ON-GRID AND OFF-GRID SOLAR PHOTOVOLTAIC GENERATOR

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Abstract

The main purpose of this study was to design and develop an On-grid and Off-grid Solar Photovoltaic Generator, to determine the performance level and acceptability of the device. This project was developed at Bohol Island State University Main Campus, Tagbilaran City, Bohol for the Academic Year 2020-2021. The study utilized the experimental method in designing and assembling the gadget. In doing this, the researcher determined the occurrences during the process. Descriptive method was utilized to gather information in a form of a survey questionnaire to determine the efficiency and acceptability of the gadget in terms of performance, convenience, safety, durability, and cost. The respondents of the study were the selected home owners in the City of Tagbilaran and different experts from the academe and industry. Using the Weighted Arithmetic Mean test, the On-grid and Off-grid Photovoltaic Generator under "performance" ranked the highest with the average weighted mean of 3.86 and interpreted as "Very High". Safety ranked second with the average weighted mean of 3.85 which is interpreted as "Very High". Durability had an average weighted mean of 3.73 and interpreted as "Very High". Convenience was rated very high with an average weighted mean of 3.70. The result of the study revealed that the functionality and acceptability of the On-grid and Off-grid solar Photovoltaic Generator is highly acceptable by the respondents with the overall rating of 3.70 interpreted as very high. Cost was ranked lowest with an average weighted mean of 3.20; although ranked lowest, the researcher made entirely a whole package of solar generator making the gadget expensive. The On-grid and Off-grid Photovoltaic Generator is more efficient due to its performance. This gadget is effective in its course of application. The improvement of the gadget with the use of combined types of photovoltaic system and the knowledge of technicians, future researchers, and teachers or instructors on Renewable solar energy maybe considered for future developments and designs.

Index terms: Renewable energy, Solar Panels, Photovoltaic Effect, Payback Time.

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1. Introduction

Electricity is one of the most important blessings that science has given to mankind. It has also become a part of modern life and one cannot think of a world without it. The rapid growth of population and fast pace of development has led to a large energy requirement. But weather, accidents, storms, and not paying the electricity bill can disrupt the power provision. Serious damage to the power lines and the electrical grid can cause outages for days or weeks.

Power outage is a nightmare for homeowners and business enterprises that depend on electricity. Homeowners experienced disrupted communications, water and home works that rely on electricity. While small business enterprises experienced closing of business especially to businesses that depend on electricity. Problem regarding to power outage and increasing electricity bills is one of the common problems that homeowners are facing now hence led to me conduct of this study.

There are renewable energy sources like light from the sun, wind and hydro power that can be harnessed to reduce relying totally on the supplied electricity. Moreover, some of the electrical devices and home lightings use only little power. Harnessing the natural energies can save money for electricity and help save the environment. Utilizing solar energy is a great asset of this device.
Solar panels are used to convert light from the sun, which are composed of particles of energy called "photons", into electricity that can be used to power electrical loads this kind of phenomenon was called photovoltaic effect (Becquerel, 1839).
The On-grid and Off-grid Solar Photovoltaic Generator contains two types of solar power systems the On-grid solar photovoltaic system and the Off-grid solar photovoltaic system that merge together to form a portable On-grid and Off-grid Solar Photovoltaic Generator. The On-grid system has solar photovoltaic systems that only generate power when the utility power grid is available and sends excess power generated by solar panels back to the grid when you are over producing and it will lessen the electricity bill. While Off-grid solar photovoltaic system allows the user to store solar power in batteries that can be used when the power grid goes down or power outage occur.

The objective of this device is to provide an eco-friendly, reliable, and portable 420 watts energy generation for homeowners and small business enterprises in the province of Bohol. Because Bohol is located in a tropical country like the Philippines it receives abundant sunlight, hence the researcher believes that having a portable energy generator based on solar energy can help homeowners in power outages and reducing high electricity bills, in order for them to have a power supply in case of emergency situations.

2. Methodology

Design
The researcher used the experimental research design method for the assembly and operation of the On-grid and Off-grid Solar Photovoltaic Generator. It was conducted using a guided-questionnaire to assess the performance and acceptability of the device for the purpose of gathering the data to establish the basis of its reliability.

Environment and Participants
This study was conducted at Bohol Island State University Main Campus – Tagbilaran City School year 2020-2021. The school is located along CPG Ave. Tagbilaran City which is the capital of the Province of Bohol. It is a government institution that promotes the advancement of technology and the university is also known for its globally competitive technology graduates.

The researcher chose ten (10) homeowners from Tagbilaran City, another five (5) small business enterprises owners and five (5) technology experts coming from Bohol Island State University. To sum up, the total number of twenty (20) respondents purposively chosen as respondents for the assessment and validation of the performance and acceptability of the On-grid and Off-grid Solar Generator.

Instrument
Prior to the distribution of the questionnaires, a draft was presented to five experts in the field, and the research adviser for suggestions and

improvements.
In obtaining valuable information/data, the researcher will made a research tool which contains questions based on the thesis statements.
1. Observation Guide has a series of descriptive statements that will determine the performance of On-grid and Off-grid Photovoltaic Generator to test the efficiency in terms of energy saved, and energy generated during sunny days and rainy days.
2. The questionnaire contained sets of questions addressed to a statistically significant number of subjects to gather information and to measure the acceptability level of the assemble device in terms of performance, convenience of use, safety, assembly of parts and cost.

Data Gathering Procedure
In the process of gathering data for this study, nine phases were followed.
Phase 1: Permission to Conduct the Study
After the written approval from the thesis adviser and the Dean of the College of Advanced Studies, the researcher submitted letters to the Campus Director of Bohol Island State University - Main Campus.

Phase 2: Designing the Device
After the approval, the researcher gathered relevant information related to designing the On-grid and Off-grid Solar Photovoltaic Generator. Designing, calculating and checking of the circuit were carefully done with the supervision of the experts to achieve its functionality and safety and eventually ensured the desired output following the electrical standards.
Phase 3: Preparation of Materials and Tools
All the needed tools and materials in making the device were meticulously secured.

Phase 4: Making the Device
The device was carefully and painstakingly assembled according to the target design at the Bohol Island State University - Main Campus, Tagbilaran City, during the second semester of the school year 2020-2021.

The device was secured with galvanized iron enclosure and coated with polyester powder for chemical resistance and protection against corrosion. The materials used in making the On-grid and Off-grid Solar Photovoltaic Generator were selected with better quality for higher performance of the device.

Phase 5: Functionality of the device
The testing of the functionality of the device was done to check if the parts are installed correctly and if it functions according to the desired operation. Through the observation guide, the researcher recorded the phases of the assembly of the device and documented properly.

Phase 6: Data Gathering
With the supervision of the adviser, the researcher personally conducted the experiment and the actual observation of the device. Then, a timetable was set in the administration of the questionnaire to the target respondents to get their response on the acceptability level in terms of performance, convenience of use, safety, assembly of parts and cost as well as the performance level of the device.

Phase 7: Analysis and interpretation of the data
The researcher gathered the data and tabulated them using the appropriate statistical treatment to arrive at proper analysis and interpretation.

Phase 8: Conclusion and Recommendation

Based on the data gathered, the researcher formulated the summary, conclusions and recommendations.

3. Result And Discussion

This contains the presentation of data gathered by the researcher on the On-grid and Off-grid solar photovoltaic generator. The presentation of data is supported with tables which illustrated the responses of the study on the performance of the On-grid and Off-grid solar photovoltaic generator. The gathered data had undergone thorough statistical treatment before these were interpreted.

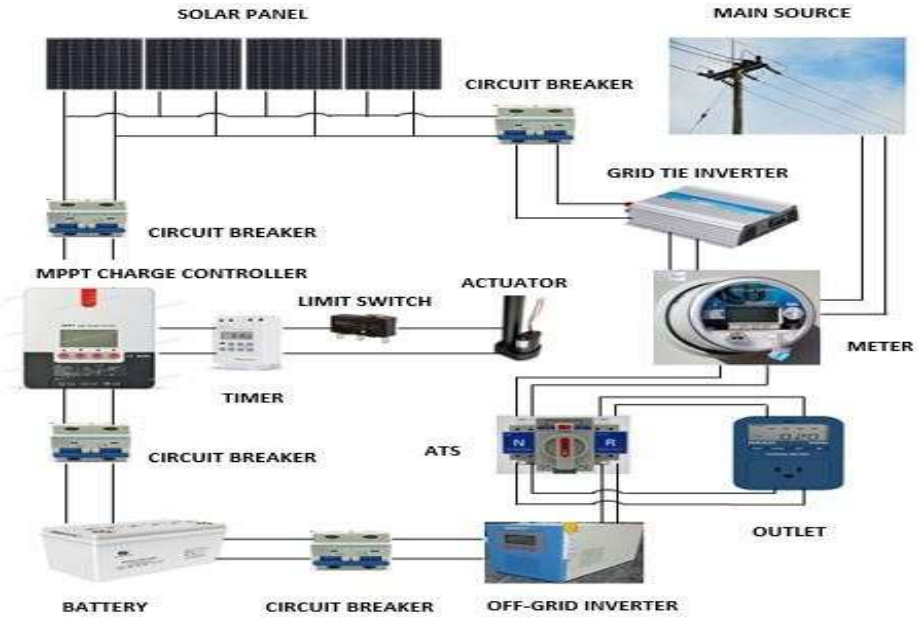

Fig 1.Pictorial Diagram of On-grid and Off-grid Solar Photovoltaic Generator

Table 1
CHARGING CONDITION OF THE BATTERY (OFF-GRID)

Battery descrip tion	Time of the day Sun hours (Hourly)	Output of solar panel (voltage)	Current injected to battery (ampere)	Total power output of solar panel (Watts)	Battery percen tage	Total no. of hours to fully charge the battery
Gel type battery 180AH 12V	9:00-10:00	17.5	20	350w	66%	4 Hours
	10:00-11:00	17.2	18	309w	80%	
	11:00-12:00	17.0	15.71	267w	92%	
	12:00-1:00	18.9	14.91	230w	100%	
	1:00-2:00	18.0	12.79	216w	100%	
	2:00-3:00	18.1	11.11	198w	100%	

Table 1 shows the charging condition of the battery (off-grid system). The researcher observed the sun for hours in a normal sunny day in order to measure the output of the solar panels and to get the number of hours to fully charge a 50% 180 AH gel type battery. The battery started charging in its 50% power to prevent discharging the battery. Avoiding the discharging of battery can increase its lifespan.

The observation started at 9:00am and recorded the data every after 1 hour. Researcher recorded the output of solar panel, current injected to battery, total power output of solar panels, battery percentage every hour and the total no. of hours to fully charge the battery.

Computation in number of hours to fully charged a 180 AH Gel type 12 volts Battery using 420 watts solar panel.

Given:

-Battery voltage: 12 volts

-Battery capacity: 180 ampere/hour

-Rated Solar panel power output: 420 watts

-Solar panel efficiency: 70%

-Battery depth of discharge (%): 50%

Formula in getting the power of 180 AH battery:

Battery power = battery ampere/hour x battery rated voltage

Solution:

Battery power (watts) = 180AH x 12 volts
Battery power (watts) = **2160 watts/hour**

Formula in getting the 50% power of 180 AH battery:

Depth of discharge (watts) = battery power x percent of discharge
Depth of discharge (watts) = 2160 watts/hour x 50%
Depth of discharge (watts) = **1080 watts/hour**

Power output efficiency of 420 watts solar panel

Power output = rated power of solar panels x solar panel efficiency
Power output = 420 watts x 70%
Power output = **294 watts**

Number of hours to full charged 180ah gel type battery No. of hours = Depth of discharge (watts) / Power output
No. of hours = 1080 watts/hour / 294 watts
No. of hours = **3.7 hours** to fully charged a 180AH gel type battery from a 420 watts solar panel

The researcher conducted a comparison between the actual gathering of data and the computation. The result of the actual gathering of data is shown in Table no. 1. It stated the 420 watts solar panel can fully charge an 180AH gel type battery in a normal sunny day by 4 hours of charging.

While the computation in getting the number of hours to fully charge an 180AH gel type battery using 420 watts solar panel shows it needs 3.7 hours of charging to fully charge the 180AH battery in a normal sunny day. The result of the actual gathering of data and the computation doesn't show a big difference.

Table 2
BATTERY CAPACITY IN SUSTAINING THE LOADS (OFF-GRID) 180AH GEL TYPE BATTERY

Loads	No. of loads	Total power consumption	No. of hours used
LED Bulb(5 watts)	5	25 watts	43 hours
Computer set (60 watts)	2	120 watts	9 hours
Cellphone charger (10 watts)	3	30 watts	36 hours

Laptop charger (64 watts)	2	128 watts	8 hours
Stand fan (60 watts)	2	120 watts	9 hours
Ceiling fan (20 watts)	2	40 watts	27 hours
Rice cooker (230 watts)	1	230 watts	4 hours

Table 2 shows the power consumption of the given loads and how long the battery sustains the given loads. The researcher observed how long the battery can sustain the loads by plugging the given loads in the outlet with power meter. The researcher collected the devices and appliances which had more use in the house.

After collecting the devices, the next step was to determine the power consumption of each device by the use of power meter. The power meter displayed the power consumption in a unit of watts. After determining the power consumption, the researcher observed how long the battery can sustain the given loads.

When the battery percentage reaches 50% the observation was stopped and the researcher recorded the number of hours on sustaining the given loads. This procedure is also used in the other devices and recorded in order to gain accurate data.

Table 3
Energy generated from On-Grid Solar Photovoltaic System

Type Solar Panel	Sun hours	Power generated	Output in percentage
Monocrystalline Solar panel (220W)	9:00-10:00	151 watts	68%
	10:00-11:00	152 watts	69%
	11:00-12:00	154 watts	70%
	12:00-1:00	153 watts	69%
	1:00-2:00	150 watts	68%
	2:00-3:00	149 watts	67%
	TOTAL AVERAGE	151 watts	69%
Power generated per day	**909 watts/day**		
Polycrystalline Solar panel (200W)	9:00-10:00	135 watts	67%
	10:00-11:00	139 watts	69%
	11:00-12:00	140 watts	70%
	12:00-1:00	140 watts	70%
	1:00-2:00	138 watts	69%
	2:00-3:00	136 watts	68%
	TOTAL AVERAGE	138 watts	69%
Power generated per day	**828 watts/day**		
Monocrystalline and	9:00-10:00	295 watts	70%
	10:00-11:00	287 watts	68%

Polycrystalline Solar panel (420W)	11:00-12:00	290 watts	69%
	12:00-1:00	298 watts	71%
	1:00-2:00	285 watts	67%
	2:00-3:00	280 watts	66%
	TOTAL AVERAGE	289 watts	69%
Power generated per day	**1,735 watts/day**		

Table 3 shows the energy generated from a 420 watts solar panel which consist two different panels. For monocrystalline and polycrystalline solar panels researcher gathered data from these two different types, the researcher also observed the efficiency of each solar panel and the amount gained from an on grid setup.

The researcher gathered the data at 9:00am to 3:00pm considered as the sun hours in the Philippines. The output of the solar panels was recorded every hour. The researcher also recorded the average power generated of the solar panels and the power gained from the combined solar panels. The average power generated was 289 watts. While the power gained from the combined solar panels is 1,735 watts per day this is also the power saved from a 420 watts solar panels.

Table 4
Return of investment of 420 watts On-grid solar photovoltaic system

Return of investment of 420 watts On-grid photovoltaic system	
Total Power Generated per year	437.22 kilowatt/year
Money saved from 420 watts on-grid system/year	Php. 4,372.20/year
Pay Back Time	4.6 Years

Given:
Price of electricity/kw = Php. 10.00
Power generated of On-grid/day = 1.735 kilowatt Percentage of sunny day per year = 70%
Total price of 420 watts On-grid system = Php. 20,300

Solution:

Total power generated per year = Power generated of On-grid/day x Number of days per month x Number of months per year

Total power generated per year = 1.735 kilowatt x 30 days x 12 months

Total power generated per year = 52.05 kilowatt x 12 months

Total power generated per year = 624.6 kilowatt/year

Total power generated per year = 624.6 kilowatt/year x Percentage of sunny day per year
Total power generated per year = 624.6 kilowatt/year x 70% **Total power generated per year** = **437.22 kilowatt/year Solution:**
Money saved from 420 watts on-grid

system/year = Price of electricity/kw x Total power generated per year

Money saved from 420 watts on-grid system/year = Php. 10.00 x 437.22 kilowatt

Money saved from 420 watts on-grid system/year = **Php. 4,372.20 Solution:**
Payback Time = Total price of 420 watts On-grid system / Money saved from 420 watts on-grid system/year

Payback Time = Php. 20,300.00 / Php. 4,372.20

Payback Time = **4.6 years**

This calculation shows how to get the Return of investment of a 420 watts On- grid system. The researcher gathered the information about the price of electricity per kilowatt, the power generated of the On-grid system a day, the percentage of sunny days here in Philippines and the total price of 420 watts On-grid setup.

Table 6
Return of investment of 420 watts Off-grid solar photovoltaic system

Return of investment of 420 watts Off-grid photovoltaic system	
Total Power Saved per year	**388.8 kilowatt/year**
Money saved from 420 watts off-grid system/year	**Php. 3,888.00/year**
Pay Back Time	**5.6 Years**

Given:
Price of electricity per kilowatt = Php. 10.00/kw

Power output of a 180AH battery x 50%(Dod) = 1.080kw Total price of 420 watts Off-grid system = Php. 22,040.00 Percentage of sunny day per year = 70%
Solution:

Total power saved per year = Power output of a 180AH battery x 50%(Dod) x Number of days per month x Number of months per year

Total power saved per year = 1.080kw x 30 days x 12 months

Total power saved per year = 32.4kw x 12 months **Total power saved per year** = **388.8kw/year Solution:**
Money saved from 420 watts Off-grid system/year = Price of electricity/kw x Total power saved per year

Money saved from 420 watts Off-grid system/year = Php. 10.00/kw x 388.8kw/year

Money saved from 420 watts Off-grid system/year = **Php. 3,888.00 Solution:**
Payback Time = Total price of 420 watts Off-grid system / Money saved from 420 watts Off-grid system/year

Payback Time = Php. 22,040.00 / Php. 3,888.00

Payback Time = **5.6 years**

This calculation shows how to get the Return of investment of 420 watts Off-grid photovoltaic system. The researcher gather the data needed in order to determine the number of years to fully pay a 420 watts Off-grid photovoltaic system.

4. Conclusion

Based on the findings gathered, the On-grid and Off-grid solar Photovoltaic generator is efficient due to its performance and showed that this device is effective in its course of application; however the power is proportional to its size, the more power needed the bigger the size of the panel and also the cost is much

higher.

Recommendations

Based on the findings, the following recommendations are given to improve the output of the device:

1. The researcher has to introduce the On-grid and Off-grid Solar Photovoltaic Generator to the area was electricity is limited and sunlight is abundant.

1.1 The researcher recommends the use of high efficiency solar panels to gain more power from the solar panels

1.2 Recommends to technicians and future researchers to engage and broaden their knowledge in Solar Photovoltaic systems.

1.3 Recommends to technicians and future researchers to engage and broaden their knowledge in renewable energies.

2. School administration shall encourage their instructors to teach their students about renewable energy that can help reduce reliance to fossil fuels and save environment.

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