SOLAR-POWERED COIN-OPERATED CHARGING STATION

Eric P. Catalan
eric.catalan@gsc.edu.ph

Jonathan G. Gabion
jonathan.gabion@gsc.edu.ph

Crisanto G. Occeña
crisanto.occeña@gsc.edu.ph

ABSTRACT This study is focused on the development of a coin-operated mobile gadget charging station that is powered by solar energy, which is attached to the charging station by means of a storage battery. The device is aimed for the promotion of solar energy as alternative off-grid source that demonstrate limitless potential for development. It can also be used for commercial use since it requires certain fee for a specified period to charge mobile gadgets. However, in case of calamities the charging station can be used as an emergency charging station in the event of prolonged power outages. Since the device is a standalone system it can charge mobile gadgets as long as there is sunlight. The coin-operated mobile gadget charging station has the ability to charge small or mobile gadgets and electronics during both day and night.

Keywords: Solar Powered, coin-operated, mobile gadget, charging station

INTRODUCTION

Background of the Study

Renewable power generation can help countries meet their sustainable development goals through provision of access to clean, secure, reliable and affordable energy. Solar technology is very popular nowadays and growing day by day. Solar powered gadgets are also taking attention of people and a use of solar energy is taking places where no electric power is available but also in cities. Many countries are aggressively producing renewable energy nowadays.1

In December 16, 2008, during the Second Regular Session of the Fourteenth Congress Republic Act No. 9513 also known as the "Renewable Energy Act of 2008" was enacted. "An Act Promoting the Development, Utilization and Commercialization of Renewable Energy Resources and for Other Purposes" 2 which aims in its declaration of policy the following: (a) Accelerate the exploration and development of renewable energy resources such as, but not limited to, biomass, solar, wind, hydro, geothermal and ocean energy sources, including hybrid systems, to achieve energy self-reliance, through the adoption of sustainable energy development strategies to reduce the country's dependence on fossil fuels and thereby minimize the country's exposure to price fluctuations in the international markets, the effects of which spiral down to almost all sectors of the economy; (b) Increase the utilization of renewable energy by institutionalizing the development of national and local capabilities in the use of renewable energy systems, and promoting its efficient and cost-effective commercial application by providing fiscal and non-fiscal incentives; (c) Encourage the development and utilization of renewable energy resources as tools to effectively prevent or reduce harmful emissions and thereby balance the goals of economic growth and development with the protection of health and the environment; and (d) Establish the necessary infrastructure and mechanism to carry out the mandates specified in this Act and other existing laws.

Governments across the Asia Pacific region are continuing the push for greater renewable energy contributions to domestic electricity demand. While the deal flow has been lower than expected over the last six months, there have been positive signs in several countries that local developers are very active at the approval level. International developers are increasingly taking advantage of the many government and market incentives for renewable energy investment and investing alongside locals.

Solar power is pollution-free during use. Photovoltaic (PV) installations can operate for many years with little maintenance or intervention after their initial set-up, so after the initial capital cost of building any solar power plant, operating costs are extremely low compared to existing power technologies. Modern technology has brought a huge impact on the way of life of many people in the globe. Paradigms of such advancement in technology are the gadgets like mobile phones, iPhones, iPods and tablet computers that make living a whole lot better than it was before.

The researcher's idea was due from the need of a green energy source to provide sustainable power to charge mobile gadgets during power outages and/or where electrical power is not available for a reasonable amount of time. The idea or a device that will charge mobile gadgets started when Guimaras State College participated in the annual Manggahan Festival booth display. The first prototype was then started and tested on September 2012. By April 2013, the first operational prototype was displayed during the said activity.

The researcher opted to engage in the field of Electronics and renewable energy, specifically the realm of mobile gadgets that is undeniably one of the most commonly used devices of today's generation. Recharging a mobile phone is one of the primary concerns of the people who use it in a daily basis.

The study is focuses on the application of photovoltaic (solar) power generation as an off-grid electrical source to power the study because it is a ubiquitous source of energy, with the huge potential of significant contribution to the development of Green Technology. The study also facilitated the understanding of the significance of promoting renewable energy as alternative source of electrical power and encourages further development, innovation and production of renewable energy systems.

In this premise, the researcher has developed the concept of developing an innovative design of the system using renewable energy from the sun which is one of the most abundant sources of energy. On this account, the researcher deal with the means of recharging mobile gadgets using solar power. Thus, this study is conducted.

Objectives of the Study

The main objective of the study is to construct a solar-powered coin-operated charging station–green technology instructional device for mobile gadgets using solar energy as alternative off-grid power source. Specifically, it will aim to: (1) develop an innovative design and application using renewable energy source as an alternative or off-grid power source for charging mobile gadgets for personal or commercial use; (2) construct a prototype that can charge various brands and models of mobile gadgets; (3) conduct testing on the compatibility by charging various brands and models of mobile gadgets; (4) conduct testing on the charge percentage of the system using various brands and models of mobile gadgets, (5) show the cost and return analysis of the project.

METHODOLOGY

Design Criteria

A conceptual design of the Solar-powered coin-operated charging station was prepared based on the technical and operational information using other common and locally available materials was gathered. Materials needed and design calculations for the solar-powered coin-operated charging station materials were determined.

During the design of the Solar-powered Coin-operated Charging Station, the following criteria were considered:

1. availability of the local resources and materials for construction;
2. overall size and shape of the solar-powered coin-operated charging station;
3. design and placement of the circuitry;
4. placement of the PV panel and power storage.

Description of the Device

The research solar-powered coin-operated charging station will deliver a nominal 1,000 watts power output in which 200 watts will serve 10 stations charging banks to be operated 12 hours a day at initial run and 100 watts was used for automatic night-time lighting of the area for 10-12 hours. The 10-station charging banks was coin- operated which will use one (1) peso coin for the charging time of six (6) minutes.

Solar (PV) System. The PV system consist of 120 watts panel passing through the 10-ampere charge regulator to regulate the charging of the 120 ampere-hour storage battery which stores and supply power to the charging system and lighting.

Charging System/ Lighting. The charging system consist ten (10) individually placed charging banks with ten (10) different types of charger connectors for each bank to adapt to different brands and models of mobile gadgets. The additional feature of the system is the lighting system which will provide internal lighting of the charging station and external lighting to illuminate the area during night-time for the preset time of twelve (12) hours from dusk to dawn.

Structural System. The electrical and electronic system is housed into a hexagonally-shaped structure of sealed steel and wood framing as casing and hexagonally-shaped dome for protection against moisture and rain.

Design Plans and Perspectives
Concept and Design

Figure 1. Detailed design concept and perspective of the solar-powered coin-operated charging station

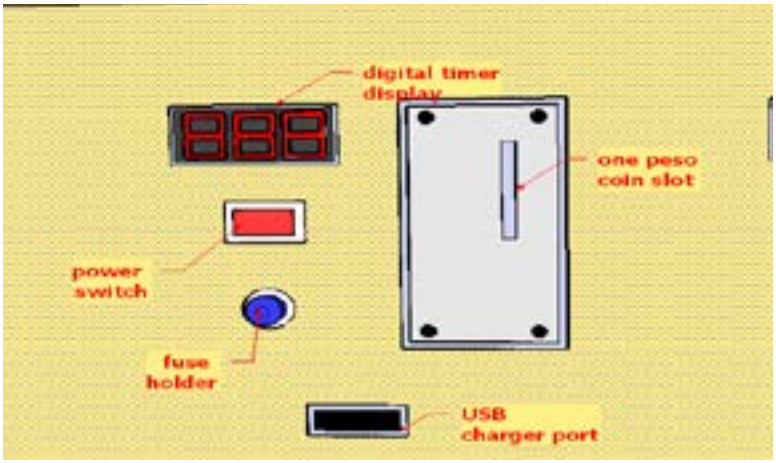

Figure 2. Detailed charging front panel showing the placement of the coin slot, digital display and other peripherals.

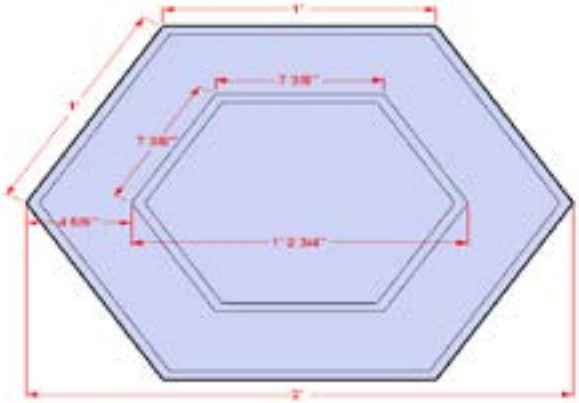

Figure 3. The hexagonally-shaped base design and dimensions of the charging station

Figure 4. Three dimensional (3D) rendering of the base casing and gadget top.

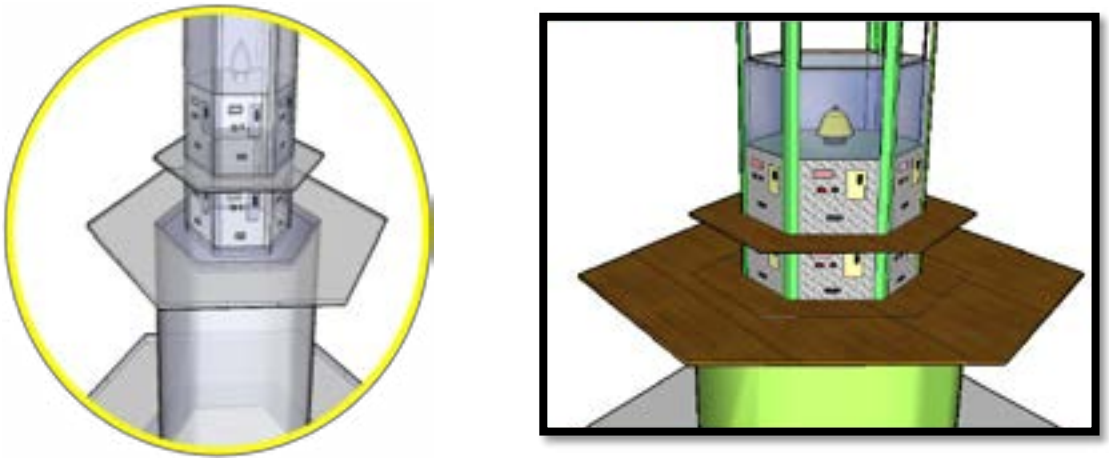

Figure 5. Three dimensional (3D) rendering of the base casing and gadget top with the internal lighting set-up.

Evaluation of the Study

Evaluation of the system was conducted using standard test equipment such as voltmeters and ammeters. Testing of the system using various brands and models of mobile gadgets according to generation classified as follows:

1. second (2nd) generation mobile gadgets are units with monochromatic (black and white) screen and digital display with touchpad commonly capable only of voice calls and text messaging,
2. third (3rd) generation mobile gadgets are units with color screen display with touchpad capable of voice calls, text messaging, multimedia service and internet browsing;
3. fourth (4th) generation mobile gadgets are units with color screen display with touch screen capability used for voice calls, text messaging, multimedia service, camera feature, Bluetooth file transfer and internet browsing;

The system evaluation will further include:

1. testing the charging system to determine the system compatibility as to charger acceptability and/ or rejection issues with various brands and models of mobile gadgets;
2. determine the charging rate percentage of various brands and models of mobile gadgets using the system.

List of Tools and Equipment

1. Welding machine
2. Power saw/ hacksaw/ jig saw
3. Electric drill press/ electric drill
4. Riveter/ wrench
5. Electric planer
6. Electric sander
7. Soldering iron
8. Side cutter/ long nose pliers

List of Materials

A. Solar (PV) System

1. 120W Solar Panel with 12V @ 10A Charge Controller
2. 12 volts @120Ah, Deep cycle Solar Battery

B. Charging System/ Lighting

1. coin slot, timer and front cover
2. 10-in-1 multifunction USB car charger with fuse
3. #18 AWG flat cord, polarized/ hook up wire
4. Rubber tape/ cable ties/ stove bolt
5. Dark activated switch with LED bulb, 12 volts, 5 watts

C. Structural System

1. GI pipe
2. plain sheet
3. Marine plywood
4. angle bar
5. bolt / blind rivets
6. Epoxy Primer/ body filler
7. Liquid tile paint/ reducer/ paint thinner
8. welding electrodes

9. cement, sand
10. paint roller/ paint brush

Procedures

1) Finalizing of design and procuring/ gathering of materials.
2) Cutting of angle bars and welding according to placement in the plan.
3) Laying out and cutting of the front panel.
4) Assembling the coin slot, timer and charging system and soldering of parts and components.
5) Preliminary testing of the system and calibration of the timer module to the desired charging time.
6) Final testing of the system to include the solar (PV) and charging system.

Picture Documentation

Fabrication, Construction and Installation

Figure 6. The first operational prototype of the solar-powered coin-operated charging station installed inside College campus

Figure 7. Inspecting the base structural frame of the charging station as shown in the picture.

Figure 8. The completed base casing and gadget top as shown in the picture.

Figure 9. Assembling the charger structural frame of the charging station as shown in the picture.

Figure 10. Completing the installation of the internal circuitry of the charging station.

Figure 12. The top dome steel framing as shown in the picture.

Figure 13. The technical expert in Steel Fabrication, Prof. Crisanto Occeña inspecting the completed steel dome.

Figure 14. Assembling the solar (PV) panel as shown in the picture.

Figure 15. The completed charging station showcased during the Municipal Fiesta 2013 as shown in the picture.

Figure 16. Additional feature of the solar-powered coin-operated charging station is the night time lighting set-up.

Figure 18. The fully operational charging station installed inside the College campus with AREC Director, Prof. Joel V. Japitana.

Instrumentation and Set-up Testing

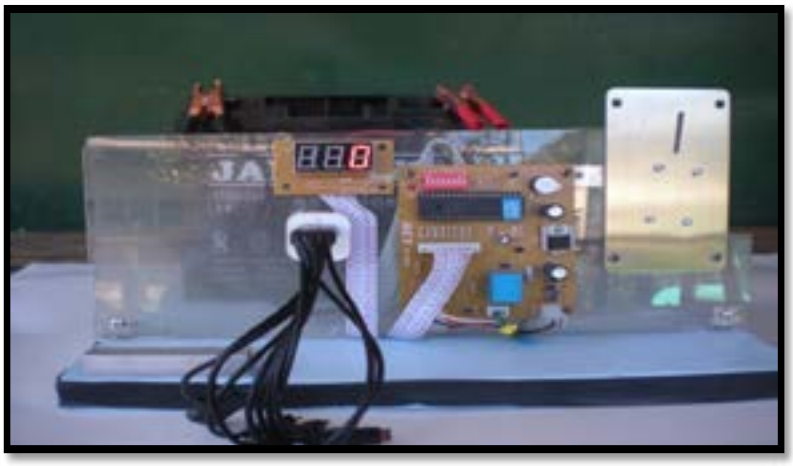

Figure 19. The operational test setup of the solar-powered coin-operated charging station as shown in the picture.

Figure 20. Charging and compatibility test of the system using the generic mobile phone brand.

Figure 21a. Charging and compatibility test of the system using the generic mobile phone brand.

Figure 21b. Charging and compatibility test of the system using the generic (4th Generation) mobile phone brand.

Cost and Return Analysis

Solar-Powered, Coin-Operated Mobile Gadget Charging Station

Basic Assumptions:

No. of Charging Banks	10 Stations
No. of Days of Operation/ Month	25 Days
Charge Rate/Cost per Hour	Php10.00
No. of Hours of Operation / Day (1st two months)	8 Hours
No. of Hours of Operation / Day (3rd month- onwards)	15 Hours

A. Estimated Project Cost

Items of Expenditure	
Solar (PV) System	19,000.00
Charging/ Lighting System	18,837.00
Structural System	23,720.00
Labor Cost , 35% (based on 3 labor work force)	21,544.95
Total Project Cost >>>>>	83,101.95

B. Revenue

Table 1. Financial Aspect as to projected monthly revenue to include expenditures, net income, project breakeven period and ROI.

Revenue	Months 1	2	3	4	5	6	7	8	9	10
Projected Daily Collection/Bank	50.00	52.00	60.00	60.00	62.00	64.00	66.00	68.00	70.00	72.00
Projected Gross Monthly Income	12,500	13,000	15,000	15,000	15,500	16,000	16,500	17,000	17,500	18,000
Less: Expenditures Cash Expenses:										
Cost of Materials	0.00	0.00	1,500	1,500	1,500	1,500	1,500	2,000	2,000	2,000
Cost of Labor	0.00	500	700	700	750	750	800	800	1,000	1,000
Miscellaneous Expenses	0.00	.000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
Contingency	1,000	1,000	1,000	1,500	1,500	1,500	1,500	1,500	1,500	1,500
Total Cash Expenses	1,000	1,500	4,200	4,700	4,750	4,750	4,800	5,300	5,500	5,500
Net Income/ Month	11,500	11,500	10,800	10,300	10,750	11,250	11,700	11,700	12,000	12,500
Projected Breakeven Period	71,602	60,102	49,302	39,002	28,252	17,002	5,302	1,069		
ROI	14%	14%	13%	12%	13%	14%	14%	14%	14%	15%

Figure 22 presents the ten-month period of breakeven assessment which is within the 8th month of operation.

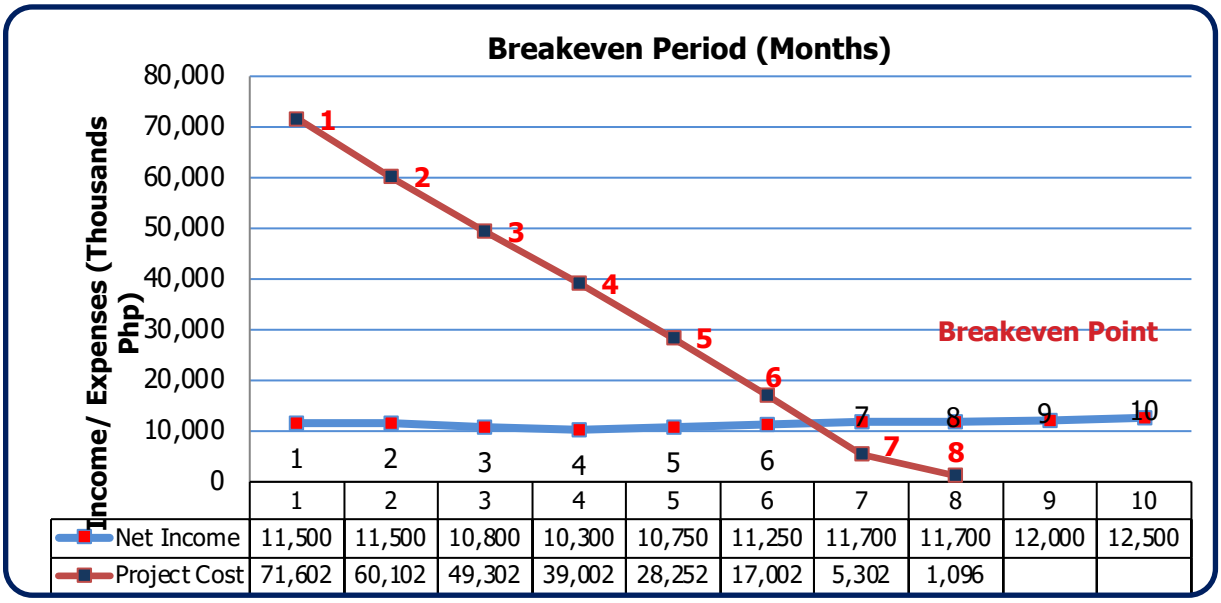

Figure 22. The breakeven period of the project as shown in the graph.

Figure 23 presents the graph of the monthly return of investment ranging from 12% to 15% during 1st month to the 10th month of operation

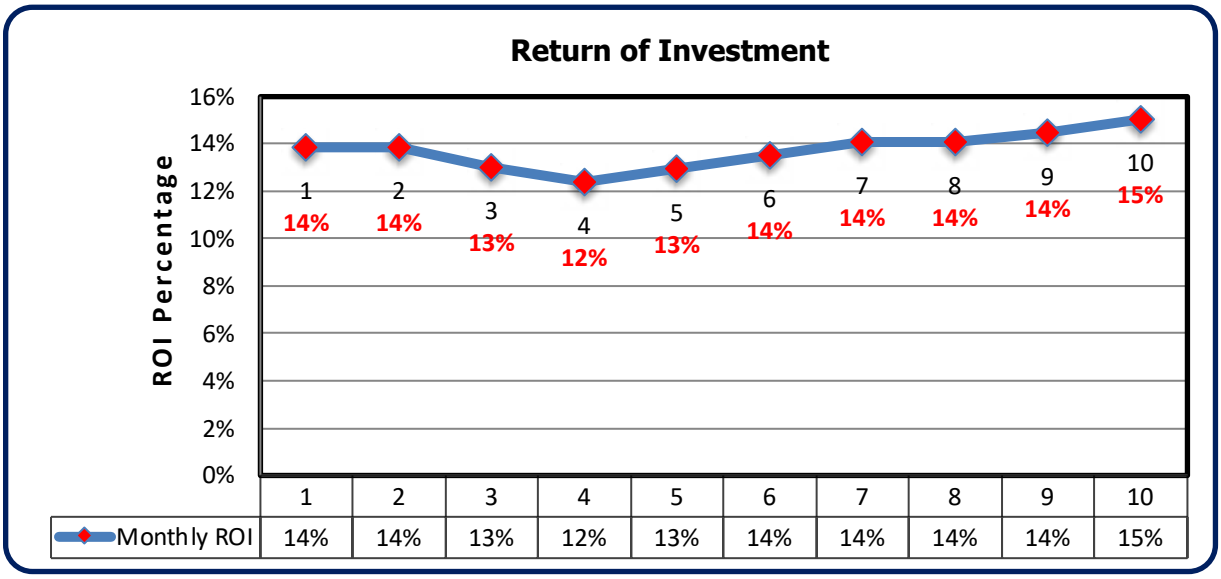

Figure 23. The monthly percentages of ROI of the solar-powered coin-operated charging station as shown in the graph.

RESULTS AND DISCUSSION

Table 2 present the charging test trials for three (3) replications conducted using the generic 2nd generation mobile phone showing the average charge percentage ranging from 22% to 62% for the charging of six (6) to thirty (30) minutes duration.

Table 2. Test trials for charge rate of generic 2nd generation mobile phone

Charge Time	6 minutes (1.00PhP)	12 minutes (2.00Php)	18 minutes (3.00php)	24 minutes (4.00 Php)	30 minutes (5.00 Php)
Replication 1	20%	26%	41%	50%	60%
Replication 2	23%	29%	44%	52%	60%
Replication 3	22%	30%	45%	55%	65%
Average Charge %	22%	28%	43%	52%	62%

Figure 24 present the graph showing charging test trials for three (3) replications conducted using the generic 2nd generation mobile phone showing the charge percentage for replication 1 ranging from 20% to 60% for the charging of six (6) to thirty (30) minutes duration, replication 2 ranging from 23% to 60% for the charging of six (6) to thirty (30) minutes duration, replication 3 ranging from 22% to 65% for the charging of six (6) to thirty (30) minutes duration.

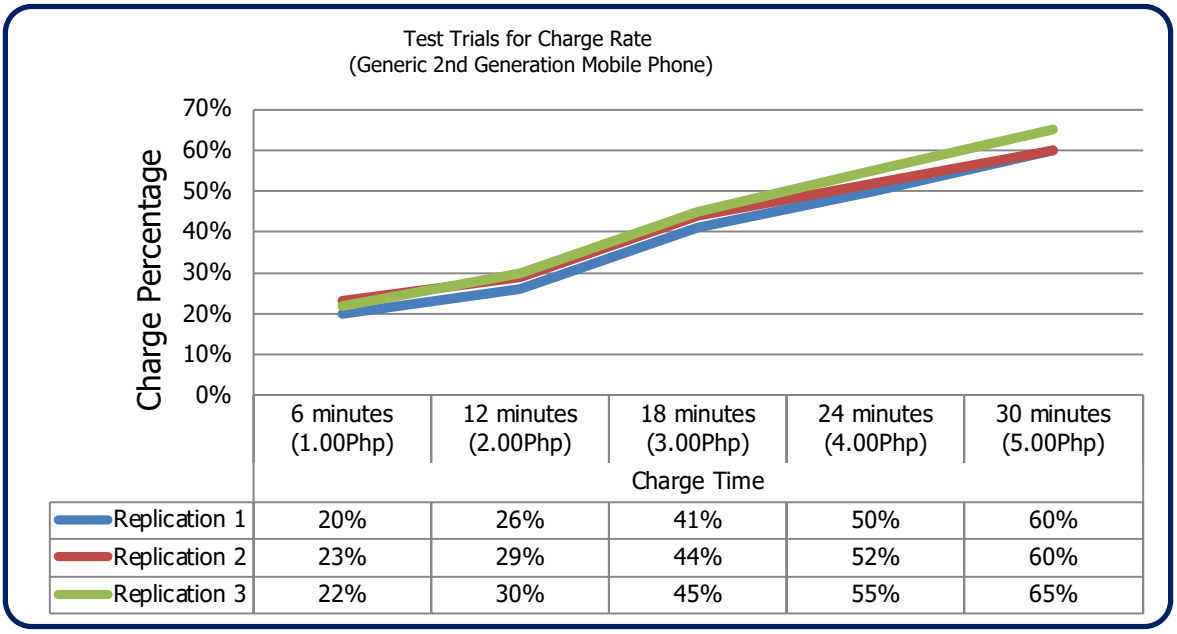

Figure 24. Test trials for charge rate of generic 2nd generation mobile phone

Table 3 present the charging test trials for three (3) replications conducted using the generic 3rd generation mobile phone showing the average charge percentage ranging from 22% to 55% for the charging of six (6) to thirty (30) minutes duration.

Table 3. Test trials for charge rate of generic 3rd generation mobile phone

Charge Time	6 minutes (1.00PhP)	12 minutes (2.00Php)	18 minutes (3.00php)	24 minutes (4.00 Php)	30 minutes (5.00 Php)
Replication 1	20%	26%	41%	49%	55%
Replication 2	23%	29%	44%	51%	54%
Replication 3	22%	30%	45%	52%	55%
Average Charge %	22%	28%	43%	51%	55%

Figure 25 present the graph showing charging test trials for three (3) replications conducted using the generic 3rd generation mobile phone showing the charge percentage for replication 1 ranging from 20% to 55% for the charging of six (6) to thirty (30) minutes duration, replication 2 ranging from 23% to 51% for the charging of six (6) to thirty (30) minutes duration, replication 3 ranging from 22% to 55% for the charging of six (6) to thirty (30) minutes duration.

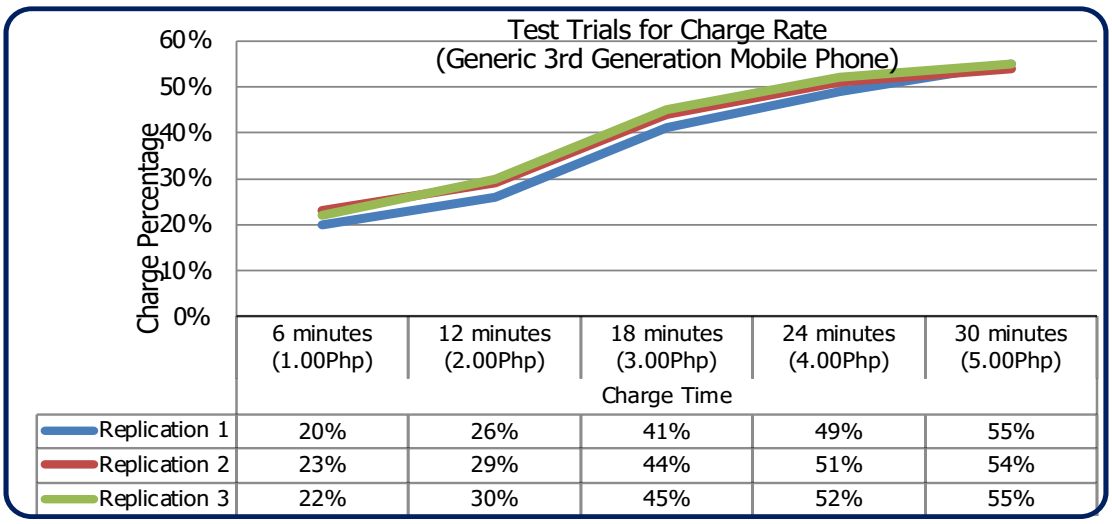

Figure 25. Test trials for charge rate of generic 3rd generation mobile phone.

Table 4 present the charging test trials for three (3) replications conducted using the generic 4th generation mobile phone showing the average charge percentage ranging from 15% to 53% for the charging of six (6) to thirty (30) minutes duration.

Table 4. Test trials for charge rate of generic 4th generation mobile phone

Charge Time	6 minutes (1.00PhP)	12 minutes (2.00Php)	18 minutes (3.00php)	24 minutes (4.00 Php)	30 minutes (5.00 Php)
Replication 1	15%	26%	35%	40%	51%
Replication 2	17%	29%	34%	42%	54%
Replication 3	12%	24%	36%	40%	55%
Average Charge %	15%	26%	35%	41%	53%

Figure 26 present the graph showing charging test trials for three (3) replications conducted using the generic 4th generation mobile phone showing the charge percentage for replication 1 ranging from 15% to 51% for the charging of six (6) to thirty (30) minutes duration, replication 2 ranging from 17% to 54% for the charging of six (6) to thirty (30) minutes duration, replication 3 ranging from 12% to 55% for the charging of six (6) to thirty (30) minutes duration.

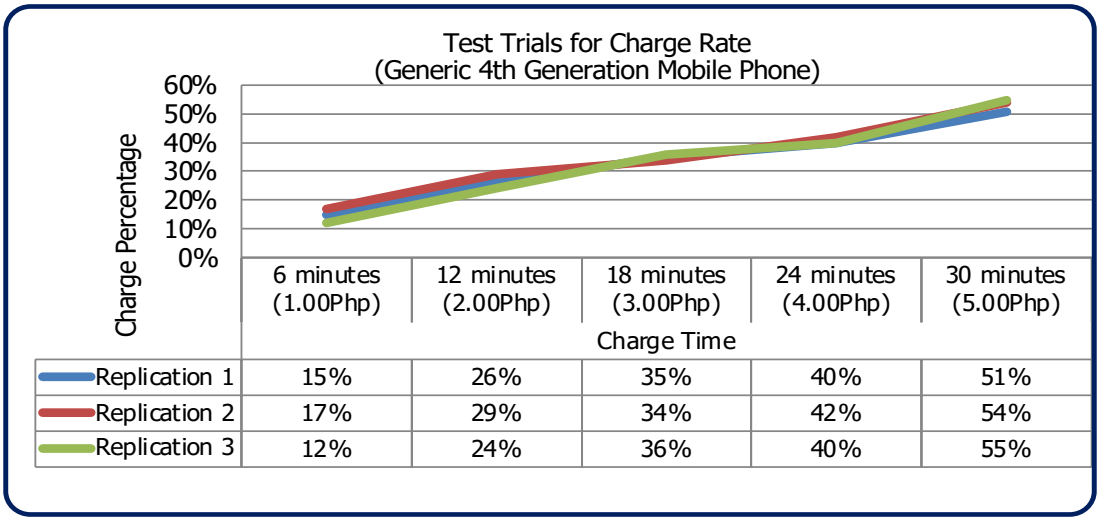

Figure 26. Test trials for charge rate of generic 4th generation mobile phone

CONCLUSION

There are no incompatibility issues to various brands and models of mobile gadgets commercially available in the market. The solar-powered coin-operated charging station can be easily constructed and can be used for personal use and commercial purposes. The solar-powered coin-operated charging station presents cost effectiveness as to sustainability for low maintenance features. The solar-powered coin-operated charging station is an environment friendly source of power by harnessing solar energy thus promoting green technology generation vision of Guimaras State College.

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