: Turbines are designed to withstand extreme winds statically. This means that they can survive a storm, but only when they are not spinning. They are not designed for extreme rotational torques or speeds. At very large aerodynamic torques or rotational speeds, the forces on the blades and other parts of the turbine are enormous and it will literally tear the turbine apart. This is why they are always designed with a cut-out speed above which breaks will slow the turbine to a halt. These control strategies can broadly be classified as pitch-regulated and stall-regulated, respectively. Pitch-regulated wind turbine have an active control system that can vary the pitch angle (turn the blade around its own axis) of the turbine blades to decrease the torque produced by the blades in a fixed-speed turbine and to decrease the rotational speed in variable-speed turbines. This will slow down the turbine's rotational speed or the torque transferred to the shaft so that the rotational speed or the torque is kept constant below a set threshold. Figure (4) shows the pitch-regulated turbine is represented by the red curve [13]

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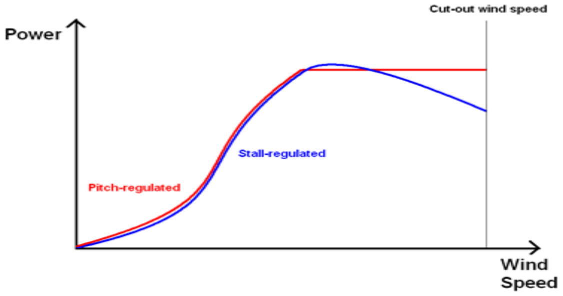


Figure -4: *Pitch-regulated and Stall-regulated Wind Turbine [13]*

Stall-regulated wind turbine, on the other hand, have their blades designed so that when wind speeds are high, the rotational speed or the aerodynamic torque, and thus the power production, decreases with increasing wind speed above a certain value (usually not the same as the rated wind speed). The benefit of stall-regulation over pitch-regulation is limited the capital cost of the turbine, as well as lower maintenance associated with more moving parts [14].

System Design and Data Collection: The present work system design will be performed by the following main steps: -

(a) Design of Combined Energy System: The proposed design of the combined energy system which will be used in this work as follows:

(1) Data Required for Solar System:

- Monthly averaged insulation incident on horizontal surface (kWh/m²/day)

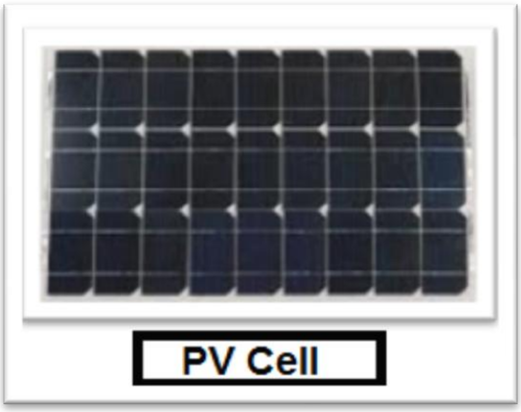
- Solar power that can be generated from the panel

(2) Data Required for Wind System:

- Hourly wind speed (m/sec)
- Wind power that can be generated from the wind turbine

(3) Technical Part

Technical components of the prototype are as shown in the figure (5)



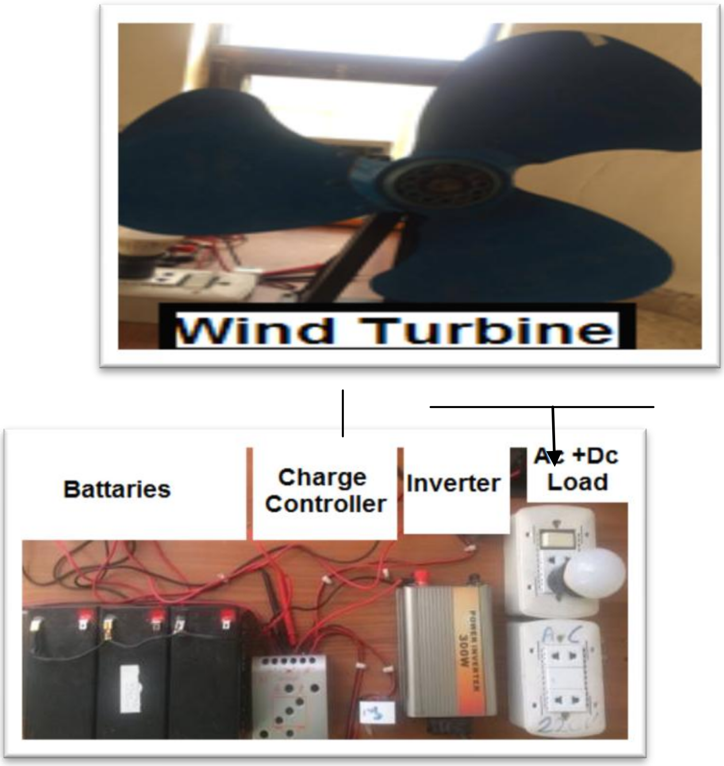


Figure-5: *Prototype of Combined Energy Resources*

(b) Calculations of the Design: During day time, DC power generated by the solar PV array is stored in the battery bank through hybrid controller, which maximizes charging current and prevents excessive discharge/overcharge. Wind turbine generator will be started generating power when wind speed exceeds cut-in speed of the minimum wind turbine (above2.7m/s). The wind turbine is self-regulated type with protection for over speed. Energy stored in the battery will be consumed by electrical loads through the inverter, which convert DC into AC power. The inverter has in-built protection for short-circuit, reverse polarity, low battery voltage and over load. The battery bank is sizing to feed loads up to two hours per day, during non-sun/wind days. The designed calculations will be performed by the following main steps (figure-6):

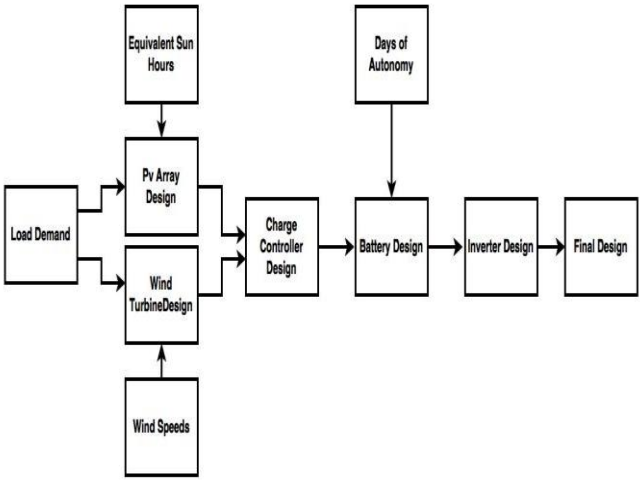


Figure -6: *Step by Step Designing of the Hybrid System*

Step- One: Calculation of the Load Demand

Calculating power consumption demands and total Watt-hours per day for some appliances for example to verify the present design used as shown in table (2).

Table 2: *The Load Demand for the Hybrid System for the Case Study*

Appliance type	Quantity	Power per item (W_{DC}, W_{AC})	Total Power (W_{DC}, W_{AC})	Time of Use (h/day)	Total Energy (W h/day)
AC Light	1	5	5	2	10
DC Light	1	9	9	2	18
AC Small TV	1	10	10	2	20
AC Small Camera	1	16	16	2	32
Total		40			80

Step -Two: Calculation of the Minimum Powers that PV and Wind Turbine Expected to deliver from the load demand which was calculated in table (2) will calculate:

(1) Outputs Energy of PV and Wind turbine:

The DC loads as calculated above = 18 watt

The AC loads as calculated above = 62 watt

(2) After it passes through the inverter where the efficiency is 90 % as in figure-, the AC load will be:-

$$P_1 = \frac{P_{AC}}{\eta_{inv}} \text{.....................} \mathbf{(4)}$$

$$\rightarrow = \frac{62}{0.9} = 68.89 \text{ W h/day}$$

(3) Minimum outputs energy of PV and Wind turbine after the power passes through charge controller and the battery where the efficiency is 85% as in figure (7):

$$P_2 = \frac{(P_1 + P_{DC})}{\eta_{cc}} \text{............} \mathbf{(5)}$$

$$= \frac{(68.89+18)}{0.85} = 102.2 \text{W h/day}$$

- If it is assumed that general losses that may occur in the system will be 10% when considering the worst situations (cable losses, attachments, development current), the total power needed per day can be expressed by the equation (Yousif. 2012)

$$P_{Load} = P_2 \times 1.1 \text{.................} \mathbf{(6)}$$

$$\rightarrow 112.42 \text{ Wh/day}$$

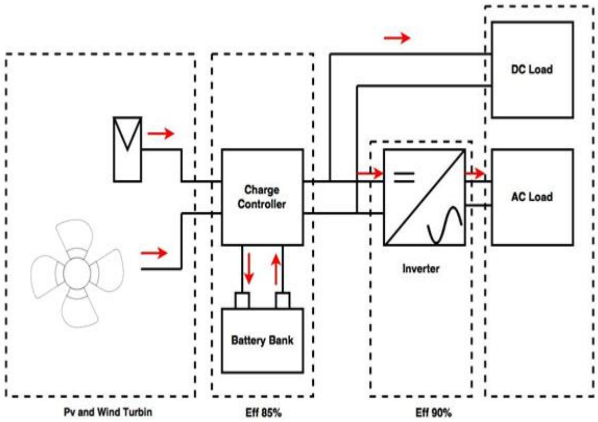


Figure-7: *The Energy Conversion for the Study*

Step -Three: Solar Panel Sizing: Solar panel is used to convert solar radiation to the electrical energy. The physical of PV cell is very similar to that of the classical diode with a PN junction (a boundary or interface between two types of semiconductor material, p-type and type, inside a single crystal of semiconductor) formed by semiconductor material. When the junction absorbs light, the energy of absorbed photon is transferred to the electron-proton system of the material, creating charge carriers that are separated at the junction. The charge carriers in the junction region create a potential gradient, get accelerated under the electric field, and circulate as current through an external circuit. Solar array or panel is a group of a several modules electrically connected in series parallel combination to generate the required current and voltage. Solar panels are the medium to convert solar power into the electrical power.

(1) **Radiation in Mutah University Site:**
The system has been designed on the basis of the solar data available for the selected area that is south Jordan and for more accurate working Mutah University has been selected as a more specific location and all the calculations are based on Mutah University, as shown in figure (8) shows monthly averaged insulation a horizontal surface.

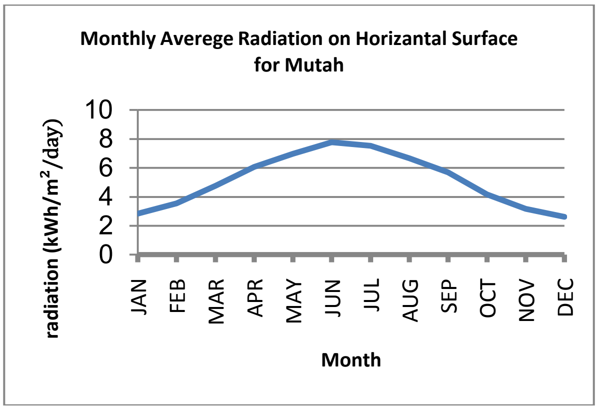


Figure -8: *Monthly Average Radiation on a Horizontal Surface (kWh/m²/day) (NASA)*

(2) **Calculating Equivalent Sun Hours:** The peak sun hours per day (PSH) is the number of hours per day of solar irradiation > 1000 Wh/m² for Jordan the PSH is 5.7 h/day.

(3) **Calculating Size of PV Panel**: To find the number of panels that the system need, and connection between them to cover the load demand.

$$\textbf{Minimum PV Power} = \frac{\textbf{Total Energy Demand}}{\textbf{Equivalent Sun Hours}} \ldots\ldots \textbf{(7)}$$

$$\rightarrow W_P = \frac{112.42}{5.7} = 19.72\ w$$

$$\textbf{Number of Panels} = \frac{\textbf{MinimumPv Power}}{\textbf{Power output of Pv}} \ldots\ldots\ldots\ldots \textbf{(8)}$$

So, the number of panels = $\frac{19.72}{50}$ = **0.39** ≈ 1 panel as shown in figure (9), the specification of the panels is shown in figure (10)

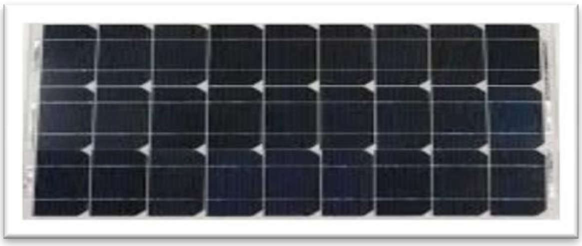
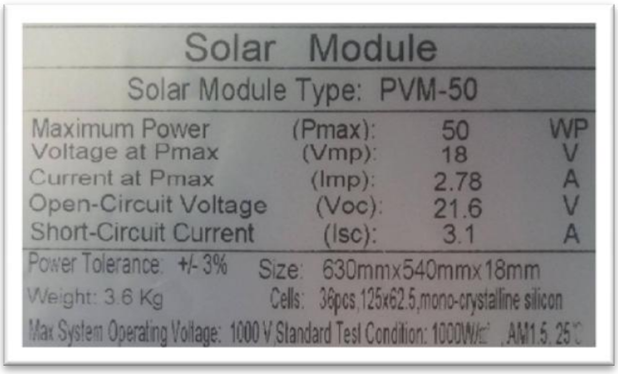


Figure-9: *Project PV Panel*



Solar Module
Solar Module Type: PVM-50

Maximum Power	(Pmax):	50	WP
Voltage at Pmax	(Vmp):	18	V
Current at Pmax	(Imp):	2.78	A
Open-Circuit Voltage	(Voc):	21.6	V
Short-Circuit Current	(Isc):	3.1	A

Power Tolerance: +/- 3% Size: 630mmx540mmx18mm
Weight: 3.6 Kg Cells: 36pcs,125x62.5,mono-crystalline silicon
Max System Operating Voltage: 1000 V Standard Test Condition: 1000W/㎡ , AM1.5, 25℃

Figure-10: *PV Panel specifications*

Step –Four: Wind Turbine Sizing: Modeling is a basic tool for analysis, such as optimization, project, and design and control, a mathematical model of wind turbine is essential in the understanding of the behavior of the wind turbine over its region of operation; Modeling enables control of wind turbines performance.

(1) **Calculations of Wind Speeds**: The system has been designed on the basis of the wind data available for the selected area that is south Jordan as shown in figure (11). For more accurate working Mutah University has been selected as a more specific location and the following calculation are based on Mutah, the data has been acquired on the basis of following details

- Site: Mutah University
- Latitude: 31°5'33" N
- Longitude: 35°41'40" E
- Elevation:820 m

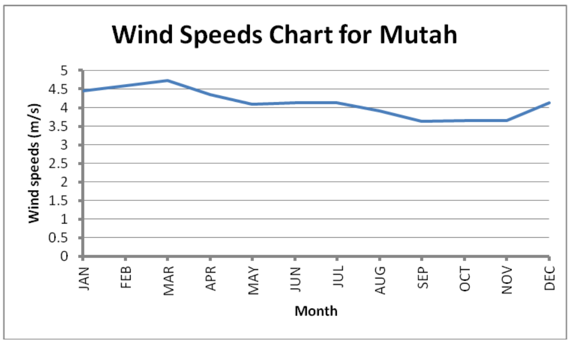


Figure-11: *Wind Speeds Chart for Mutah University at 10 m (NASA)*

So, the annual average wind speed value was calculated as 4.12 m/s.

(2) Calculating the Size of Wind Turbine

Energy needed =$\mathbf{112.42}\ \ Wh/day$, annual average wind speed = 4.12 m/s.

From the following equation [15]:

$$\textbf{Power (W)} = \mathbf{0.5} \times \mathbf{C_P} \times \boldsymbol{\eta} \times \boldsymbol{\rho}_{\mathbf{air}} \times \mathbf{A} \times \mathbf{V^3} \ldots\ldots\ldots \textbf{(9)}$$

Where;
C_P: Rotor efficiency; but C_P= 0.45 is often used in this type of calculations;
η: Efficiency of driven machinery;
A: Swept rotor area (m²),
ρ_{air}: Air density
V: Wind speed (m/s)

So, the turbine radius, $\mathbf{R} = \sqrt{\frac{2\times P}{C_P\times\rho\times\pi\times V^3}} \rightarrow \frac{2\times112.42}{0.45\times1.123\times\pi\times(4.12)^3} = \mathbf{1.4\ m}$

In this work prototype is going to use a small wind turbine as shown in figure (12) with area equals 962 cm², so, R = 17.4 cm, because it is not possible to use a turbine with 1.4 m radius in a small prototype.

(3) Calculating Turbine Revolutions

From equation [15]:

$$\textbf{Revolutions (rpm)} = \frac{\mathbf{V\times TSR\times60}}{\mathbf{6.28\times R}} \ldots\ldots\ldots\ldots \textbf{(10)}$$

Where;

TSR: Tip Speed Ratio,
R: Radius of rotor,
So, the calculated revolution RPM = 720 at average wind speed = 4.12 m/s.

Figure-12: *The Project Wind Turbine*

(4) Calculating the Tip Speed Ratio

The Tip Speed Ratio (TSR) is an extremely important factor in wind turbine design. TSR refers to the ratio between the wind speed and the speed of the tips of the wind turbine blades, so, from the equation (Ashish, 2015):

$$\textbf{Blade Tip Speed} = \frac{\mathbf{RPM\times\pi\times R}}{\mathbf{T(time)}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \textbf{(11)}$$

➔ **Blade Tip Speed** $= \frac{720\times\pi\times0.174}{60} = \mathbf{6.56}\ \boldsymbol{m/s}$

TSR (λ) $= \frac{\textbf{Tip Speed of Blade}}{\textbf{Wind Speed}}$**…………………. (12)**

➔ $\boldsymbol{TSR}$ **(λ)** $= \frac{6.56}{2} = \mathbf{3.28}$

The tip speed ratio is very important factor in the different formulas of blade design

Wind turbines must be designed with optimal tip speed ratios to get the maximum amount of power from the wind, for optimum Tip Speed Ratio and maximum power output, this formula has been empirically proven:

$\boldsymbol{\lambda} = \frac{\mathbf{4\pi}}{\mathbf{n}}$**…………………… (13)**

n: number of blades

➔Optimal tip speed ratio $= \frac{4\times\pi}{3} = \mathbf{4.1}$

Step –Five: Charge Controller Sizing: Charge controller has a basic function which is to control the source for active or inactive; it simultaneously charges battery and also gives power to the load. The controller has an over-charge protection, short-circuit protection, pole confusion protection and automatic dump-load function. Also its function is to vary the power as per the load demand. It adds both powers so that the load demand can fulfill, and when power is not generating it should extract power from battery and gives it to the load. Figure (13-a) shows the charge controller which will be used in the prototype of this study. The charge controller depends on the specification of PV and figure (13-b) shows its specifications.

Figure 13-a: *Project Charge Controller*

Figure 13-b: *Specifications of the Charge Controller****.***

Step –Six: Battery Bank Sizing: The battery bank size per the load requirement should be chosen s to fulfill the requirements of the required load and to calculate the battery bank size needs to have following data:

(1) Total daily use in watt-hour (W h).
(2) Total back up time of the battery

To increase the battery bank size must connect cell in series so that will get the larger battery bank size. Also should calculating the minimum capacity of the battery bank, because the capacity of the battery affected by number of days and the losses.

Total amp/day $\frac{\textbf{Watt−Hours per day} \times \textbf{battery loss factor}}{\textbf{system voltag}}$**…… (14)**

➔ $\frac{\mathbf{103.27\times1.2}}{\mathbf{12}}$ **= 10.33 Ah / day**

Number of Battery needed = $\frac{\textbf{Total}\ \frac{\textbf{Amp}}{\textbf{day}}}{\textbf{Battery Amp rating}}$**…… (15)**

➔ $\frac{\mathbf{10.33}}{\mathbf{7}} = \mathbf{1.48 \approx 2}$

In present prototype will going to use three batteries to storage more loads, the specifications of the battery which will be used in this study is shown in the figure (14).

Figure 14: *Specifications of the Battery*

Step –Seven: The Inverter Sizing: Greater rating inverter than the desired rating must be chosen, the pure sign wave inverter is recommended in order to prolong the lifespan of the inverter. The inverter is needed to convert DC power into AC power because the load working on the AC supply. The input voltage, the output voltage, the frequency, and the overall power handling depends on the design of the specific device or the circuitry. The inverter does not produce any power but the power is provided by the DC source. Calculating minimum nominal power rating of the inverter is as following:

Minimum Nominal Power Rating:

$= \frac{\textbf{Total Power Demand for AC Loads}}{\textbf{Inverter Efficiency}}$**…….. (16)**

➔ $\frac{\mathbf{31}}{\mathbf{0.9}} = \mathbf{34.4\ Watt}$

But in present work prototype 300-watt inverter will be chosen for more loads in future

Results and Discussion: Sample of three days' analysis and discussion will be taken:

(a) **Results of the first day:** Figures-15, 16 and 17 (Solar, Wind, and both) show that the total daily power production from PV cell is 180.63 W/day and the wind power is 13.221 W/day. So, the combined system capacity is able to generate 193.851 W/day or 8.077W h/day. Also, can see in table (3), that the hourly electricity production from wind turbine is variable through 24 hours, the power production results of the systems

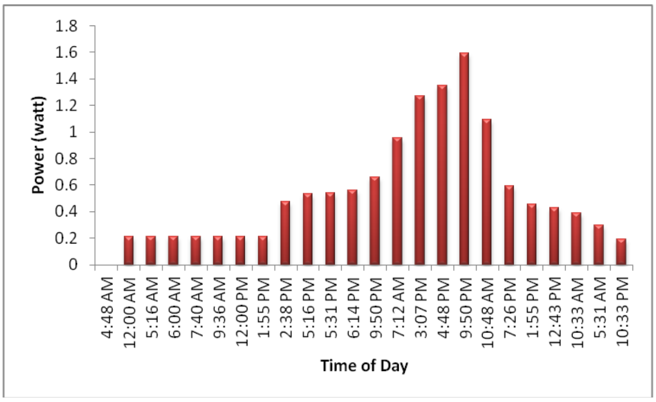


Figure-15: *Daily Average Electricity Production from the Wind System of the first day*

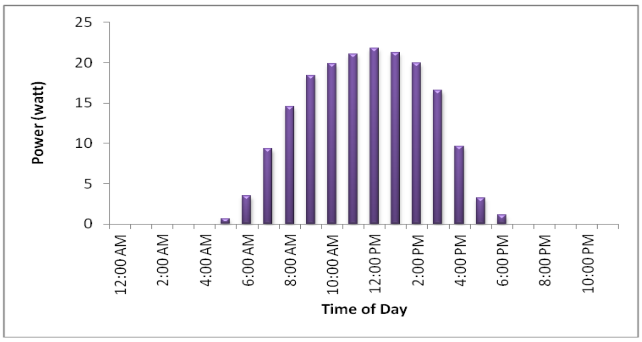


Figure -16: *Daily Average Electricity Production from the PV System of the first day*

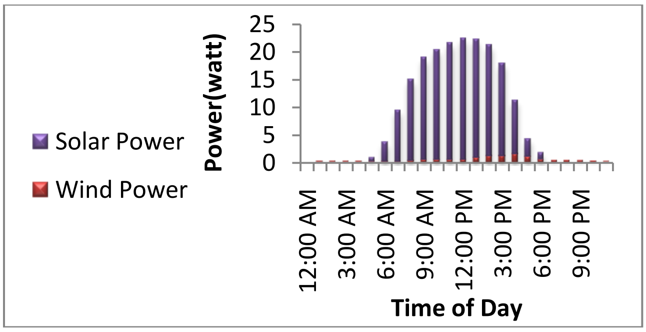


Figure -17: *Daily Average Electricity Production from the combined (Hybrid) Wind and PV System of the first day*

(b) Results of the second day: Also figures- 18,19 and 20 (Solar, Wind, and both) show that the total daily power production from PV cell is 211.08 W/day and the wind power is 18.688 W/day. So, the combined system capacity is to generate 229.768/day or 9.573W h/day

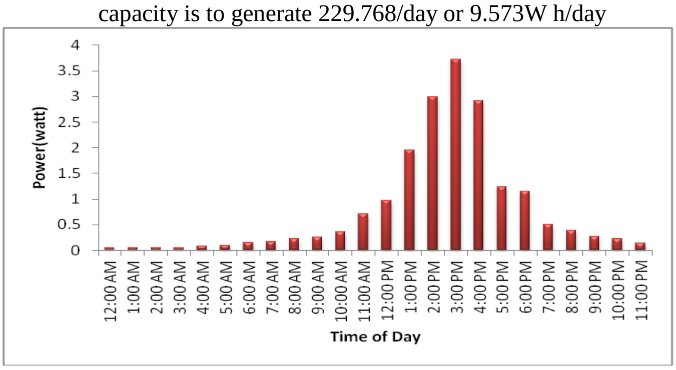


Figure-18: *Daily Average Electricity Production from the Wind System of the second day*

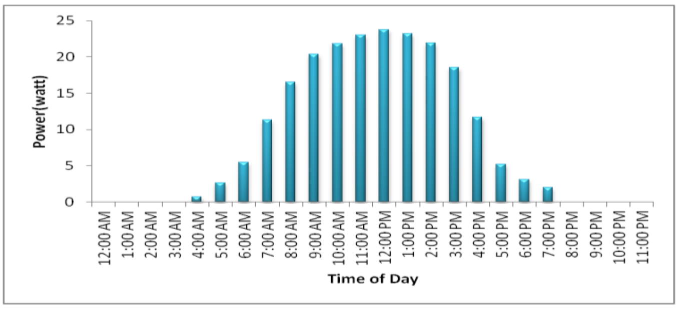


Figure -19: *Daily Average Electricity Production from the PV System of the second day*

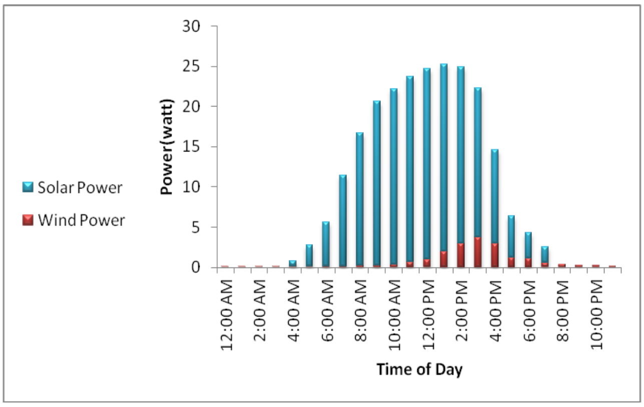


Figure -20: *Daily Average Electricity Production from the Hybrid Wind-PV System of the second day*

(c) Results of the third day: From figures -21, 22 and 23 (Solar, Wind, and both) can see that the total daily power production from PV cell is 197.34 W/day and the wind power is 14.598 W/day. So, the combined system capacity is able to generate 211.938 W/day or 9.83W h/day. The power production results of solar

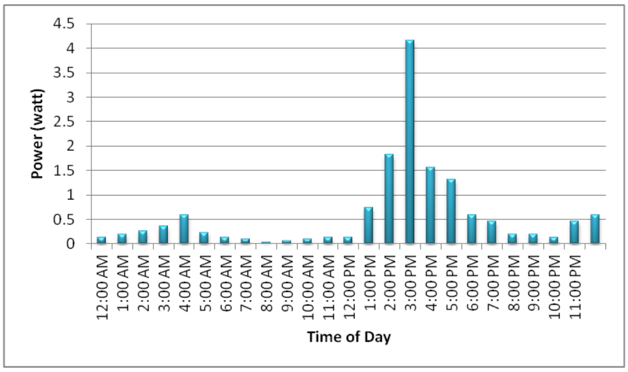


Figure-21: *Daily Average Electricity Production from the Wind System of the third day*

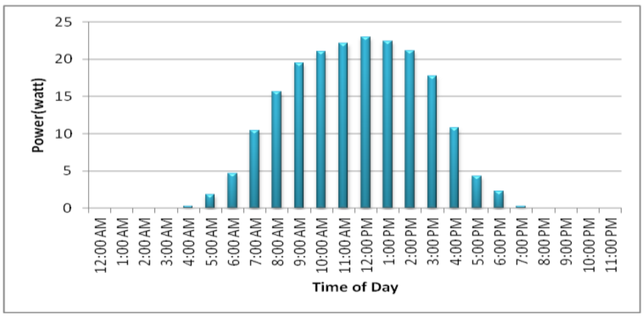


Figure -22: *Daily Average Electricity Production from the PV System of the third day*

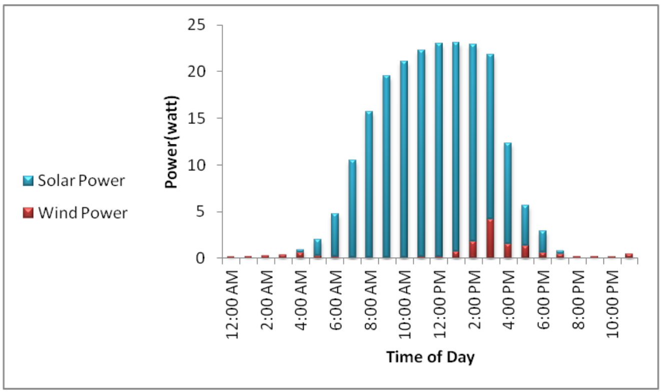


Figure -23: *Daily Average Electricity Production from the Hybrid Wind-PV system of the third day*

Wind power generation shown in figures (15), (18) and (21) demonstrates a continuous power production during the day with high values at night, while figures (16), (19) and (22) depict that highest solar electricity generation levels occur between 05:00 M and 18:00 PM. The combination of both power generations are shown in figures (17), (20) and (23). In these figures it can be observed that PV energy has a dominant contribution in the hybrid energy model from 04:00 AM to 18:00 M, which means when the sun existing, while the wind power is continuous during the whole day variable values depending on wind speed and giving uninterrupted power to supply the loads.

Conclusions: Through this work an insight into the energy situation and renewable energy potential has economically feasible power generation potential of wind and solar energy. The design of hybrid prototype for solar and wind energy has proved its effectiveness by installation of 50 watt PV panel and one 25-watt wind turbine which can supply a power for example is of 40-watt load which is efficient to operate TV, Camera, DC Light, and AC Light in effective way for 24 hours. The results of this work give an incentive to proceed with building and using such sustainable power generation systems (hybrid) that have proven to be efficient and economically feasible to use for continuous energy generation.

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