A Portable Solar-Powered Generating Apparatus for Irrigation System of Small Scale Farming "Tubig at Ilaw Mula sa Araw"

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Keywords:

battery charging, construct, design, evaluate, irrigation system, lighting, solar-powered, ventilating

ABSTRACT

This study was concentrated on the performance of a portable solar-powered apparatus for water pumping systems intended for small irrigation, safe drinking water, sanitation water supply, and wide variety of lighting, ventilating and charging applications. This is a 4 in 1 apparatus which answers to the biggest challenge facing the world today which is Energy Independence and Food Production (EIFP). The project was evaluated along *design*, *construction*, *efficiency*, *acceptability*, *functionality*, *affordability* and *safety*.

The Project Development Method (PDM) was used in making the project. The descriptive-evaluative research design was applied to test its performance. There were one 140 respondents of the study. The five-point Likert's Scale and WAM were applied to interpret the equivalent meanings of the data gathered. Likewise, the ANOVA was used to determine the significant difference between the responses of the four groups of respondents.

The findings revealed that the apparatus gave an "*excellent*" performance. It has a *good design*, *constructed properly*, *efficient*, *highly acceptable*, *functional*, *affordable* to own and *very safety to use*.

It can satisfactorily produce a volume of 600 m3 (159,600 US-Gal. /day), /day of water at a lift of 15 meters (46 ft.). The Evapo-Transpiration (ETo) is 5.5 mm/day. The irrigation efficiency is 65 % and the irrigation area is 7.1 ha (28.7 acres). It can efficiently run a 1 HP (750W) submersible pump with 2,500 liter/hour. The maximum jet of water is 20 meters. The total savings after 60 months is Php 109,800.00. The apparatus is economical, affordable and technically practical.

INTRODUCTION

Many countries are now exploring ways to stimulate social and economic growth through the development of the renewable energy sector. Investment in renewable energy can generate new sources of growth, increase income, improve trade balances, contribute to industrial development and create jobs. While such socio-economic benefits are increasingly gaining prominence in the global renewable energy debate, specific analytical work and empirical evidence on this important subject remain relatively limited, (Amin, Clean Energy Ministerial (CEM), May 2014,).

The solar energy is universal, freely available, and environmental friendly. Green inventions are environmentally friendly that often involve: energy efficiency, recycling, safety and health concerns, renewable resources, and more. It supports entrepreneurial rural people with technical and skills training to engage in more productive, diverse and sustainable means of agricultural production, and facilitates their access to capital for investment and to markets. Agriculture solar developers are doing a brilliant job developing solutions to the performance of renewables in the agribusiness; as well as in understanding the behavior and availability of agriculture resources. Power is everywhere, and harnessing that power can bring clean renewable electricity to agribusinesses throughout the world. Converting the solar power into electricity is done by the use of *photovoltaic cell* or commonly known as *solar cell*.

There is increasing demand for the use of alternate or renewable energy sources to achieve clean and low-cost electricity for agricultural water pumping requirements. It is expected that the farmers use a portable solar-powered generating apparatus for irrigation system to reduce farming inputs. The application of solar powered water pumping systems for drinking water, sanitation and small irrigation projects has resulted in a reliable water supply delivered in a cost effective and economically sustainable way. This project has significantly improved the lives of people especially farmers.

So let us look into how we can design and construct apparatus that can be used to ensure that crops are being maintained using the battery. Hence, the simulation circuit will include all realistic components of the system. This time solar energy that convert electricity make machines functional. Socio-economic benefits are gaining prominence as a key driver for renewable energy deployment. With many economies faced with low growth, policy makers see potential for increased income, improved trade balance, contribution to industrial development and job creation.

Objectives of the Study

The following are the main objectives of the study:

1. To design, construct and evaluate a *solar-powered generating apparatus for irrigation system of small scale farming* and high value crops under Cagayan Valley conditions using submersible pump to reduce farming inputs.
2. To contribute in the environmental conservation and income generation through the establishment of solar-powered water system and wide variety of lighting, ventilating and charging applications in urban and rural areas.

Specific Objectives

Specifically, it aims to contribute to a better understanding of the potential impact and limitations of PV technology on sustainable agriculture and rural development, especially concerning income-generating activities. Furthermore this study tends to:

1. Evaluate a portable solar-powered generating apparatus for irrigation system along, *design, construction, efficiency, acceptability, functionality, affordability and safety*.
2. Determine the performance of a portable power generating apparatus for irrigation system for flood irrigation in terms of *Evapo-transpiration* (ETo)*, irrigation efficiency, irrigation area, vertical lift and water volume pumped up*.
3. Determine the significant difference between the perceptions of the respondents along the selected variables used in the evaluation.
4. Find out the advantages of solar-powered portable generating apparatus for irrigation system.

Hypothesis of the Study

The posted null hypothesis of the study is: "There is no significant difference between the perceptions of the respondents along the selected variables used in the evaluation."

Impact of the Project

Immediate or potential impact

to national economy. Renewable energy technologies mainly driven to improve energy security, enhance energy access and mitigate climate change. Green inventions are environmentally friendly that often involve: energy efficiency, recycling, safety and health concerns, renewable resources, and more. It supports entrepreneurial rural people with technical and skills training to engage in more productive, diverse and sustainable means of agricultural production, and facilitates their access to capital for investment and to markets. It is expected that the farmers use a portable solar-powered generating apparatus for irrigation system to reduce farming inputs. The application of solar powered water pumping systems for drinking water, sanitation and small irrigation projects has resulted in a reliable water supply delivered in a cost effective and economically sustainable way. This project has significantly improved the lives of people especially farmers.

Research and development breakthrough. A combination of demand-reduction and innovation policies provides the most promising approach to achieve a net financial benefit. Renewable energy has significantly lower operational costs compared to the high ongoing expenses of coal and gas extraction and transportation. The long and short term impact an invention has on the environment is what we are talking about. One of the best known examples of green technology would be the solar cell. A solar cell directly converts the energy in light into electrical energy through the process of photovoltaics. Generating electricity from solar energy means less consumption of fossil fuels, reducing pollution and greenhouse gas emissions.

Result for policy and planning, formulation and implementation. To keep economies growing and avoid dangerous climate change, the world will need to transition to a low-carbon or green energy system. Regions that consume more oil than they produce can act independently of net oil producers and still enjoy almost all of the benefits of the transition to low-carbon transport. For example, if the U.S., Europe, China, India, and other oil importers were all to institute policies to reduce demand for oil, these countries could still achieve 80% of the target reduction in oil usage to keep from dangerous global warming, and receive 95% of the financial benefit they could see with global action. If these net consumers acted, net oil producing countries would benefit from reducing their consumption as well. Innovation would have an equally important cross-border impact.

METHODS AND PROCEDURES

The Project Development Method (PDM) was applied in this research wherein the researchers conceptualized the design and specifications of the apparatus for irrigation system, lighting and ventilation. The project has been constructed and assembled the parts in conformity to the design. Later, revisions were made for any observed defects and reassemble the device until it can be seen functional and suitable.

The descriptive-evaluative research design was applied to evaluate the solar-powered generating apparatus along *design, construction, efficiency, acceptability, functionality, affordability and safety*. And the main data gathering instrument used is set of questionnaire-checklist supplemented by unstructured interviews and observation.

There were one 140 respondents, composing of 20 electrical engineers, 30 electricity and electronics instructors, 38 electricity students and 52 farmers. Meanwhile, the five-point Likert's Scale and WAM were applied to interpret the equivalent meanings of the data gathered. Furthermore, the Weighted Average Mean (WAM) was used to interpret the equivalent meaning of the data gathered.

Timetable of Activities in Making the

Project

Table 1 presents the timetable of activities that has been followed in the making of the portable solar-powered generating apparatus for irrigation system, lighting, ventilation and charging.

It can be seen from the Table the seven activities that has been done for three months. During the first month, the apparatus was conceptualized. To create the most appropriate design, the researchers research different designs and prior art as reference for revisions. After which, the needed materials were prepared. For the second month, the homemade solar-powered apparatus was constructed and completed ready for testing. The apparatus has been tested and revised for almost three weeks. For any observed defects, it was revised and reassembled until it can be seen functional and proper. During the third month, the project was completely finished and polished in preparation for final evaluation. After the evaluation, all the suggestions of the evaluators had been incorporated. Since the suggestions were satisfied, the claims for patent have been prepared for submission. As soon the application for patent is accepted, the patent pending number is released. While, waiting for the Certificate of Patent, the apparatus can be fabricated in preparation for its commercialization.

Table 1. Timetable of Activities/Gantt Chart

Monthly Activities	Months		
Number of Months	**1**	**2**	**3**
Design the apparatus	x		
Materials Preparation	x		
Construction of Project		x	
Testing		x x x	
Revising		x x x	
Patenting			x
Commercializing			x

Expected Output

Mature technologies for dissemination/potential for business incubation. The program invests in renewable energy initiatives to create clean, affordable sources of energy and (new) income-generating activities that boost productivity and enhance value addition. In addition, the capacity of service providers – ranging from business development services to financial institutions – is strengthened to increase their rural outreach and to provide services that meet the demands of green entrepreneurs. Using a solar energy technology is a viable and sustainable source of energy for water pumping for irrigation utilizing various irrigation methods (paddy, furrow, sprinkler, flush, drip and mist irrigation), lighting and ventilation. After the completion of this project, it is expected that the farmers will be convinced to use the apparatus.

As seen in Table 2, the homemade apparatus is portable and equipped with assembled built-in charging system with automatic charging controller.

The inverter is a homemade with a maximum wattage capacity of 1,500 Watts pure sine wave (PSW) with automatic sensor giving warning if the battery is weak. To automatically open and close the lights during sudden brown out a self-charging light dependent resistor (SLDR) was included. The apparatus is also equipped with safety mechanism device (SMD) that automatically closes the circuit in case of short circuit due to overloading. A laptop battery can be used for emergency lighting. The battery is charge by two pieces 100W German monocrystalline solar panel. It has been tested that a 12V 200A8 Deep Cycle Battery can sustain 50 pieces 7W LED lamps for 12 hours. For small LED TV it can be sustained for 6 hours, likewise to 45W electric fan for 5 hours. Any appliance can be sustained by the apparatus with a maximum wattage of 400-900W for 5 hours depending irradiant of the sun. To pump voluminous water for irrigation, a ¾

Table 2. Features of the Apparatus Different from the Commercial One

Built-in Charging System	Rectifier Diode
Built-in Inverter	1,500 Watts Pure Sine Wave
Built-in Light Dependent Resistor (LDR)	220V, 5W LDR to automatically open and close the lights during sudden brown out
Built-in Safety Device	Safety mechanism device that automatically close in case of overloading and short circuit.
Laptop Battery	Laptop battery can be used for emergency lighting
A-12 Volt 200A8 Deep Cycle Battery can sustain-	50 pieces 7W LED lamps for 10 hours. Small LED TV for 6 hours. 45W electric fan for 5 hours. Any appliance with a maximum wattage of 400-900W
12 Volts 200A8 Deep Cycle Battery parallel connected with Laptop battery can sustain-	50 LED lamps @ 3W for 15 hours Large LED TV for 5 hours Fan for 5 hours Any appliance with a maximum wattage of 400-900W

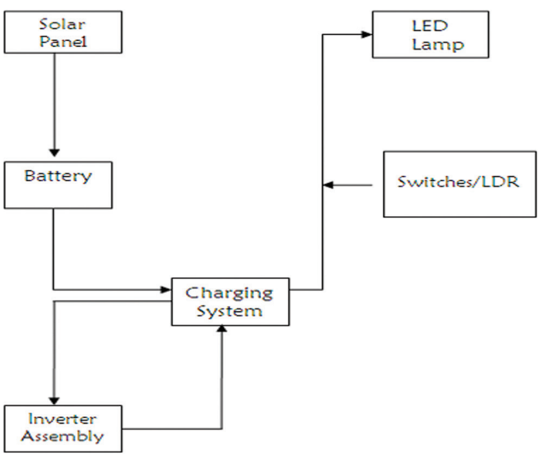

Figure 1. Interrelationship of the Component Parts of the Portable Solar-Powered Generating Apparatus

HP shallow water submersible pump is used with flexible hose (2-inch diameter).

The solar panel is the source of power. In the diagram, the solar plate is directly connected to the battery to the charging system to facilitate the charging. The charging system is composed of charger controller to control the excess power from the solar panel to battery. From that point, the battery is connected to the inverter assembly to invert the charged direct current (DC) to alternating current (AC). The AC that has been inverted will be connected to the convenient outlet to connect loads like the submersible pump for irrigation and lighting and ventilating components.

RESULTS AND DISCUSSION

As seen in Table 3, the design of the project is "*very good*" based from the common ratings of the evaluators. However, the shop instructors rated the design "*good*". Despite of that, the evaluators preferred the design of the apparatus. It was done appropriately, suitable for water pumping for irrigating the plants and for lighting, ventilation and charging batteries.

Mijares (2007) confirm with the findings of the researchers by pointing out that one of the factors to be given importance in making a project feasible is its design. Consequently, the project should be simple, economical and easy to construct.

Furthermore, Seguban, (2012), suggested that to find out the appropriate dimensions for the machine elements, one should consider the forces acting on it, its material, and design to stress. The size of the machine elements should be considered in such a way that they should not distort or break when loads are applied.

Table 3. Project Design

Evaluators	Weighted Mean	Qualitative Description
Farmers	4.87	Very Good
Shop Instructors	4.65	Good
Electricity Students	4.83	Very Good
Electrical Engineers	4.70	Very Good
Grand Mean	**4.76**	**Very Good**

N=140

Table 4. Construction

Evaluators	Weighted Mean	Qualitative Description
Farmers	4.74	Properly Constructed
Shop Instructors	4.70	Properly Constructed
Electricity Students	4.78	Properly Constructed
Electrical Engineers	4.61	Slightly Constructed
Grand Mean	**4.70**	**Properly Constructed**

N=140

Table 5. Functionality

Evaluators	Weighted Mean	Qualitative Description
Farmers	4.65	Very Functional
Shop Instructors	4.74	Very Functional
Electricity Students	4.61	Functional
Electrical Engineers	4.65	Very Functional
Grand Mean	**4.66**	**Very Functional**

N=140

As to the project design, the solar-powered generating apparatus is "*properly constructed*." However, the electrical engineers perceived it that the apparatus is "*slightly constructed*". This may be due to fact that the casing of the apparatus is made of fiber glass and not galvanized iron.

But the farmers, shop instructors and electricity students believed that the researchers applied the most appropriate construction methods by following the design and measurements. In support the given findings, Olivares (2005) stressed that one feasibility aspect of a machine is the method of construction applied by the maker. Furthermore, the time frame is dependent upon the materials and methods of construction used.

Along functionality, the three groups of respondents revealed that the apparatus is "*very functional*". On the other hand, the electricity students said that it is "*functional*". Despite of that the researchers implied that the machine is essentially functional in all its functions. It can be used effectively not only for water pumping purposes but for lighting, ventilating and battery charging. Dena-en (2006) supports the implications given by the present researchers in suggesting that a technological research studies should be multi-purpose to perform more than one functions.

It can be seen in Table 6 that the solar-powered generating apparatus is "*very efficient*" as revealed the four groups of respondents. This means that the generating apparatus is effective in all its functions. It is economical because it can generate electricity by not using conventional fuel. In support to the given implications, Albajeso (2008) concluded in his study that the prime requirement to prove whether the project research is feasible and acceptable is its "*efficiency*".

As to the acceptability of the generating apparatus, the respondents revealed that it is "*highly acceptable*". This implies that the apparatus is highly accepted by the respondents due to its performance. Hence, the solar-powered machine for irrigation, lighting, ventilating and charging apparatus is extremely preferred by the people since it is environment-friendly and economical. Palabay (2006) admits that utility models which are properly designed and constructed designed for energy saving are "highly accepted" for these projects are manageable.

Table 8 presents the evaluation of the respondents as to the affordability of the apparatus. It can be seen that the evaluators have strongly agreed that the generating apparatus is "*highly affordable*". This implies that the generating apparatus can be acquired easily due to its minimal price. It can be acquired for Php. 55,000.00 only. It is easy to maintain, environment-friendly and economical. In support to the implication, Torres (2009) concluded that feasible projects are affordable; the materials are available in the market and in cheaper value.

Along safety, the shop instructors, electricity students, and electrical engineers gave the same qualitative description of "*very safe*". This shows that the respondents have strongly agreed that the apparatus is safety as it equipped safety devices to prevent accidents while using. On the other hand, the farmers rated the apparatus "*safe*" for they compare the apparatus to AC generators using conventional fuel which are easy to install.

Again, Yangco (2008) supports the findings of the present researchers by suggesting that utility model projects should have safety devices for secured use. Likewise, it is important to follow the user's manual to safeguard the life of the operator and the machine.

Finally, the summary of F-test on the evaluation of the four groups of respondents along the selected variables exhibited a non-significant result. This shows that the four groups of respondents gave the same interpretations as to the evaluation of the apparatus along *design, construction, efficiency, acceptability, functionality, affordability and safety*.

Table 6. Efficiency

Evaluators	Weighted Mean	Qualitative Description
Farmers	4.80	Very Efficient
Shop Instructors	4.77	Very Efficient
Electricity Students	4.78	Very Efficient
Electrical Engineers	4.74	Very Efficient
Grand Mean	**4.77**	**Very Efficient**

N=140

Table 7. Acceptability

Evaluators	Weighted Mean	Qualitative Description
Farmers	5.00	Highly Acceptable
Shop Instructors	4.82	Highly Acceptable
Electricity Students	4.79	Highly Acceptable
Electrical Engineers	4.80	Highly Acceptable
Grand Mean	**4.83**	**Highly Acceptable**

N=140

Table 8. Affordability

Evaluators	Weighted Mean	Qualitative Description
Farmers	4.71	Very Affordable
Shop Instructors	4.69	Very Affordable
Electricity Students	4.65	Very Affordable
Electrical Engineers	4.70	Very Affordable
Grand Mean	**4.68**	**Very Affordable**

N=140

Performance of Solar-Powered Portable Generating Apparatus for Flood Irrigation

The vertical lift [H, measured in meters] that must be coped with and the water volume pumped up [Q, measured in m3/day]

The following findings showed standard demands and pumping operations in flood irrigation (paddy rice).

Output: Volume [Q] = 600 m3/day at a lift [H] = 15 m
(600 m3/day = 159.600 US-Gal./day; 15 m = 46 ft)

An 8.400 W (p) solar generator, with 500 V DC, can satisfactorily produce a volume of 600 m3 of water per day, equivalent to 159,600 US-Gal. of water/day. Using a 2-inch diameter hose, the water is lifted at 15 meters or (46 ft.) high. If the Evapo-Transpiration (ETo) is 5.5 mm deep/day the irrigation efficiency is 65 % and the irrigation area is approximately 7.1 ha (28.7 acres). Therefore, the irrigation area is bigger. However, if the Evapo-Transpiration (ETo) is 7.0 mm deep/day the irrigation efficiency is lower at 50% with an irrigation area of approximately 4.3 ha (17.3 acres). Therefore, the deeper the water the smaller is the irrigation area.

Table 9. Safety

Evaluators	Weighted Mean	Qualitative Description
Farmers	4.57	Sage
Shop Instructors	4.83	Very Safety
Electricity Students	4.65	Very Safety
Electrical Engineers	4.70	Very Safety
Grand Mean	**4.73**	**Very Safety**

N=140

Advantages of Solar-Powered Portable Generating Apparatus for Irrigation System

Listed are the advantages of PV-powered irrigation system:

1. The solar-powered portable generating apparatus for irrigation system can be erected at any place, preferably closer to the water source and thus reducing cable length. It is designed for use in remote and in any condition.
2. It is portable, fast and simple installation. It can be flexibly extended, if the farmer needs more water for new acreage.
3. The generating apparatus need no fuel or lubrication. The PV generators can be installed in the water or in environmentally protected zones where no emission of fume and noise. Smart modular design for simple and cost effective servicing and repair.
4. With solar tracking systems the solar energy yield and accordingly the amount of daily pumped water can be increased by approximately 33%. This reduces the number of panels needed to run the system and lowers the investment.
5. PV panel manufacturer usually give

Table 10. Summary of F-test on the Evaluation of the Four Groups of Respondents

Source of Variations Probability	Sum of Squares (SS)	Degree of Freedom (DF)	Mean Square (MS)	F	Decision
Between groups	4.13	2	2.07	.42	ns
Within groups	59.60	12	4.97		
Total	63.73	14			

performance warranties between 20 to 30 years. This ensures long-term safety of the investment. Long life expectancy and proven in service record.

6. Cost effective spare parts philosophy. Very strong ROI against diesel powered pumping.

It can be seen in Table 12 that the life span of a solar panel is 30 years. So, the owner will be compelled to buy 2 Units of Solar Panel 100W for charging after 30 years. Another replaceable major component of the apparatus is 4D Battery. After 5 years the owner should buy 2 Units of 12V battery amounting to Php. 15,000.00. In case, the 1,500W Inverter (Pure Sine Wave) has backed down after 5 years, the owner has two options; have it repair or buy new one.

The inverter is 1,500W and can generate a maximum wattage of 1,300W. The remaining 200W is tolerable to safeguard the life of the inverter and battery.

The apparatus can generate 100 pieces LED bulb @ 3W for 10 hrs @ full charge condition of the battery. With fully-charged battery the house will be lighted with 6 LED bulbs @ 3W per bulb the lighting operation will last for 10 hours or more.

If a 12V battery is full charge (11.9V) it can efficiently light and ventilate a 100W lighting and ventilating facilities for 5-6 hours. Furthermore, an 85W solar plate can charge a 12V battery for 2 hours and 20 minutes during hot sunny day. On the other hand, a-75W computer facilities can be used for 9 hours using a full charge battery. In this case, the battery can be charged for 3 ½ hours using a 100W 1 ½ meters solar panel. Meanwhile, a 100W lighting and ventilation facilities can be powered by a 12V battery for 8 hours and charge for 3 hours using a 100W 1 ½ meters solar panel. Charging rate of battery can be determined by the wattage of the solar panel. The solar powered water system can

Table 11. Performance of Model: PS 9K C-SJ95-1 with an 8.400 W(p) solar generator, 500 V DC (with LORENTZ tracker) With 600.000 l (159,600 US Gal.) per day you can provide water for the following flood irrigation area

Evapo-Transpiration (ETo)	Irrigation Efficiency	Irrigation Area
5.5 mm/day	65 %	app. 7.1 ha. (28.7 acres)
	50 %	app. 4.3 ha. (17.3 acres)

Table 12. The Replaceable Parts, Life Span, Cost and Budget for Labor and Materials

Replacement Parts	Life Span	Cost	Labor/Materials
2 Units Solar Panel 100W	30 years	Php. 16,000.00 (8,000/Unit)	-
2 Units 12V Battery Motolite 4D	5 years	Php. 15,00.00 (7,500/Unit)	-
1,500 Watts Inverter (Pure Sine Wave)	5 years	Php. 8,000.00	Php. 3,00.00
Total		**Php. 39,000.00**	**Php. 3,00.00**

Table 13. Inverter Requirements

Wattage of Inverter Pure Sine Wave	Maximum Wattage to Use	Tolerable Wattage Allowance
1,500W	1,300W	200W

be operated for 5-6 hours and water a ½ hectare for three inches water deep depending on the terrain and condition of the soil. The length of irrigating time is dependent on the number of batteries used. The more batteries used, the longer is the irrigating power. Apparently, the efficiency of the charging system vary on the sizes of the solar plates. For lighting facilities, for a 100W composition of bulbs it can efficiently operate 8-9 hours. Light Emitting Diode (LED) should be used for it is more economical and luminous.

An 8.400 W (p) solar generator, 500 V DC, can satisfactorily produce a volume of 600 m3/day of water (159,600 US-Gal. /day) at a lift of 15 meters (46 ft.). Furthermore, if the Evapo-Transpiration (ETo) is 5.5 mm/day the Irrigation Efficiency is 65 % and the Irrigation Area is approximately 7.1 ha (28.7 acres). The normal lift is approx. 1 to 15 meters.

It can also run efficiently a 1 HP (750W) submersible pump with 2,500 liter/hour. The maximum jet of water is 20 meters. The total savings before maintenance (5-year life span of battery) 60 Months X Php 1,830 = Php 109,800. The evaluators concluded that the apparatus is more economical and affordable as compared to a machine operated by gas and electricity. It is technically practical to design an apparatus using solar energy for irrigation system using submersible pump to reduce farming inputs. The device can be also used for wide variety of lighting, ventilating and charging applications.

Summary of Findings

The following were the significant findings of the study taken from the data gathered and interpreted as follows:

1. The design of the portable solar-powered generating apparatus is "*very good*". It is "*constructed properly*", "*very functional*", "*very efficient*", "*highly acceptable*", "*very affordable*" and "*very safe*" to use.
2. The four groups of respondents gave the same perceptions as to the evaluation of the apparatus along the identified variables.
3. An 8.400 W (p) solar generator, 500 V DC, can satisfactorily produce a volume of 600 m3 per day of water at a lift of 15 meters. Furthermore, if the Evapo-Transpiration (ETo) is 5.5 mm per day the irrigation efficiency is 65 % and the irrigation area is about 7.1 ha. The normal lift is almost 15 meters. It can also run

Table 14. Lighting Load

Number Light Emitting Diode (LED) Bulbs	Maximum Wattage of the LED Bulb	Number of Hours of Operation
100	3W	10 Hrs.

Table. 15. Loads, Battery Condition, Effectivity, Charging and Size of Solar Plate

Load	Condition of Battery	No. of Hrs of Effectivity	Charging Time	Size of Solar Plate
100W Lighting and Ventilation Facilities	Full charge 100% (11.9)	5-6 hrs	2 hrs. 20 min (hot sunny day)	1.5 meters, 85W
75W Computer Facilities	Full charge 100% (11.9)	9 hrs	3 hrs. 30 min	1.5 meters, 100W
100W Lighting and Ventilation Facilities	Full charge 100% (11.9V)	8 hrs	3 hrs	1.5 meters, 130W

efficiently a 1 HP (750W) submersible pump with 2,500 liter/hour. The maximum jet of water is 20 meters.

4. The apparatus is more economical and affordable as compared to a machine operated by gas and electricity.
5. It is technically practical to design an apparatus using solar energy for irrigation system using submersible pump to reduce farming inputs. The device can be also used for wide variety of lighting, ventilating and charging applications.

CONCLUSIONS

Based on the findings, it is concluded that it is technically practical to design a solar-powered portable generating apparatus for irrigation system using submersible pump to reduce farming inputs. The device can be also used for wide variety of lighting, ventilating and charging applications. Hence, the project is designed to contribute to environmental conservation and income generation through the establishment of a solar-powered water system for urban and rural irrigation purposes.

RECOMMENDATIONS

Based from the given conclusions, the following recommendations are hereby given:

1. Bigger size of solar panels should be used for more efficient charging.
2. For nighttime irrigation where PV-powered pumps cannot operate due to lack of solar irradiation, fully-charge spare batteries should be used.
3. Likewise, water reservoir is necessary for nighttime irrigation using PV pump systems. The tank capacity should be equal to the minimum daily requirement as security stock. This is only for very small plots (field beds) are feasible. For medium size fields (basins) a reservoir with plastic lining is an option.
4. In this case often a booster pump is requested, if the water level is too low for gravity flow. For bigger systems only daytime irrigation is possible.

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