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A Multi-USB Ports Solar Powered Charging Station for Mobile Phones in Duracurve Sheds of Don Honorio Ventura State University

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Abstract— The current study proposed a design for a Multi-USB Ports Solar Powered Charging Station for Mobile Phones in Duracurve Sheds of Don Honorio Ventura State University located at Cabambangan, Bacolor Pampanga Philippines. This research specifically aimed at addressing the issue of prohibiting the students of electrical engineering in Don Honorio Ventura State University (DHVSU) to charge their mobile phones inside the classrooms. This study, as a quantitative research, utilized a developmental type of method since the study will provide a design, also a Likert scale type of questionnaire is used and through electronic generated forms (google form), and a thorough data analysis. The participants were composed of twenty (20) professionals and were chosen through the use of purposive sampling technique. The study revealed that the proposed design of the researchers for the solar-powered charging station that is based from the result of the survey questionnaire, after considering its specifications with the help of computations, the materials and possible cost of its installation, its expected lifespan, and the total expenditure it will take and this studycould be an alternative way to provide a solution for each student's concern of lack of charging station at DHVSU and also it was created especially for educational purposes.

Indexed Terms— Data Analysis, Developmental Type, Lifespan, Likert Scale, Quantitative Research, Solar-powered Charging Station,

I. INTRODUCTION

The primary energy components in our world today come from sources such as coal, petroleum, and other fossil fuels. Utilizing solar-powered electricity is one of these energy sources (Stephen & Eric, 2016). Renewable energy may be utilized to generate electricity; the sun's energy can be used to heat fluids for turbines in solar thermal systems or turned directly to electricity using photovoltaic principles. Oil price increases, increased awareness of energy-related pollution, and the negative consequences of climate change have all contributed to a re-evaluation of energy consumption. This re-evaluation has resulted in increased energy efficiency in industry and electricity generation, as well as lighting, home appliances, and transportation. The efficient use of energy is a major factor that contributes to the improvement of energy consumption that has occurred in the last decades in almost all industrialized countries, Lacap (2004). According to Wilczynski (2015), these phone chargers will become more common as solar-powered electricity becomes more widespread. Nonrenewable energy sources and fossil fuels are a thing of the past. Suppose not having to use an electrical outlet to charge your phone, but instead being able to use the sun's energy to capture it. By this, it can save money, the usage of energy will become more efficient, and the source coming from the sun is significant to use rather than an outlet. Mobile phones are now the most widely used electronic device in practically every country in the world. According to the International Telecommunication Union, there are over 6.8 billion cell phone users worldwide, and the number is rapidly increasing as technology improves and production costs fall. As mentioned by Nolasco Jr., E.L. (2008), Cell phone is one of the most common means of communication today and through advancements in technology, also one of the most affordable electronic gadgets that one can avail. Many systems and gadgets have been incorporated into mobile phones, transforming them into multifunctional devices capable of processing photographs, emails, and other data. Moreover, as stated by Maroma A.N. (2014), cell phones rely on electric current to carry out its many functions and they require to be charged every so often. Hence, to address the issue of prohibiting the students of electrical engineering to charge their mobile phones inside the classrooms (DHVSU E.E Handbook, 2017), the researchers opted to propose a design of Multi-USB Ports Solar Powered Charging Station for Mobile Phones in Duracurve Sheds of Don Honorio Ventura State University.

II. BACKGROUND OF THE STUDY

One of the aspects that contribute to today's innovative lifestyle is technology. In this setting, there are several technical advantages.When implemented effectively, technology can offer us with the advancements we want and need, while maintaining our existing efficiency. One of the most significant technical triumphs is the cellular phone, a widely used communication tool and was quickly evolved into a smart phone with additional functions. People are becoming more interested in learning about the capabilities of this energy as new technology becomes more high-tech and more solar technology designs are made. The expense of installing a solar system is most likely the restriction of this energy. Many individuals are becoming increasingly reliant on a variety of electronic communication devices for both business and social purposes as technology improves. It's difficult to keep mobile devices charged in today's fast-paced world. Although commercially available, portable solar charging panels are not widely available to the general public. But mobile phone has its main problem that is its inability to sustain its battery charge for a long time. According to (Rahmati et al.,2007) he coined the term Human-Battery Interaction (HBI) where he describes mobile phone users' interaction with their cell phones in managing the battery available. In 2017, the United States consumed approximately 95 million gigawatt-hours of electricity, making power plant construction difficult "given the short-term supply–demand relationship and rising financing rates," according to Francia (2018). According to Maroma (2014), Solar power charging stations are operated through a backup storage battery and solar power that comes from the sun. In the case of a protracted power outage, it may be utilized as an emergency charging station. As long as there is sunlight, it can charge devices. Since the battery of the mobile phones limits the productivity of each learner it will be an answer to this long-term issue. A key reason why a free solar charging station will be a great help in sustaining the battery charge of each user. As an outcome, as long as the battery is charged, the gadget may continue to charge phones. Rubio et al., (2018), the system has accurately categorized a variety of materials that have been deposited within the system's chamber based on tests for accuracy, power conservation, and dissipation. Sanchez (2014) conducted research on a portable solar charging station. Based on the reports, it assesses the functionality of mobile charging station that will be used on campus to recharge grounds keeping tools. According to Caplan (2017), the stations allow locals to charge their phones for free while on the go. The stations are powered by solar energy with battery storage, allowing use at night or on a cloudy day. Due to the sheer growth of education not just in the Philippines but across the world, gadgets, particularly mobile phones, are becoming increasingly vital in academics. Mobile phones and other smart gadgets continue to run all the time, consuming their batteries. Even though academic institutions in the Philippines employ technology, the utilization of traditional resources and information such as books is still prevalent, as it is at Don Honorio Ventura State University. Traditional resources are quite useful, but it is certain that mobile phones are equally significant for educational purposes.

III. REVIEW RELATED LITERATURE

From the previous year's, cellular phones are considered a distraction to each learner within the classroom. But as technology evolves into modern teaching, a better outcome will sprout when they are used appropriately. Mobile phones can improve the learning process including easier tasks for the learners about the assignments and better engagement with each other. But its downside is its inability to sustain its battery charge for a long time.

(Rahmati et al.,2007) coined the term Human-Battery Interaction (HBI) where he describes mobile phone users' interaction with their cell phones in managing the battery available. 80% of users take steps to extend their battery life which will remain a top priority for them owing to the significant usability concerns involved.

Both personal phone chargers and public phone charging stations for company owners have been developed by phone charging sectors and corporations that last for 7 to 10 hours (Flores, 2018). In 2017, the United States consumed approximately 95 million gigawatt-hours of electricity, making power plant construction difficult (Francia, 2018).

According to (Maroma, 2014), Solar power charging stations are operated through a backup storage battery and solar power that comes from the sun. As long as there is sunlight, it can charge devices. Since the battery of the mobile phones limits the productivity of each learner, it will be a reason why a free solar charging station can produce a great help in sustaining the battery charge of each user.

Solar energy is a technology that has grown in popularity as it has been developed. As an outcome, when the battery is charged, the gadget may continue to charge phones. (Rubio et al., 2018) offered an alternate method of garbage disposal with a microcontroller-controlled charging station that rewards customers who correctly dispose of their plastic bottle scraps by providing a power source to charge their electronic devices. The system has accurately categorized a variety of materials that have been deposited within the system's chamber based on tests for accuracy, power conservation, and dissipation.

The study of (Sanchez, 2014) was about portable solar charging stations. Based on the reports, it assesses the functionality of mobile charging that will be used on campus. It also compares several solar tracking systems and discusses which option is suitable for the climate of the locale. According to (Caplan, 2017), the stations allow locals to charge their phones for free while on the go that are powered by solar energy with battery storage, allowing use at night or on a cloudy day. The placement of charging stations across the city could charge their gadgets in the event of a power outage.

Due to the sheer growth of education across the world, mobile phones are becoming increasingly vital in academics. Since they consume their batteries, they suddenly shutdown due to lack of charge. Recharging mobile phones requires a certain time and location. Charging stations are significant for those learners and guests who go to university especially in case of an emergency. Academic institutions in the Philippines employ technology but the utilization of both traditional and modern resources are prevalent and useful, as it is at Don Honorio Ventura State University which are equally significant for educational purposes.

IV. STATEMENT OF THE PROBLEM

Charging one's gadget relies heavily on the quantity of power provided by the battery. As one of the university rules, no student is allowed to charge their phone in the classroom. Furthermore, in a power outage, there is no alternative way to charge one's device because not every student can afford to acquire an individual power bank.

Specifically, the study attempts to answer the following questions:

- Is the proposed Auto CAD 3D layout design of the solar powered charging station is physically compatible to the duracurve sheds of DHVSU?
- What is the charging and discharging time of the mobile phone battery and solar panel battery?
- What are the suitable components of the solar powered charging station to charge six mobile phones in terms of:

a. Solar panel wattage and battery size
b. Type of USB ports for charging phones and specifications of the charger controller
c. Sizes of wires

- What is the total cost of the set-up?
- What is the expected lifespan of the solar powered charging station?

V. OBJECTIVES

The researchers sought to address the problem by designing a solar-powered charging station to assist the students of Don Honorio Ventura State University in charging their mobile phones quickly using renewable energy harvesting, which they will be able to acquire whenever they need it.

Thus, it will also serve as a backup source during power outages, which will be beneficial to the university and visitors.

Specifically, the Researchers sought to find out the following objectives:

- To determine the acceptability of the proposed AutoCAD 3D model design of solar powered charging station to the duracurve sheds of DHVSU.
- To solve for the charging and discharging time of solar powered charging station and mobile phone battery.
- Determine the acceptability of the materials of the design in terms of:

a. Solar panel wattage and battery size.
d. Type of USB ports for charging phones and specifications of the charger controller
b. Sizes of wires

- To evaluate the acceptability of the possible cost of the set-up.
- To determine the acceptability of the expected lifespan of solar powered charging station.

V. SCOPE AND LIMITATIONS

The researchers proposed a solar-powered charging station to be installed in the duracurve sheds of Don Honorio Ventura State University (DHVSU) for purposes of charging the mobile phones of its community, especially students in cases of emergencies in connection with their education. This study specifically applies to the said University and is not applicable to other educational institution within the area. Materials and their specifications will be shown and analyzed at the end of this study.

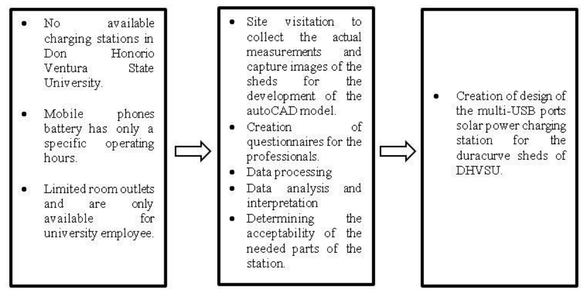
VI. ASSUMPTION

The research study was anchored on the assumption that every student at Don Honorio Ventura State University has a mobile phone, so the researchers came up with this study to help each learner. Furthermore, the research study is timely and apt for Don Honorio Ventura State University students because it will produce a design that will serve as a foundation for future research studies.

VII. SIGNIFICANCE OF THE STUDY

This study is significant and beneficial only to the DHVSU Community by helping them charge their phone whenever necessary, especially in connection with their studies; to the DHVSU itself by helping the institution reduce its financial disbursement of energy consumption; and Future Researchers who want to venture topics in connection to the present study as their reference.

Conceptual Framework



For the input, there is no available charging stations provided for the DHVSU community because it is being restricted by the management, hence, they cannot charge their phone in the University. As for the process, the researchers collected the actual measurement of the duracurve sheds for an AutoCAD model of the proposed design, conduct survey from solar-panel experts, and analyze the data gathered by determining the acceptability of the needed materials in setting up the design. Lastly, for the ourput, the creation of the said design of multi-USB port solar powered charging station to be installed on the duracurve sheds of the DHVSU.

VIII. METHODOLOGY

This section includes the research methods, the description of the respondents, procedures for gathering data, population, research instruments, and the techniques used in performing the study. Since the questions to the survey will be answered by twenty (20) professionals in order to apply an appropriate treatment to incoming results from the data, the study was determined as quantitative research.

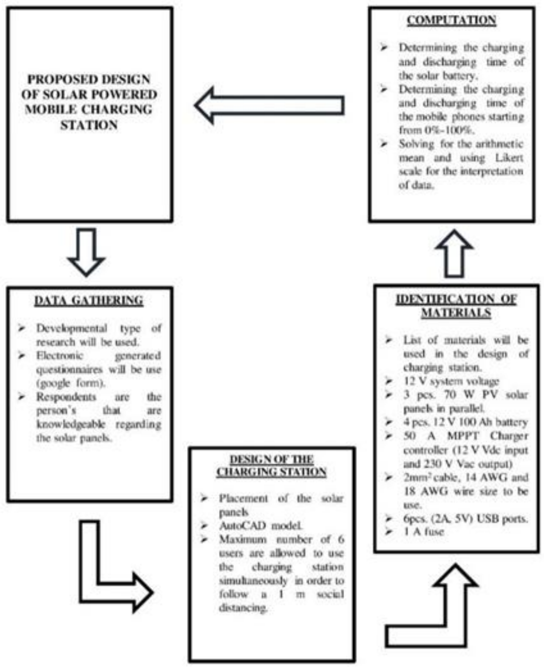


Figure 2: Research procedure of the study

The researchers use a developmental type of research to achieve the study's developed objective. It is widely used in the analysis of the product development process, which is appropriate to the study since the output is the design of a multi-USB port solar-powered charging station. In the world of instructional technology, developmental research is very important.

The main data gathered from the respondents' assessment of the administered questionnaire was tallied, organized, analyzed, and interpreted through the use of the most appropriate statistical procedures. Also a Likert scale will be used in scoring method for analyzing people's opinions, attitudes, and behaviors. Likert scales are common in survey research because they make it easy to operationalize personality traits or perceptions.

Through that, the researchers came up with the design of the solar-powered charging station as shown in figure 3.

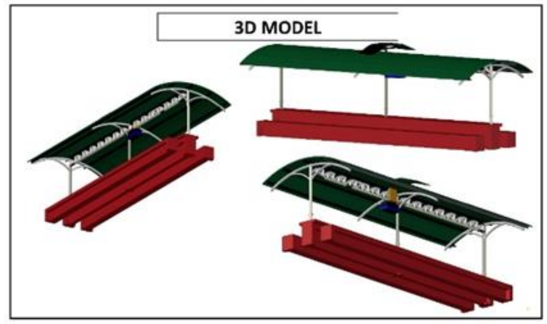


Figure 3. Proposed AutoCAD design of the solar powered charging station

The list of materials that will be used in the proposed design of the charging station is based on the questionnaire that was utilized to gather data, and these are the following: 12 V system voltage, three 70 W photovoltaic (PV) solar panels connected in parallel to collect energy from the sun and produce electrical power, four 12V 100 Ah batteries to store excess electricity generated by the solar panels, a 50 A Maximum PowerPoint Tracking (MPPT) charger controller (12-Vdc input and 230-Vac output), and six 2A, 5V USB ports. With the aforementioned equipment, the researchers will have to determine the placement of the solar panels and the acceptability of materials in terms of solar panel wattage and battery, the type of USB ports for charging phones, the possible cost, and the lifespan of the solar charging station based on the information that will be given by the experts. More importantly, the target number of users in the proposed design will be six (6) people at a time to maintain social distance.

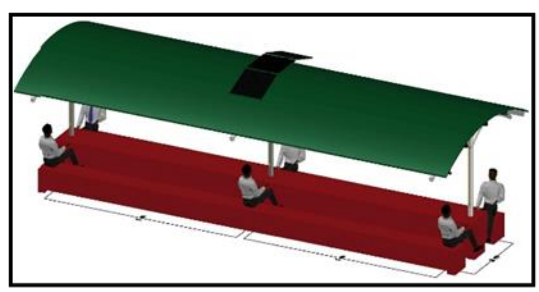


Figure 4. Proposed AutoCAD design of the solar powered charging station that shows the social distancing between the users.

Equation 1: Charging time of the battery

$$CT = \frac{Ah}{I}$$

Where:
CT = Charging Time in hours
Ah = battery capacity in Ampere hour
I = generated current in Ampere (A)

Adopted from: Akash Sharma, (2021), Battery Charging Time.

Equation 2: Discharging time of the battery

$$DT = \frac{\text{Battery (Ah) x Battery (V)}}{L}$$

Where:
DT = Discharging Time in hours
Battery Ah = Battery capacity in Ampere-hour
Battery V = Voltage produced of the battery
L = Applied Load in Watts
Adopted from: electrical4u, (2017), Battery Life Calculator.

Equation 3: Computation for the total wattage of solar panels

$$\text{Solar Panel Wattage} = \frac{\text{(Total watt−hours per day)(Energy loss in the system)}}{\text{Panel Generation Factor}}$$

Where:
Solar Panel wattage = Solar panel size that is required in the system.
Total watt hours per day = Expected load present in the system in Watt-hour
Energy loss in the system = Expected loss factor when the light energy is converted to electrical energy and has a constant value of 1.3 and is unit less.
Panel generation factor = It is automatically used in computation of solar panel sizing that is a varying factor that is dependent to the climate of a country. In Philippines the panel generation factor is 3.43 and is unit less.

Equation 4: Computation for the size of solar panels (S.S.P)

$$\text{S.S.P} = \frac{\text{Total Solar Panel Wattage}}{\text{Number of solar panel to be used}}$$

Where:
Total Solar Panel Wattage = Is the solve value derived from equation 3
Number of solar panel to be used = Number of panels suggested for the design for mixed light conditions

Equation 5: Computation for the battery capacity

$$\text{Battery Capacity (Ah)} = \frac{\text{Total Watt−hours per day used x Days of autonomy}}{\text{(0.85 x 0.6 x nominal battery voltage)}}$$

Where:
Total watt hours per day = Expected load present in the system in Watt-hour.
Days of autonomy = Is the number of days that the battery can last wihout any support from generation source. In this study the researcher used 4 days.
0.85 = Is the battery loss in the system.
0.6 = Is the depth of discharge in the system.
Nominal battery voltage = Voltage of battery when delivering its rated capacity in a specific discharging rate. The researcher used 12 V.

Equation 6: Computation for the current size

$$\text{Solving for the current size} = \frac{\text{Total Watt−hours per day}}{\text{Expected voltage output}}$$

Where:
Total watt hours per = Expected load present in the system in Watt-hour.
Expected voltage output = Is the voltage set to be produced in the system its unit is in volts (V)

Equation 3-6 are Adopted from: LEONICS, (2009), How to Design Solar PV System.

Equation 7: Solar Panel Tiltation Angle
Solar Panel Tilt Angle = Latitude x 0.87

Here is the list of statistical tools done in presenting the data
Formula 1: The formula of weighted mean is as follows:
fx = (f) (x)

Where:
fx = weighted mean
f = frequency
x = scale
Adopted form: Diksha Keni, (2022), Weighted Mean Formula.

Formula 2: The formula for an average weighted mean is as follows:

$\bar{x} = \frac{\sum Fx}{\sum F}$

Where:

$\bar{X}$ = average weighted mean
F = frequency
$\sum f$ = total number of respondents
$\sum fx$ = summation of weighted mean

Adopted from: Achilleas Kostoulas, (2013), On Likert scales, ordinal data, and mean values.

Formula 3. Percentage

$P = \frac{f}{N} \times 100$

Where:

P = Percentage
f = frequency of each variable
N = total number of population

Adopted from: Indeed, Editorial Team, (2022), How to Calculate percentage in three easy steps.

The rating of the area means comes within the reliable and legitimate answers of the respondents that correspond to the transportation indicators.

Likert Scale. Likert Scale measures the degree of response from the area mean on each item.

Formula 4. Population standard deviation

$\sigma = \sqrt{\frac{\sum(x_i - \bar{X})^2}{N}}$

Where:

$\sum$ = Summation
x_i = Each value of the population
$\bar{X}$ = average weighted mean
N = total number of population

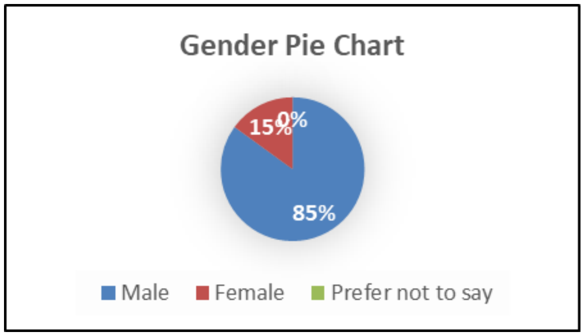
Adopted from: Pritha Bhandari, (2021), Standard Deviation, A step by step Guide with Formulas.

Shown in Table No. 1 is the category of the 5-point Likert Scale for the level of responses with its verbal

SCALE	Verbal Interpretation
4.00 - 5.00	Highly Acceptable
3.00 - 3.99	Acceptable
2.00 - 2.99	Moderately Acceptable
1.00 - 1.99	Unacceptable
0 - 0.99	Highly Unacceptable

IX. RESULTS AND DISCUSSION

This section was used to calculate how long the battery of the solar panel and mobile phone will be fully charged and how long it will take to discharge to 0%. Equation 1 was the formula used for the charging time and equation 2 was used in determining the discharging time

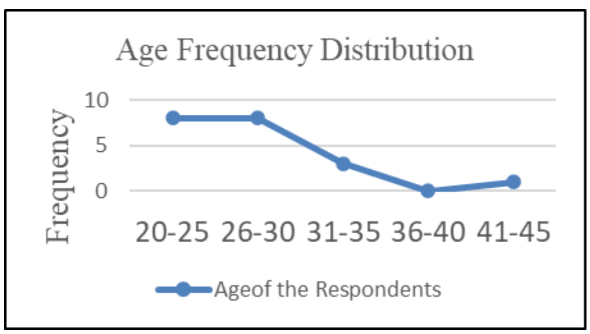


Part 1. Demographic Profile of the Respondents

Figure 4. Summary of the percentage distribution of the respondents according to gender.

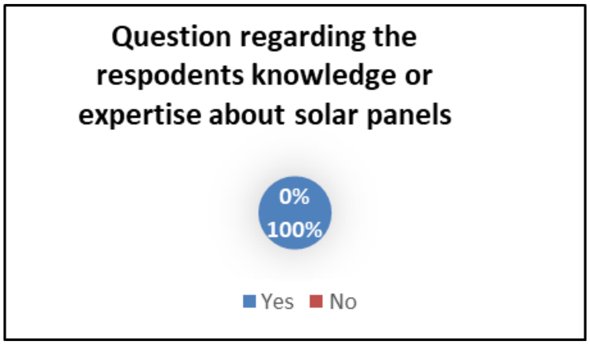
According from the results gathered, seventeen (17) or 85% of the respondents were male while three (3) or 15% among the twenty (20) respondents were female. Lastly, zero (0) or 0% among them answers prefer not to say.

Figure 5. Summary of the frequency distribution of the respondents according to age.



As shown in Figure 5, eight (8) or 40% of the respondents were aging 20-25 years old and same data was achieved to 26-30 years old. While three (3) or 15% of the respondents fall under 31-35 years of age. On the other hand, none of the respondents were 36-40 years old, and lastly one (1) among the twenty (20) informants whose age fall between 41-45 years old. See appendix G for the frequency distribution table and percentage of the respondents according to age.

Figure 6. Respondents answer if they have knowledge or expertise regarding solar panels



As shown in the figure 6, twenty (20) or 100% among the respondents answered that they have knowledge or expertise regarding solar panels. While among them, zero (0) or 0% answered no. That validates the informants chosen for the study will do have reliable and concrete information regarding the study, since they do have proficiency about the solar panels.

Part 2. Research Questionnaire

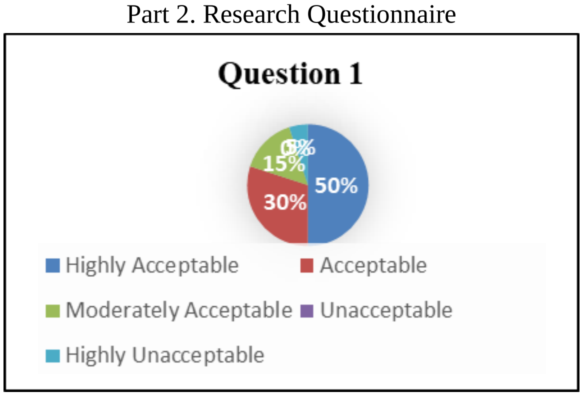
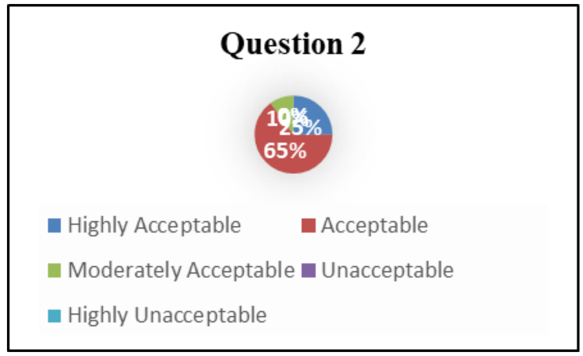


Figure 7. Summary of the respondents' answers regarding the acceptability of the AutoCAD design model

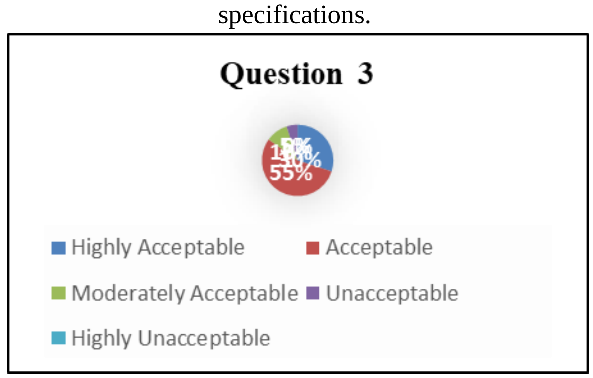
The findings showed that ten (10) or 50% of respondents selected extremely satisfactory. Out of twenty (20) respondents, six (6) gave satisfactory and three (3) gave somewhat acceptable responses, accounting for 30% and 15% of the total. One (1) of them, or 5% of them, replied severely unacceptable, while none of them, or 0%, answered unacceptable. With an average weighted mean (AWM) of 4.20, it can be concluded that the solar panel's physical compatibility with the Don Honorio Ventura State University's duracurve sheds in the suggested AutoCAD design is quite acceptable. The obtained standard deviation for this query is 1.03 as well.

Figure 8. Summary of the respondents' answers regarding the acceptability of the proposed solar panel specifications.



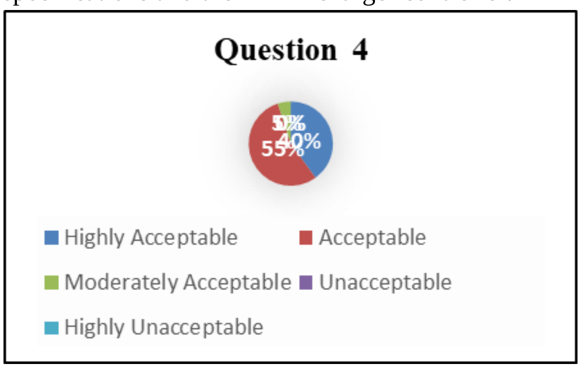
The results gathered from the survey states that five (5) or 25% of the respondents says that the proposed size of solar panels is highly acceptable. Thirteen (13) out of twenty (20) respondents or 65% states that it is acceptable. Two (2) or 10% answered that it is moderately acceptable. Zero (0) of them or 0% answered unacceptable and highly unacceptable. An AWM of 4.15 is calculated which means that the three (3) pieces of seventy (70) W solar panels is highly acceptable for the design in order to deliver enough energy to charge 6 mobile phones simultaneously. In addition, the acquired standard deviation for this question is 0.572.

Figure 9. Summary of the respondents' answers regarding the acceptability of the proposed battery specifications.



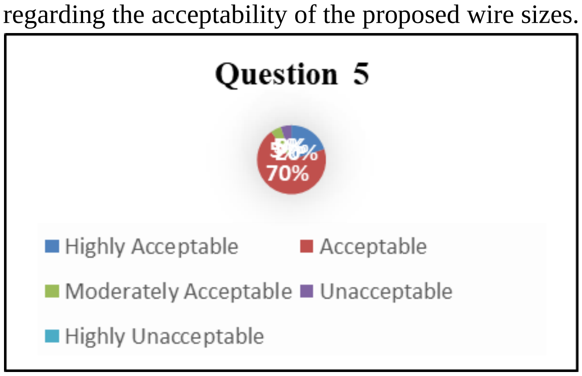
Cruz (2022) states that regardless of whether you're utilizing a tiny solar system or charging your second battery using a battery isolator, we've found that 100-amp hours offer the optimum energy and price combination for the ordinary van dweller. For charging cell phones and tablets, LED lighting, and small accessories, inverters are frequently adequate. Applications for energy storage are numerous. However, small to medium-sized appliances are routinely powered by standard 12V 100Ah batteries in a variety of locations, including boats and campers. Some people build up a parallel connection of 12V 100Ah batteries to store extra energy produced by their off-grid solar panel systems

Figure 10. Summary of the respondents' answers regarding the acceptability of the proposed USB ports specifications and the MPPT charger controller.



The results revealed that eight (8) or 40% of the respondents answered highly acceptable. Out of twenty (20) respondents eleven (11) of them or 55% answered acceptable and one (1) or 5% answered moderately acceptable. None of them or 0% responded unacceptable and the remaining and similar respond to highly unacceptable.

Figure 11. Summary of the respondents' answers regarding the acceptability of the proposed wire sizes.

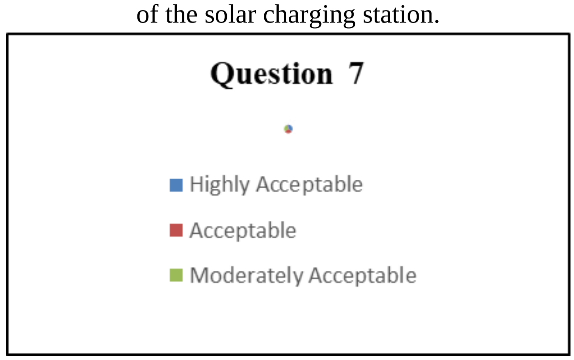


The result of this question showed that four (4) or 20% of the participants responded Highly Acceptable. Fourteen (14) or 70% of them responded Acceptable, one (1) or 5% of them answered Moderately Acceptable, and one (1) or 5% of them also answered Unacceptable. None of them responded Highly Unacceptable. In addition, the acquired standard deviation for this question is 0.669.

Figure 12. Summary of the respondents' answers regarding the acceptability of the possible cost of the solar charging station.

The results revealed that five (5) or 25% of the respondents answered Highly Acceptable, 12 or 60% of them responded Acceptable, 3 or 15% of them retorted to Moderately Acceptable, and none or 0% of the twenty (20) participants responded to Unacceptable and Highly unacceptable options.

Figure 13. Summary of the respondents' answers regarding the acceptability of the expected life span of the solar charging station.



Presented in this question a totality of seven (7) or 35% of respondents answered Highly acceptable, six (6) or 30% of them retorted to Acceptable, another six (6) or 30% of them responded Moderately Acceptable, one (1) or 5% of them responded to Unacceptable, and none or 0% from them answered Highly unacceptable.

CONCLUSION

In this study, the researchers proposed the design of a solar-powered mobile charging station for students and guests at Don Honorio Ventura State University using an AutoCAD Application Software. Solar energy was considered in producing a charging station that would allow users to charge their devices quickly. The researchers concluded that the solar-powered charging station could be an alternative way to provide a solution for each user's concern, especially for educational purposes.

APPENDIX

A. Computation of the Solar Panels using off-Grid Set-up using off Grid Inverter (OGI)

Main Components
1) Photovoltaic Solar Panels (PV)
2) Solar Charge Controller (SCC, MPPT)
3) Battery
4) Off Grid Inverter

Table 2. Solving the consumption of the Solar powered charging station

Table 2. Solving the consumption of the Solar powered charging station

Loads	Qty	Wattage (w)	Total Wattage	Usage (hr)	Total Wh
Cellular Phones	6	7	42	12	504
			42		504

Therefore, the total expected load per day in Watt-hour is 504

Specification of off-grid inverter:
- 12V battery voltage
- Pure Sine Wave (PSW) Inverter
- 80% max load to ensure safety

Using Equation 3: Computation for the total solar panels wattage

$$\text{Solar Panel Wattage} = \frac{(\text{Total watt-hours per day})(\text{Energy loss in the system})}{\text{Panel Generation Factor}}$$

$$\text{Solar Panel Wattage} = \frac{(504\ AH)(1.3)}{3.43}$$

Solar Panel Wattage = 191.02 Watts

Using Equation 4: Computation for the size of solar panels (S.S.P)

$$\text{S.S.P} = \frac{\text{Total Solar Panel Wattage}}{\text{Number of solar panel to be used}}$$

$$\text{S.S.P} = \frac{191.02\ W}{3}$$

S.S.P = 63.67 W or approximately 70 W solar panels are needed which are suggested by the solar Thermo Tank company during the canvassing of materials

Note: The reason why the number of solar panels are three (3) because the researchers wanted to provide a design of the solar power charging station that can operate in mix light conditions. Which is visible to the provided AutoCAD design model wherein the panels are plotted from east to west direction. And similarly, this number was also suggested by the solar Thermo Tank company.

Using Equation 5 Computation for the size of the battery

The battery type recommended for using in solar PV system is deep cycle battery. Deep cycle battery is specifically designed for to be discharged to low energy level and rapid recharged or cycle charged and discharged day after day for years. The battery should be large enough to store sufficient energy to operate the appliances at night and cloudy days. To find out the size of battery, calculate as follows:

Calculate total Watt-hours per day used by appliances. Divide the total Watt-hours per day used by 0.85 for battery loss. Divide the answer obtained in item 4.2 by 0.6 for depth of discharge. Divide the answer obtained in item 4.3 by the nominal battery voltage. Multiply the answer obtained in item 4.4 with days of autonomy (the number of days that you need the system to operate when there is no power produced by PV panels) to get the required Ampere-hour capacity of deep-cycle battery.

$$\text{Battery Capacity (Ah)} = \frac{\text{Total Watt-hours per day used x Days of autonomy}}{(0.85 \text{ x } 0.6 \text{ x nominal battery voltage})}$$

$$\text{Battery Capacity (Ah)} = \frac{504 \text{ Watt-Hour x 4 days}}{(0.85 \text{ x } 0.6 \text{ x } 12\text{ V})}$$

Battery Capacity (Ah) = 329.411 Ah

Therefore: 4 pcs. of 100Ah battery is needed

Specification of the Maximum Power Point Tracking Charger Controller or MPPT Controller

Using Equation 6. Solving for the needed current size

$$= \frac{\text{Total Watt-hours per day}}{\text{Expected voltage output}}$$

Solving for the needed current size = $\frac{504}{12}$
Solving for the needed current size = 42 A
Therefore, the specifications of the MPPT Charger Controller will be:

- 50 A
- 12 Vdc Input
- 230 Vdc Output

Computation for the Wire sizing
Three types of wire will be needed:

- Wire size 1: From the solar panel to the MPPT Charger controller.
- Wire size 2: From MPPT Charger controller to solar batteries.
- Wire size 3: From the MPPT charger controller to USB charging ports.

Solving the current from the solar panels up to the MPPT Charger controller
Using Equation 6. Solving for the current size of wire size 1 = $\frac{\text{Total Wattage}}{\text{Expected voltage output}}$
Solving for the needed current size = $\frac{(3 \times 70)\ W}{12\ V}$
Solving for the needed current size = 17.5 A
Therefore:14 AWG DC type of wire is needed between solar panels and charger controller based from the table 4.
Using Equation 6. Solving for the current size of wire size 2 = $\frac{\text{Total Wattage}}{\text{Expected voltage output}}$
Solving for the needed current size = $\frac{42\ W}{12\ V}$
Solving for the needed current size = 3.5 A
Therefore: 18 AWG DC type of wire is needed between charger controller and solar batteries based from the table 4.
Using Equation 6. Solving for the current size of wire size 3 = $\frac{\text{Total Wattage}}{\text{Expected voltage output}}$
Solving for the needed current size = $\frac{42\ W}{230\ V}$
Solving for the needed current size = 0.183 A
Therefore: 2 mm^2 TW AC type of wire is needed between solar panels and charger controller based from the table 3.
Solving for the fuse that will serve as the overcurrent protection in the circuit
Using Equation 6. Solving for the needed current size of fuse = $\frac{\text{Total Watt}}{\text{Expected voltage output}}$
Solving for the needed current size = $\frac{42\ W}{230\ V}$
Solving for the needed current size = 0.183 A
Therefore: 1A glass fuse is needed.

APPENDIX B. Solving for the charging and discharging time of the solar panel battery and mobile phone battery.

APPENDIX C. Solving for the charging time of the solar panel battery
Using equation no. 1
CT = $\frac{Ah}{I}$
CT = $\frac{(4)(100Ah)}{4(25)\ A}$
CT = 4 hrs.
Note: The 25 A is the derived from the 25% of the battery capacity which is recommended by the manufacturers it is based from Johnson, L. C. (2007). Battery Charging Tutorial | ChargingChargers.com. Battery Charging. Retrieved May 24, 2022, from https://www.chargingchargers.com/tutorials/charging.html

APPENDIX D. Solving for the charging time of the cellphone battery
Using equation no. 1
CT = $\frac{Ah}{I}$
CT = $\frac{5\ Ah}{2\ A}$
CT = 2.5 hrs.
CT = 2 hrs. and 30 minutes
Note: The 2 A is based from the expected current output of the multi-USB port solar charging station.

APPENDIX E.Solving for the discharging time of the solar panel battery
Using equation no.2
DT = $\frac{\text{Battery (Ah) x Battery (V)}}{L}$
DT = $\frac{4\ (100\ Ah) \times 12(V)}{42\ W}$
DT= 114.29 hrs.

Note: 42 W was achieved from Table 2. The total wattage to be supplied by the solar battery.

APPENDIX F. Solving for the discharging time of the cell phone battery
Using equation no.2
DT = $\frac{\text{Battery (Ah) x Battery (V)}}{L}$

DT = $\frac{5\ \text{Ah} \times 5\ (\text{V})}{2\ \text{W}}$
DT= 12.5 hrs.

Note: 2 W came from (Energy use, 2020) who coined that cell phones uses a 2 W power when unplugged and in use.

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