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PROPOSED DESIGN OF SOLAR OPERATED BLENDER FOR USE IN UPPER EAST REGION OF GHANA: CASE STUDY OF YOROGO, YIPAALA AND VEA COMMUNITIES OF BOLGATANGA MUNICIPALITY

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DECLARATION

STUDENT'S DECLARATION

I, JOSEPH APODI, declare that this Dissertation, with the exception of quotations and references contained in published works which have all been identified and duly acknowledged, is entirely my own original work, and it has not been submitted, either in part or whole, for another degree elsewhere.

SIGNATURE ………………………………………..

DATE …………………………………………………….

SUPERVISOR'S DECLARATION

I hereby declare that the preparation and presentation of this worked was supervised in accordance with the guidelines for supervision of Dissertation as laid down by the University of Education, Winneba.

NAME OF SUPERVISOR: MR. FRANCOIS SEKYERE

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DATE ……………………………………………………………………………

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DEDICATION

This research work is dedicated to the Apodi'sfamily, especially my wife Founders Akurugo and my children Kenneth AtanbireApodi, Anaba Kelvin Apodi, and Antonio NanpaheyaApodi, and to all Ayikai family members not forgetting of Mr. ApodiAyikai my father, AnamopokaAdongo my mother and Robert Apodi my cherished brother for the encouraging love and care that I have for all of them.

ABSTRACT

This report outlines systematic design of a solar operated blender for use in three communities (Yorogo, Yipaala and Vea) in the Bolgatanga municipality of Ghana that has no electricity and presents the results of calculations of the design parameters as well as the final design of the solar operated blender. The base of the blender is the housing which contains the D.C motor as well as the switch. The individual components of the blender are assembled together and then connected to the solar panel. When the sun rays fall on the solar module it produces a direct current which causes the D.C motor to operate thereby turning the blade of the blender, for the blender to work. The hourly variations of the temperature in these communities is between 11.00 and 15.00 hours local time and this was considered as a good sun hours for the blender since the blender has the ability to grind about 5 grams of tomatoes and other ingredients reasonably and rapidly for almost 2 hours in a day. Also the materials used for the design are readily available in the local market and at a reasonable price,thereby making the design affordable for the people since most of them are low income earners.

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GLOSSARY

NPV	Net present value
I	Irradiation
DC	Direct current
AC	Alternating current
Sd	Design load
Ed	Design energy
mV	Voltage drop per meter
PSH	Peak sun hours
PV	Photovoltaic
NPV	Net present value
IRR	Internal rate of return
LCC	Life cycle cost
ICC	Initial capital cost
MC	Maintenance cost

CHAPTER ONE

INTRODUCTION

1.1. BACKGROUND TO THE STUDY

This chapter discusses the importance of solar energy and how it is use to operate solar appliances, by definition, solar energy is that beaming light and heat that is generated from the sun. Solar power is used in a widespread of the ever so progressing technologies of the world. Solar electricity is the energy which is extracted by Sun using solar power plants. Sun is the richest source of energies like light and heat. Huge amount of energies are available for us to take and make big impact on our electricity requirements. The need for conserve solar energy and using it properly has led to the demand of solar energy related products and solar equipments. Solar power has been used as a traditional technology for centuries and is coming into widespread use where other power supplies are absent, such as in remote locations and in space. Humanity has been able to give good use to solar power due to advancement of technology. (Ayhan, 2012)

Solar power plays an important role in everyday life because it's currently used in a lot of applications like heat, electricity, and the desalination of seawater. The application of this type of power is spreading as the environmental costs and limited supply of other power sources such as fossil fuels are increasing. Many new technologies have been developed to make good use of solar energy. These technologies are classified as either direct or indirect, and passive or active.

In general, direct solar power involves a single transformation of sunlight into a useable energy, while indirect solar power involves multiple transformations of sunlight into useable energy. Passive solar systems use non-mechanical techniques of capturing, converting, and distributing sunlight to outputs such as heating, lighting, or ventilation systems. These techniques involve selecting materials with favorable thermal properties, designing spaces that naturally circulate air, and referencing the position of a building to the sun. In the other hand, Active solar systems use electrical and mechanical components such as photovoltaic panels, pumps, and fans to process sunlight into useable outputs.

Solar energy is a useful and abundant source of energy which can help to generate electricity without social conflicts and pollution. Solar equipments are capable of conserving photons into them which helps them to support the desired applications. There are many types and models of solar equipments in the global market. Solar energy is not only utilized by governments and industry to produce power but is of many uses to household. There is an array of solar equipments to be used in home. First of all, there are solar panels that are used to produce electric current. This electric current can be conserved in a battery for later use or use directly**.** However for the conversion of electric current to the usable energy like alternate current an inverter is used. This inverter turns the direct current into alternate current to support the functioning of electrical appliances. The basic purpose of domestic solar equipments is that the end users can also benefit from these free sources of energy and conserve the electricity produced by using fossils, hydro, thermal or other forms of energy sources. The design of solar equipments is really simple and small. Domestic solar equipments are adjusted according to the need of the home.(Solar Power Product, 2011).

1.2. STATEMENT OF PROBLEM

Rural electrification as well as the over dependence on hydro and thermal power is a major problem faced by past and current governments in Ghana, but one area many have not thought of is the need to look for other sources of energy such as solar. Solar energy products are becoming common these days and there is the need to adjust to the use of these modern technologies. There is a long list of solar equipments ranging from solar cookers, solar lights, solar lantern, solar lamps, solar water pump sand many more. The use of all these solar equipments does not put much pressure on your pocket once they are installed. It is against this backdrop that the designer is seeking to add to the existing ones solar operated blender to help improve the standard of rural dwellers in Ghana.

1.3. PURPOSE OF THE STUDY

The rising cost of electricity has led people to search for ways to cut costs relating to powering their homes and appliances, the free energy provided by the sun, makes the use of solar appliances a cost-effective way to offset your utility bills. Power from the sun is clean and infinitely renewable. It is in view of the above benefits that one can derive from the use of solar energy that the researcher is seeking to convert the existing electric blender to solar operated one to be used in communities without electricity. He will do this by trying to;

- Determine the correct type of DC motor to replace the existing AC motor in the electric blender.

- Find out if the amount of solar radiation in the 3 communities is good enough to power the D.C motor to operate a solar blender.
- Select the correct type and size of solar panel to produce the required power to operate the solar blender.
- Determine the viability and or otherwise of the design.
- Design a solar operated blender for use in the 3 communities in Upper East Region that have no electricity.

1.4. RESEARCH QUESTIONS

The primary objectives of the study is to come up with answers to the following questions and then to implement them and test their feasibility.

1. Can a DC motor be used in place of AC motor to power a blender?
2. Will the solar radiation in the three communities be good enough to operate a solar blender?
3. What will be the required solar panel to be used for the DC motor.
4. Will the design be viable?
5. Will the design be environmentally friendly?

1.5. SIGNIFICANCE OF THE STUDY

Solar panels are used to transform solar heat into electricity. Solar panels can be attached to the existing electricity grids or electric appliance for savings in electricity. Solar cookers and ovens can save a lot of electricity when used during cooking. The use and production of solar equipments is increasing as the world is shifting to alternative and renewable energy source and the use of solar appliances can save a lot of energy and make life easy for rural people who do not have access to electricity. In order to make the use of solar equipments common it is important to come out with more and simple solar appliances or try to convert the existing electrical appliances to solar appliance such as solar blender which will be of tremendous help to the rural people in Ghana and this would also help shift our next generation towards the desire of solar appliances.

1.6. DELIMITATION

Even though the Upper East Region has many second cycle schools where data could have been gathered from the major stake holders (teachers and students). However this study was narrowed down in scope due to financial and time constrains, it therefore confined itself to only three communities (Yorogo, Yipaala, and Vea).Thus for a more complete evaluation, the views of stake holders in the other communities may have to be surveyed.

1.7. LIMITATION

Due to the limitation of financial and time resources, the study was based on the accessible population of 3 communities without electricity. This procedure therefore decreases the generalization of the findings. The study will therefore not be generalized to all rural communities in the Upper East Region because it does not reflect the entire views of the rural communities without electricity.

1.8. ORGANISATION OF THE STUDY

This report comprised of five chapters. Chapter one deals with background to the study, statement of problem, research questions and the purpose of the study. Other aspects of the chapter are the significance of the study, delimitation and limitation of the study. Also in chapter one is the definition of terms. Chapter Two focuses on the review of related literature whiles the methodology is in Chapter Three. The chapter on the methodology talks about conceptual designs, D.C motor selection, cable sizing and economic analysis. In chapter four, results and discussion of the findings are presented. Finally, the Summary, conclusion and recommendation and suggestions for further research forms the concluding chapter of the report.

CHAPTER TWO

LITERATURE REVIEW

2.1. INTRODUCTION

In developing countries such as Ghana most of the rural people have no access to grid electricity. They have no alternative after sunset but to live in the dark and spend the night quietly. The introduction of Solar Photovoltaic provides a solution to brighten up the rural silent nights dramatically, thereby improving the quality of life of the people. A survey conducted in some communities revealed that Solar PV accessible to rural households, are not used to operate any appliances but for lighting only, and most of the PV systems are not working properly because of a high failure rate coupled with lack of after sales services. (Solar resources, 2011)

As stated in (United Nations, 2011) "the urban electrification growth in Africa reached 66.8% in 2008 while the rural electrification was stuck at 22.7 % the same year. It also stated that about 59.6% of Africans are estimated to live in sparsely populated rural areas and have access to energy but electricity still remains a major issue for the continent". The trend of renewable energies in the continent together with the inability of the people to pay for the use of the energy, as well as the non electrified rural communities has resulted in the use of other forms of energy like biomass for their cooking and heating needs, and this development if not checked could lead to the depleting of the forest. Another area to consider for the use of solar energy is financial relief that one can get from it. This can be seen in the area of your utility bills.

Statistically, in (solarpowernotes, 2012) it is stated that "the United States of Americans is known to be consuming 25% of the world's oil production on a daily basis. On the whole, the planet is being drained of its oil resources and the energy prices are only bound to go up. The only way to mend your own personal cost of energy is to go solar". Solar energy systems has high initial as well as installation and maintenance cost, but with the help from the government, coupled with the programs that are now available in Ghana to help in the installation costs. It will be prudent to use solar energy in rural communities which than to rely on other forms of energy.

According to (Energy Resuorces, 2013) ‘‘solar energy is the radiant light and heat from the sun. It is harnessed using a range of ever-evolving technologies such as solar heating, solar photo voltaic, solar thermal electricity, solar architecture and artificial photosynthesis’’ . But this solar energy when harnessed can be used in a variety of ways, some of the ways in which this solar energy is used includes: solar fan, solar phone charging and solar radio.

In 2011, according to (I.E.A, 2011), the International Energy Agency said that ‘‘the development of affordable, inexhaustible and clean solar energy technologies will have huge longer-term benefits. It will increase countries’ energy security through reliance on an indigenous, inexhaustible and mostly import-independent resource, enhance sustainability, reduce pollution, lower the costs of mitigating climate change, and keep fossil fuel prices lower than otherwise’’. It is in view of all this advantages that the use of solar energy as stated above is the researcher seeking to come out with, to help alleviate the suffering of the rural communities in Upper East Region who are not hooked to the national grid. The above advantages are worldwide, hence the additional costs of the incentives for early implementation should be considered.

According to (I.E.A, 2011)‘‘solar technologies are broadly characterized as either passive or active depending on the way they capture, convert and distribute sunlight. Active solar techniques use photovoltaic panels, pumps, and fans to convert sunlight into useful outputs. Passive solar techniques include selecting materials with favorable thermal properties, designing spaces that naturally circulate air, and referencing the position of a building to the Sun. Active solar technologies increase the supply of energy and are considered supply side technologies, while passive solar technologies reduce the need for alternate resources and are generally considered demand side technologies''.

In view of the above technologies the most appropriate technology that can be used for a solar operated blender which the researcher is seeking to design will be the photovoltaic panel which captures the sun's energy and convert it into useful energy such as electrical energy. "Solar power can also be obtained by converting the sunlight into electricity, either directly using photovoltaic's (PV), or indirectly using concentrated solar power (CSP).The CSP systems use lenses or mirrors and tracking systems to focus a large area of sunlight into a small beam. PV converts light into electric current using the photoelectric effect." (Duffie, J.A and Beckman, W.A, 1991).

Also according to (Alternative Energy, 2012) ''Pakistan is an energy deficient Country. Energy Crisis in the country is as a result of continuous negligence and mismanagement of the successive governments. Energy crisis has crippled economy of the county. In Pakistan, this crisis is increasing day by day and everyone is thinking of ways to resolve this crisis. Some have the view that it can be resolved by energy conservation and some have the view to increase the use of Alternate Energy and some have the view to generate electricity through Hydro and coal resources. Every strategy has its own merits and demerits.''

In Ghana the situation is not different as successive governments have not been able to solve the energy crisis that is facing the country. It is in line with this that the researcher is seeking to divert attention from the over dependence of hydro to other alternative energy sources such as solar by coming out with a solar appliance like the solar operated blender. The easiest way to solve the energy problems is to enhance the use of solar energy applications in rural communities that are far from the national Grid. There are many barriers in its growth like upfront costs because of taxes and duties, designing rights, awareness & quality standards which need attention of the Government. Alternate Energy sector cannot grow without Government commitment towards this.(Alternative Energy, 2012).

2.2. SOLAR PHOTOVOLTAIC AND IT'S APPLICATIONS

" Solar Photovoltaic is the technology by which solar energy is converted into electrical energy and its major applications in industrial and commercial sectors are; Solar Homes Systems up to 2000 W, Solar Lighting, Solar Power Plants from 10 KW to 20 MW, Solar Parks up to 20 MW, Solar UPS, Solar Roof Based On Grid Power Generation, Solar Traffic Signals Lights, Power for Remote Terminal Units, Power for Telecommunication Towers, Building Integrated Photovoltaic System, Military signaling applications, Solar water Pumping, Solar Lighting for Parking lots, Solar Lighting for Bus Stop Shelters etc.(Griffiths, 2012). He further elaborated that Solar Electric Power can be generated varying from 100 Watts small solar home systems to 100 MW Solar Power Plants or sometimes more than that. The solar power systems are of two types; one is off-grid and other is on-grid systems. In off-grid systems, the system has no link with Utility grid and components used in Systems are Solar Panels, Charge Controllers, Inverters, Deep Cycle Batteries, mounting and electrical accessories. Solar Panels convert solar radiations into electric current and this current passes through charge controllers which charges the battery by controlling current for the battery. Charge controllers maintain control on charging the battery for its long life. So the DC power is stored in Batteries and this stored energy is converted into AC Power to operate the AC appliances. The DC appliances can be operated directly with the battery. So DC and AC load can be operated through a solar power system. Un-professional and un-trained people in the market are selling under-designed and low quality systems as a result of which the customers are losing confidence in solar technology.(Griffiths, 2012). On the one hand, solar technology has high upfront costs, selling low quality and under-designed systems to cut down the costs. The most important thing in solar Power systems is its right design and using high quality system components which should guarantee faultless operation of the whole systems for 20 years. The other important thing for customers is that they should not buy system in watts but systems in watt-hours. For example 500W system can work for one hour and can work for 24 hours. If it generates power for one hour, the system capacity will be 500 Watt-Hour and if the system works for 24 hours, 12000 Watt-Hours (12 KWHR per day means 12 units per day). Now both systems are of 500 W but their operational hours vary. The cost of the system is calculated as per watt-hours, not as per watt, so customers should note that they buy their electrical energy in watts hours or Kilo Watts hours which is called the "Units" in common language, which is the real cost of electrical energy .

On-Grid system is that system which is connected with Utility Grid with built in two meters one is export meter and other one is import meter and in some case one bi-directional meter which reverses when electricity is sold to Grid and at the end, the user pays for the net meter reading. In two meters system, when energy is sold to Grid, the export meter counts and when energy is bought from grid, import meter counts the power consumption and user has to pay the net reading of both meters. User/power producer will be paid by the utility if utility has bought more and sold less" (Griffiths, 2012) .This system is becoming common in the world these days, and there is therefore the need to encourage people to use this type of technology in other to meet their energy needs or to reduce their electricity bills, Also since solar photovoltaic has many applications and if adopted for use in rural communities in Ghana and for that matter Upper East Region which has enough solar radiation could help reduce the poverty level in that part of the country.

2.3. METHODS OF GRINDING TOMATOES AND OTHER INGREDIENTS

Grinding means to crush, pulverized crush, pulverize, or reduce to powder by friction, especially by rubbing between two hard surfaces (Oxford dictionary, 2011). Also according to (Biological Samples, 2012)"Grinding refers to the disrupting of cells and tissues by applying a force. Force not inherent to the sample is considered a mechanical disruption method. Mechanical homogenization procedures generate lysates with characteristics different than those produced by chemical lyses. By avoiding detergents and chaotropes, many cytosolic proteins may remain intact following liberation from the cell. This is useful for protein isolation and enzyme assays. However, mechanical homogenization may simply be the tool used to rapidly disrupt cells and tissues with the use of denaturing reagents. Regardless of the mechanical approach, whether it is to beat, grind, shear, or explode cells, there are tools that can be applied in many different ways to sample preparation. The methods used for sample disruption have been divided into four groups: grinding, shearing, beating, and shocking. Many engineers may cringe by this delineation, but we are approaching the topic practically. Foremost, it must be highlighted that many methods make use of more than one force, as with conical homogenizers which grind and shear. Additionally, there are many tools and methods which are discussed below;

2.3.1. Hammer mills

Hammer mills are mostly impact grinders with swinging or stationary steel bars forcing ingredients against a circular screen or solid serrated section designated as a striking plate. Material is held in the grinding chamber until it is reduced to the size of the openings in the screen. The number of hammers on a rotating shaft, their size, arrangement, and sharpness, the speed of rotation, wear patterns, and clearance at the tip relative to the screen or striking plate are important variables in grinding capacity and the appearance of the product. Heat imparted to the material, due to the work of grinding, is related to the time it is held within the chamber and the air flow characteristics. Impact grinding is most efficient with dry, low-fat ingredients, although many other materials may be reduced in size by proper screen selection and regulated intake. Most hammer mills have a horizontal drive shaft which suspends vertical hammers but for some ingredients, such as dried animal byproducts, a "vertical" hammer mill is more efficient. In this mill, the drive shaft is positioned vertically and screens and hammers are positioned horizontally. Material successfully reduced in size to the diameter of screen holes or smaller, is carried by gravity outside the mill and thence by air or conveyor to storage in "make-up" bins. Over-size particles, not easily broken, drop through the mill and may be re-cycled or discarded. Thus foreign materials, such as metal and stones, are discharged before they are forced through the screen causing damage.

2.3.2. Cutters.

Rotary cutters are a type of grinder which reduces dry particle solids mainly by shearing with knife edges against a striking plate. The mill also includes the processes of attrition and impact, although these actions are limited if the material is easily reduced by cutting and the screen limiting discharge has large perforations. The mill consists of a rotating shaft with four attached parallel knives and a screen occupying one fourth of the 360 degree rotation. The mill is best used to crack whole grains with a minimum of "fines". It is not used as a final process for reducing the size of ingredients used in fish feeds.

2.3.3. Grinding Stone.

The grinding stone consist of a large flat stone and a small round one. The round one is placed on top of the large one and the ingredients to be grind are forced between the two by pushing the small round stone to and fro on the surface of the large flat stone.

Figure 2.1: The grinding stone

2.3.4. Mortar and Pestle

The mortar is a bowl, typically made of hard wood, ceramic or stone. The pestle is a heavy club-shaped object, the end of which is used for crushing and grinding. The substance to be ground is placed in the mortar and ground, crushed or mixed with the pestle. Mortars and pestles have been used in cooking up to the present day; they are frequently also associated with the profession of pharmacy due to their historical use in preparing medicines. They can also be used in masonry and in other types of construction.

Figure 2.2: Mortar and Pestle.

2.3.5Blenders

A blender is a kitchen appliance used to blend ingredients or puree food. The term typically refers to a stationary, upright electrical device, which is to be distinguished from a hand-powered or electric mixer that may be used for similar purposes. A typical blender is built around a vessel for the ingredients to be blended. At the top of the vessel is a cap to prevent ingredients from escaping when the blender is switched on. At the bottom is a blade assembly, typically removable for cleaning purposes. The bottom seal is most likely watertight. The vessel rests upon a base containing a motor (for turning the blade assembly) with controls on its surface. Most modern blenders offer a number of possible speeds. (Wildi, 2005)

Of all the methods used for grinding ingredients that are stated above, a survey conducted by the researcher revealed that the only method available in the three communities is the use of the grinding stone and the mortar and pestle.

2.4. ELECTRIC MOTORS:

An electric motor is an electric machine that converts electrical energy into mechanical energy. They are broadly classified into two categories as AC Motors and DC Motors.

An AC motor is an electric motor driven by an alternating current (AC). It commonly consists of two basic parts, an outside stationary stator having coils supplied with alternating current to produce a rotating magnetic field, and an inside rotor attached to the output shaft that is given a torque by the rotating field. There are two main types of AC motors, depending on the type of rotor used. They are the induction (Asynchronous) motor and the Synchronous motor.

2.4.1. The Induction Motor:

An induction motor has two main parts, namely the stator and the rotor. The Stator is the immobile part of the motor. It is made from cast iron or a light alloyand houses a ring of thin silicon steel plates (around 0.5mm thick). The plates are insulated from each other by oxidation or an insulating varnish. The “lamination” of the magnetic circuit reduces losses by hysteresis and eddy currents. The plates have notches for the stator windings that will produce the rotating field to fit into three windings for a 3-phase motor.

The Rotor on the other hand is the mobile part of the motor. Like the magnetic circuit of the stator, it consists of stacked plates insulated from each other and forming a cylinder keyed to the motor shaft. The two types of rotors are the Squirrel-Cage Rotor; which consists of thick conducting bars embedded in parallel slots. These bars are short-circuited at both ends by means of short-circuiting rings, and Wound Rotor; which has a three-phase, double-layer, distributed winding. It is wound for as many poles as the stator. The stator operates in the following ways:

- The stator is usually connected to the grid and, thus, the stator is magnetized.
- Stator magnetic field cuts the rotor windings and produces an induced voltage in the rotor windings.
- Due to the fact that the rotor windings are short circuited, for both squirrel cage and wound-rotor, and induced current flows in the rotor windings.
- The rotor current produces another magnetic field.
- A torque is produced as a result of the interaction of those two magnetic fields.

The difference between the synchronous speed (Ns) and the shading ring speed (N) is called slip and is expressed as a percentage of the synchronous speed.

S= (Nsyn – Nm) / Nsyn

Where s is the slip. Slip is one of the most important variables in the control and operation of induction machines.

s= 0: if the rotor runs at synchronous speed.

s = 1: if the rotor is stationary.

s is –ve : if the rotor runs at a speed above the synchronous speed.

s is +ve : if the rotor runs at a speed below the synchronous speed.

A driving torque can only exist if there is an induced current in the shading ring. It is determined by the current in the ring and can only exist if there is a flux variation in the ring. Therefore, there must be a difference in speed in the shading ring and the rotating field. This is why an electric motor operating to the principle described above is called an “induction motor”.

2.4.2. Synchronous electric motor

These motors have the rotor rotating at the same speed as the speed of rotation of the stator current. In other words, we can say these motors don't have slip with respect to the stator current. They are sometimes used not to drive the load but instead act as "synchronous condenser", to improve the power factor of the local grid to which it is connected to. These kinds of motors are used even in high precision positioning devices like modern robots. They can also act as stepper motors.Normally its construction is almost similar to that of a 3 phase induction motor, except that the rotor is given DC supply, the reason of which is explained later. Now, let us first go through the basic construction of this type of motor.

Synchronous motor having no load connected to its shaft is used for power factor improvement. Owing to its characteristics to behave at any electrical power factor, it is used in power system in situations where static capacitors are expensive.Synchronous motor finds application where operating speed is less (around 500 rpm) and high power is required. For power requirement from 35 kW to 2500 KW, the size, weight and cost of the corresponding three phase induction motor is very high. Hence these motors are preferably used. Ex- Reciprocating pump, compressor, rolling mills etc. (Krause Paul, C, and Wasynczuk, O, 1989)

2.5. THE BLENDER MOTORS

The type of motors used for electric blender is the single phase induction motors. This type of motor has one stator winding, operate with a single-phase power supply, have a squirrel cage rotor, and require a device to get the motor started. This is by far the most common type of motor used in household appliances, such as fans, washing machines and clothes dryers, and for applications for up to 3 to 4 horsepower, (2.2Kw to 3Kw). Single phase induction motors comes with a wound rotor which has excellent starting and accelerating characteristics, and they are ideal for various domestic applications. Some common types of single phase induction motor is shown in Figure 2.3

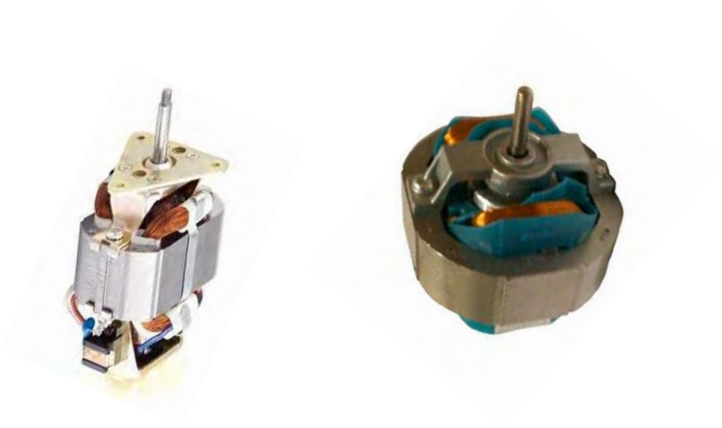

Figure 2.3: Single phase Induction Motor. Source: Searspartdirect, 2011

In view of the above description of the single phase AC motor, the researcher is seeking to replace the single phase AC motor with a DC motor that will perform the same function so it could be used in areas without electricity. For the purpose of this research greater emphases will be made on the induction motor.A typical electric blender motor is shown in figure 2.4.

Figure 2.4: Single phaseAC induction motor for electric blender.

Table 2.1 Blender motor specification:

Model: UM 3470 (GL7620A230)

Voltage	**220 / 240 volts**
Frequency	50 /60 Hz
Power	500 W
Speed	2500 rpm
Torque	2 Nm

CHAPTER THREE

METHODOLOGY

3.1 INTRODUCTION

Methodology is the systematic, theoretical analysis of the methods used to realize the design of study; it typically, encompasses concepts such as paradigm, theoretical model, phases and quantitative or qualitative techniques. A methodology does not set out to provide solutions but offers the theoretical underpinning for understanding which method, set of methods or so called "best practices" can be applied to a specific case.In view of this, a survey was conducted in three communities in Bolgatanga. (Yorogo, Yipaala, and Vea) and it was observed that the absence of electricity in these communities has compounded the problems of house wives and other traditional caterer as they have no other options than to grind their tomatoes and other ingredients manually.

The target population of the three communities (Yorogo, Yipaala, and Vea) that have no electricity is 1,150 people representing 20 % of the total population in which majority of them are women, who are either house wives or traditional caterers who prepare food for their families or who sell food within the communities.

3.2. CONCEPTUAL DESIGNS

Conceptual design is a type of art which gives precedence to hypothetical function; it is the creation and exploration of new ideas.A review of the literature and an analysis of studies on the design and the use of solar operated blender showed that most of the people used in the survey will enjoy using the device if they get it. In view of this a conceptual design was developed in other to find a suitable solution to the research problem. Two of such conceptual designs (conceptual design A and conceptual design B) can be found in appendix A and B.

Table 3.1: Design Criteria Values of Solar Operated blender

Design criteria	DESIGN A	DESIGN B
Customer	25 kwh	20kwh
Aesthetics	5	8
Environment	20 years	25 years
Safety	8	10
Ergonomics	8	8
Quality	5	7

Table 3.2: **Desirable ranges of each criterium**

Design criteria	Questions to spark ideas	Design 1	Design 2
Customer	Who is the product intended for?	3	5
Aesthetics	What appealing features would it have?	4	7
Environment	How will the product relate to the environment – recycling parts, the manufacturing process	3	3
Safety	How will you ensure that the product is safe?	4	5
Ergonomics	How will the product relate to people's size, shape etc?	3	5
Quality	What design and manufacturing features will ensure a quality product?	4	5

Table 3.3: Evaluation of result of each design

	Design A	Design B
Total Score	92	108
Rank	2	1

Selection of the best alternative.

Considering the two designs taking into account the criterium assigned to each, design B has the highest score and therefore design B is selected

3.3. DETERMINATION OF SOLAR ENERGY INCIDENT ON A SURFACE.

Solar radiation is the amount of radiant energy emitted by the sun, which is electromagnetic energy. The amount of solar radiation on a horizontal surface in Bolgatanga using Ret Screen is as shown in the Table 3.2. According to (Modern Ghana, 2012) Bolgatanga lies at latitude 10.8 º N and longitude – 0.9 º E.The land is relatively flat with a few hills. The natural vegetation is that of the savannah woodland characterized by short scattered drought-resistant trees and grass.

TABLE 3.4:Amount of solar radiation on a horizontal surface in Bolgatanga

MONTH	DAILY SOLAR RADIATION (Kwh/m^2/day)
January	5.72
February	5.96
March	6.11
April	6.06
May	5.82
June	5.32
July	4.88
August	**4.61**
September	4.95
October	5.58
November	5.56
December	

(Retscreen, 2012)

In other to size the P.V module, the solar radiation for the month of August which has a value of 4.61 Kwh/m2/dayfrom table 3.4, and is the worst month of solar radiation was used as a reference for the P.V module sizing, also the global irradiance on a tilted surface on earth consists of three components namely; direct irradiance (I, dir) , diffuse irradiance (I, dif) and the reflected irradiance (I ref),and varies throughout the day, depending on the position of the sun in the sky, and the condition of the weather so a south facing position of the solar module was used to ensure that maximum solar energy is obtained.

3.4. DETERMINATION OF PEAK SUN HOUR (PSH)

Peak Sun Hours (PSH) is the total number of hours per day in which solar irradiance averages 1000 w/m². It describes an accumulated irradiance for a period of time usually one hour. In general, the more peak sun hours available, the more watts are produced from a solar module.(Ecowho, 2011).

A peak sun hours of 1.28 Kwh/m^2 as shown in appendix F was used to determined the sun exposure in other to select the most appropriate photovoltaic module for the design.

This means that the radiation will have to stay at the rate of 1 kW/m^2 for 1.28 hours.

Now, readings of the site's irradiance levels for one day from 6 am till 5 pm was taken and got a result of 5 peak sun hours (5 PSH), this would mean that, the energy received for the whole day will equals the energy that would be received had the irradiance for 5 hours been 1 kW/m^2 is shown in figure 3, 1.

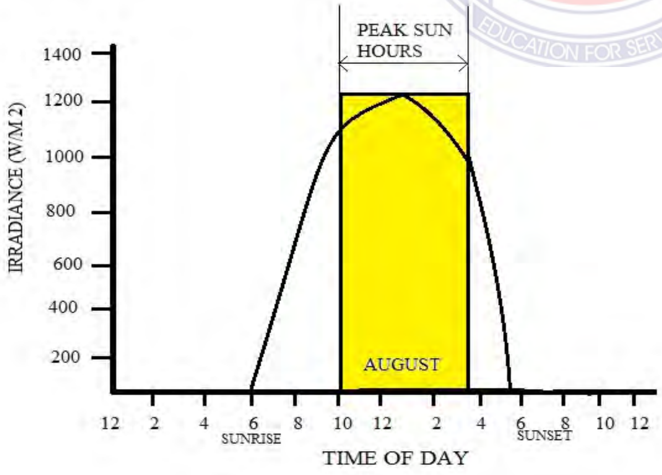

Figure 3.1: Graph showing the periods of peak sun hours.

3.5. D.C MOTOR SELECTION

A direct current (DC) motor is a fairly simple electric motor that uses electricity and amagnetic field to produce torque, which causes it to turn; it requires two magnets of opposite polarity and an electric coil, which acts as an electromagnet. The repellent and attractive electromagnetic forces of the magnets provide the torque that causes the motor to turn.DC motors can be used in areas where there is no electricity and for a variety of purposes. Their simple design and reliability makes them a good choice for many different uses. (Wisegeek, 2012)

It is as a result of these advantages of a DC motor that as a researcher I have tried to incorporate the DC motor with a solar panel to power a solar blender to be used in communities without electricity.

3.5.1: Types of DC Motors.

The two types of DC motors are the Brush DC motors (BDC) and the Brushless DC motors (BLDC). A brushed DC motor (BDC) is an internally commutated electric motor designed to be ran from a direct current power source. Brushed DC (BDC) motors are inexpensive, easy to drive, and are readily available in all sizes and shapes. The different types of BDC motors are distinguished by the construction of the stator or the way the electromagnetic windings are connected to the power source.

3.5.2. BrushlessDC Electric Motor (BLDC Motors, BL Motors).

Brushless DC electric motor (BLDC motors, BL motors) also known as electronically commutated motors (ECMs, EC motors) are synchronous motors that are powered by a DC electric source. A typical brushless motor has permanent magnets which rotate around a fixed armature, eliminating problems associated with connecting current to the moving armature.

Brushless motors offer several advantages over brushed DC motors, including more torque per weight, more torque per watt, increased reliability, reduced noise and longer lifetime. When converting electricity into mechanical power, brushless motors are more efficient than brushed motors. This improvement is largely due to the brushless motor's velocity being determined by the frequency at which the electricity is switched, not the voltage. Brushless motors are ideally suited for manufacturing applications because of their high power density, good speed-torque characteristics, high efficiency and wide speed ranges and low maintenance.(Electrical Know How, 2012)

As a result of the above characteristic of the brushless DC motor the designer researched and has come out with a brushless DC motor which has similar features as the Electric blender motor to be used for the solar blender.

Figure 3.2: Sample DC motors recommended for the solar blender

Table 3.3: Specification of the DC motor.

Type: BLDC (Brushless DC Motor)

Model Number: DSCN0276

Rated Voltage	**24 volts**
Rated current	31.25 A
Rated Power	750 W
Rated Speed	3000 rpm

(Globalsource, 2012)

3.5.3. Determination of the motor torque:

Torque is the force that produces rotation. Itconsists of force acting at a distance. Torque, like work, is measured in Newton meter (N.m). However, torque, unlike work, may exist even though no movement occurs.

Torque is calculated as:

Torque (Nm) = Force (N)x Distance (m)

Full-load torque is the torque to produce the rated power at full speed of the motor. The amount of torque a motor produces at rated power and full speed can be found by using a horsepower-to-torque conversion chart. When using the conversion chart, place a straight edge along the two known quantities and read the unknown quantity on the third line.

To calculate motor full-load torque, apply this formula:

$$T = \frac{[Px\ 5252]}{rpm}. \qquad (3.1)$$

Where;

T = torque (N.m)

P = power = 750 W

5252 = constant

rpm = revolutions per minute.

For a DC motor rotating at 3000 rpm and having a power of 750 W will have a torque of 1.5 Nm as shown in appendix F, which is equal to an AC motor rotating at 2500 rpm and having a power of 500W.

(This indicates that the DC motor will work the same way as the AC motor in the electric blender, .hence the lower the speed the higher the torque and vice visa.).

3.6. CABLE SIZING

Solar panels use low voltage DC wiring and connectors that are able to carry high currents, thicker cable should therefore be used for long runs to minimize voltage drop.To determine the suitable size of cable for the solar panel wiring, we must determine:

We know that all conductors and cables (except Super conductor) have some amount of resistance, this resistance is directly proportional to the length and inversely proportional to the diameter of conductor$R \propto L/d$

[Laws of resistance $R = \rho\ (L/d)$]. ……….. (3.2)

Whenever current flows through a conductor, a voltage drop occurs in that conductor.

According to (IEEE Rule B–23, 2013) at any point between power supply terminal and installation, voltage drop should not exceed 2.5% of supply voltage and that of sub circuit and final sub circuit should be half of the allowable voltage drop.

Therefore since our supply voltage is 24 V, the value of allowable voltage drop should be;

Allowable Voltage Drop = 24 x (2.5/100) = 0.6 mV, and that of sub circuit and final sub circuit allowable voltage drops is 0.3 mV (i.e. 0.5 of 0.6 mV).

3.6.1 Determination of the actual Cable size;

For the wiring of the solar blender, (from solar panel to the blender motor), the following condition were considered;

Load of 0.75 kW = 750 W

Total length of cable (from solar panel to blender motor) is assumed to be5 meters.

Supply voltage = 24V

Ambient temperature is assumed to be 40°C.

Additional load of 2% as shown in appendix F = 15 W

Total Load of 765 and a total Current (I) = 32 A(in appendix F)

Therefore to select the size of cable for load current of 32 A(from Table 3.4) the nearest value is 7/1.04 (31 Amperes), it means we can use 7/ 1.04 cable according table 3.4.

Table 3.4: Current rating of copper cables

Current carrying Capacity (in Amp)	**Number of wires and Thickness of each wire**	**Area (in mm^2)**
11	1 / 1.13	1
13	1 / 1.38	1.5
18	1 / 1.78	2.5
24	7 / 0.85	4
31	**7 / 1.04**	**6**
42	7 / 1.35	10
56	7 / 1.70	16
73	7 / 2.14	25
90	19 / i.53	35
145	19 / 1.78	50
185	19 / 2.14	70
230	19 / 2.52	95

Next check the selected cable (7/ 1.04) with temperature factor in table 3.5, the temperature factor of 0.94 at 40 °C corresponds to a current carrying capacity of 31A, therefore current carrying capacity of this cable at 40°C would be determined as;

Current rating (at 40°C) = 29.14 Amp. (Refer to appendix F)

Since the calculated value (29.14 Amp) at 40°C is less than that of current carrying capacity of (7/1.04) cable which is 31A, this size of cable (7/1.04) is suitable with respect to the ambient temperature.

Table 3.5: Temperature factor

Temp Factor	**1.02**	**1**	**0.93**	0.94	**0.91**	**0.88**	**0.77**	**0.63**
Temp °C	25	30	35	**40**	45	50	55	60

Finally find the voltage drop for per ampere meter for this cable. From table 3.6, the voltage drop is 7mV, but in our case, the length of cable is 5 meter. Therefore, the actual voltage drop for 5 meter cable would be:

Actual Voltage drop (for 5 meter) = Voltage drop (mV) x Current carrying capacity at 40 °C (I) x Length of cable (m) = mV x I x L = 1 mV. (Refer to appendix F)

Table 3.6: Cable Size, Current rating with Voltage drop

Single Phase one Cable (AC / DC)

Current rating (Amp)	**Voltage drop (mVolts)**	**Number and Diameter of wires (mm)**	**Cross sectional Area (mm^2)**
11	41	1 / 1.13	1
13	28	1 / 1.38	1.5
18	17	1 / 1.78	2.5
24	11	7 / 0.85	4
31	**7**	**7 / 1.04**	**6**
40	4.1	7 / 1.35	10
53	2.6	7 / 1.70	16
60	1.7	7 / 2.14	25
74	1.2	19 / 1.53	35

Since this drop is almost equal to that of maximum allowable voltage drops of 0.9mV this cable is the most appropriate and suitable cable size to use.(Electrical Technology, 2013)

3.6.2: Cable Specification

The selected cable to use for the design has the following specification

Length of Cable (L) = 5 m

Cross Sectional area (A) = $6mm^2$

Material = copper

3.7. SOLAR PANEL SELECTION:

The following pre-requisite information is required in other to select the appropriate solar panel for the design:

- Loads required to be supported by the solar PV system
- Autonomy time or minimum tolerable downtime (i.e. if there is no sun, how long can the system be out of service?)
- Measurements of the solar irradiation at the site
- Output voltage. (DC)

The calculation is based on AS/NZS 4509.2 (2002) "Standalone power systems - System design guidelines". Which has the following six steps?

- Step 1: Estimate the solar irradiation available at the site (based on GPS coordinates or measurement)
- Step 2: Collect the loads that will be supported by the system
- Step 3: Calculate design load and design energy
- Step 4: Calculate the required battery capacity based on the design loads
- Step 5: Estimate the output of a single PV module at the proposed site location
- Step 6: Calculate the size of the PV array

Estimate Solar Irradiation at the Site

We will estimate the solar radiation available at the site based on data collected from ret screen which is 4.61 Kwh/m^2/day as shown in table 3.2

The Loads of the System

The type of load that the solar panel needs to support is the solar blender motor which has a power of 750 W.

Design load and Design energy determination

The consumed apparent power of the loads (in watts), is calculated as follows:

$$Sl = \frac{Pl}{\cos\emptyset \ \mathrm{x}\ \eta}$$

Where;

Sl is the consumed apparent power (w)

$Pl$is the actual load (W) = 750 W

Cosø is the load power factor (pf) = 0.85

η is the load efficiency = 75 %

Therefore;

Sl= 1000 watts

3.7.1: Design Load Demand

The design load is the instantaneous load for which the power conversion, distribution and protection devices should be rated. It is calculated as follows:

$$S_d = S_p\,(1 + K_g)\,(1 + K_c) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (3.4)$$

Where

$S_d$is the design load (w)

$S_p$is the peak load = 765 w (from cable sizing)

K_g is a contingency for future load growth = 2% of 765 = 15 w

K_c is a design margin (for inaccuracies in load estimation) = 3% of 765 = 23 w.

3.7.2: Design Energy Demand

The design energy demand is used for sizing energy storage devices such as the battery; the total energy (in terms of Kwh) is calculated by assuming 2 hours operational time for the blender. It is calculated as follows;

$$E_d = E_t\,(1 + K_g)\,(1 + K_c) \quad \ldots\ldots\ldots\ldots\ldots \quad (3.5)$$

Where;

E_d is the design energy demand (Kwh)

E_t is the total load energy, = 0.765 Kw x 2 = 1.53 Kwh

K_g is a contingency for future load growth as defined above (%)

K_c is a design contingency as defined above (%)

Step 4: Calculate the required battery capacity based on the design loads.

Vented lead acid battery with the following specification is assumed;

Nominal battery voltage (V_{dc}) = 24 V,

Cell charging voltage (V_c) = 2 V/ cell,

End-of-discharge voltage (V_{eod}) = 1.8 V/cell

Maximum load voltage tolerances are ($V_{l,max}$) = 20%

The minimum load voltage tolerances ($V_{l,min}$) = 10%

Therefore;

The maximum number of cells in series (N_{max}) was determined using the relation

$$N_{max} = \frac{V_{dc}\,(1 + V_{Lmax})}{V_c}$$

and was found to be i4 cell as stated in appendix F whiles the minimum number of cells in series was also found to be 12 cells using the relation below

$$N_{min} = \frac{V_{dc}\ (1 - V_{lmin})}{V_{eod}}$$

Therefore the selected number of cells in series is 13 cells.

Now given a depth of discharge k_{dod} = 80%, battery ageing factor k_a = 25%, temperature correction factor for vented cells at 30 deg C of k_t = 0.956 and a capacity rating factor of k_c = 10%, the minimum battery capacity (C_{min}): was determined from the formular;

$$C_{min} = \frac{E_d \times K_a \times K_c \times K_t}{V_{dc} \times K_{dod}} \quad \text{……….…………. …..} \quad (3.6)$$

Step 5: Estimate a Single PV Module's Output

A PV module with the following characteristics is chosen:

- Peak module power (p_{peak}) = 270 w
- Nominal voltage (V_{dc}) = 36.65 v
- Solar PV Standard temperature (T_{stc}) = 25 ºC
- Manufacturer's power output tolerance(T_t) = 5 %

If we assume that the average ambient temperature (T_{amb}) is 40 ºC. Then the effective PV cell temperature (T_{pv}) = $T_{amb} + T_{stc}$

Given a medium dirt reduction factor (f_{dirt}) of 0.97, the power output of the solar P.V (P_{panel}) will be:

$$P_{panel} = P_{peak} \times T_{stc} \times T_t \times f_{dirt} \quad \text{……………….………..} \quad (3.7)$$

Step 6: Number of solar PV panels needed to power the DC motor is 2 and was determined by given an oversupply coefficient (f_o) of 4 and a PV sub-system efficiency of 85%, the number(N) of PV modules required is ;

$$N = \frac{Ed \times fo}{P\,(panel) \times Radiation \times \eta\,(pv)} \quad \text{…………………………} \quad (3.8)$$

Therefore the design will need two solar models with the following specification

Table3.7: Solar panel specification of 270W polycrystalline solar modules.

Model number: CNSDPV-270P

Rated maximum power(P)	**270 W**
Open circuit voltage (Voc)	44.50 V
Short circuit current (Isc)	8.28 A
Maximum power voltage (Vmp)	36.65 V
Maximum power current (Imp)	7.64A
Cell efficiency (%)	14.74
Solar cell and configuration	72 cells 6*12 crystalline solar cell (156*156)
Dimension	1940*996*50 mm
Weight	8kg
Operating temperature	40°C

3.8 CONSTRUCTION OF THE BLENDER.

The A,C motor of the electric blender will be removed and replaced with a D.C motor whose specifications is in Table 3.3, and then connected to the solar panel using the size of cable shown in (3.2.6). The base of the blender which is the mechanical heart of the unit houses the DC motor as well as the switch. The blade of the blender is attached to the motor shaft with a screw to ensure it stays in place. The individual components of the solar blender are assembled together and then connected to the solar panel. When the sun rays falls on the solar panel, it produces a direct current which causes the DC motor to operate when the switch is turn on thereby causing the blade to rotate for the blender to work.

3.8.1. FINAL DESIGN OF THE SOLAR BLENDER

The final design of the solar operated blender showing the solar panel and how it will be connected to the DC motor which is housed in the base of the blender.

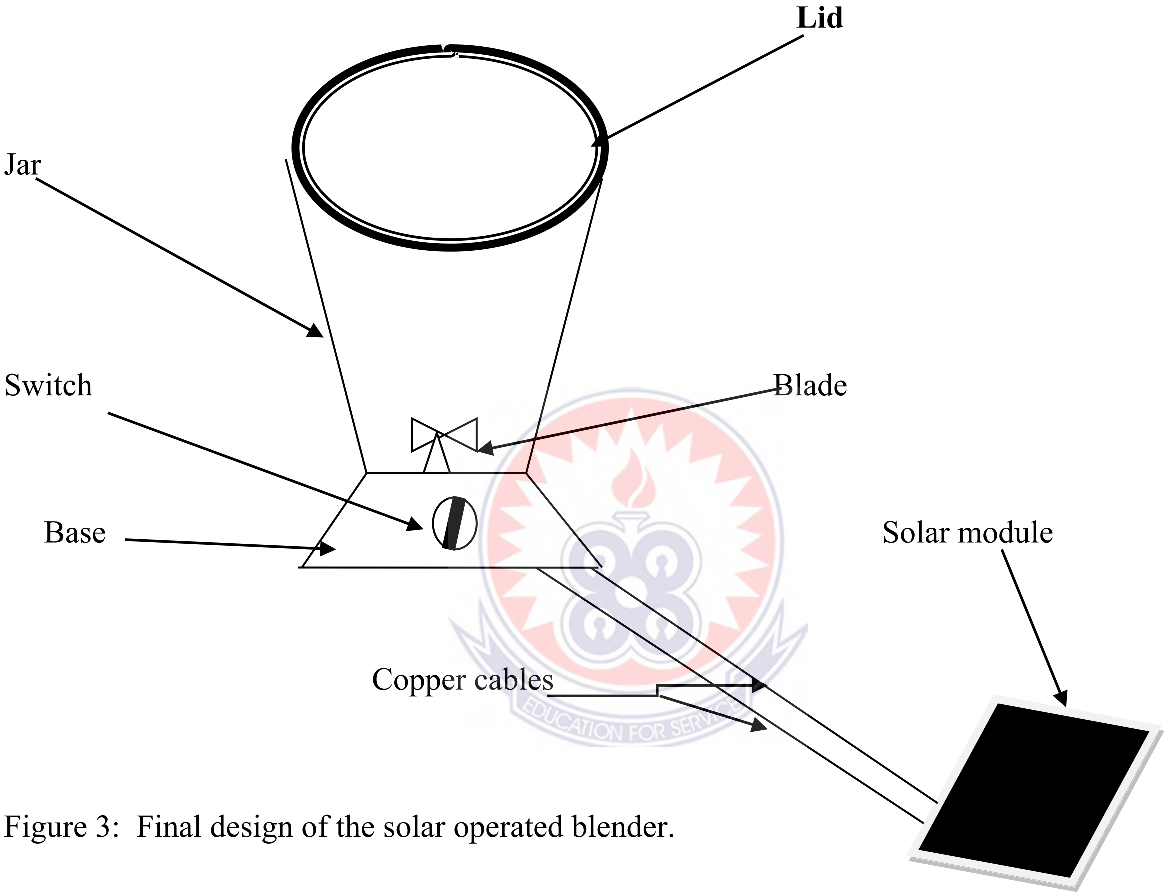

Figure 3: Final design of the solar operated blender.

3.9. ECONOMIC ANALYSIS OF THE SOLAR BLENDER.

Economic analysis is defined as the monetary evaluation of alternatives for meeting a given objectives and this evaluation is based on a comparison of discounted costs and benefits over a fixed time period of time. (WBDG, 2011). Everybody has the problem of allocating limited resources such as capital and other natural resources to a variety of different uses such as production of consumer goods with an aim to reach a more fundamental goal of reducing poverty and increasing income. Given limited resources, choices have to be made between alternative uses of these resources such that greater benefit is achieved. It is against this that the researcher tries to see if the solar blender is viable or not. The economic analysis of the solar blender will be pivoted around the following economic indicators which\h were used to assess the viability of the solar operated blender;

- The simple Payback period (SPB)
- Net Present value (NPV)
- Internal Rate of Return (IRR)

. 3.9.1. Simple Payback Period

Simple payback period is the time in which the initial cash outflow of a project is expected to be recovered from the cash inflows generated by the project. If the payback period is less than the target payback then theproject should be accepted.

The formula for calculating simple payback is;

$$\text{Payback} = \frac{\text{Initial investment}}{\text{Cash inflow per period}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (3.9)$$

3.9.2. Net Present Value (NPV)

Net present value, (NPV), is use to evaluate the potential profitability of a design or project. NPV expresses the total value of the design, in its current value, based on its estimated future cash flows and its initial cost. The NPV is used to determine whether the design should be accepted or not. If the NPV is positive then it suggests that the investment is profitable and should be accepted. The formula for calculating the NPV is:

$$\text{NPV} = \text{Future Cash Flow} / (1 + \text{Required Rate of Return})^{n} \quad \ldots\ldots\ldots\ldots\ldots \quad (3.\ 10)$$

Where n is the number of Years You Have to wait for the Cash Flow

3.9.3. Internal Rate of Return (IRR)

Internal rate of return (IRR) is the interest rate at which the net present value (NPV) of all the cash flows (both positive and negative) from the design will equal zero. IRR is used to evaluate the attractiveness of a project or design. If the IRR of the design exceeds the required rate of return, then the design is desirable. If IRR falls below the required rate of return, then the design should be rejected..

The formula for *IRR* is:

$$0 = P0 + \frac{P1}{(1+IRR)} + \frac{P2}{(1+(IRR)2} + \frac{P3}{(1+IRR)3} + \ldots . \frac{Pn}{(1+IRR)n} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(3.11)}$$

Where;

P0, P_1 . . .Pn equals the cash flows in periods 1, 2 . . . n, respectively; and IRR is the project's internal rate of return.

3.9.4. Life Cycle Cost (LCC)

Life-cycle cost (LCC) refers to the total cost of ownership over the life of an asset. It is normally referred to as "cradle to grave" or "womb to tomb" costs. The Costs considered in LCC include the financial cost, environmental and social. Typical areas of expenditure which are included in calculating the whole-life cost include, planning, design, construction and acquisition, operations, maintenance, renewal and rehabilitation, depreciation and cost of finance and replacement or disposal. In our case only the planning, design and acquisition, operations, maintenance, depreciation and cost of finance and replacement or disposal will be considered.

The life cycle cost of an asset is expressed as;

Life Cycle Cost (LCC) = Initial capital costs (ICC) + projected life-time operating costs (OC) + projected life-time maintenance costs (MC) + projected disposal costs (DC) - projected residual value . ……………………… ……………………. (3.12)

3.9.5. Daily operational hours.

The daily operational hours of the solar blender was determined by observing the number of hours the appliance runs continuously in a day. It also considers the period of the intermittent on and off and sum all the active periods. Table 3.8 in appendix F shows the daily operational hours carried out in the three communities.

CHAPTER FOUR

RESULTS AND DISCUSSIONS

4.1. THE DC MOTOR

The DC motor selected has a rated voltage of 24 volts, rated power of 750 watts and run at a speed of 3000rpm. The output torque at this speed is 2 nm which is similar to the AC motor used in electric blender. Since the motor has similar specification as the AC motor it will be able to perform the task in much the same way as the AC motor in the electric blender.

4.2. THE SOLAR PANEL

The solar panel (270 w polycrystalline, model CNSDP – 270P) is selected for the solar blender. It has a maximum operating power of 270 watts whiles the power required by the DC motor for effective operation of the blender is 750 watts. It is therefore important to note that in other for the solar panel to produce the required power to operate the DC motor; two solar panels of the same specifications will be required to be connected in parallel to produce the required power to meet the demand of the DC motor.

4.3. AMOUNT OF SOLAR RADIATION ON SITE

The data taken for the performance of the Solar Blender were at three different sites that is Yorogo, Yipaala and Vea communities. The data were taken in August which according to (Retscreen, 2012) has the lowers solar radiation in Upper East Region. The data were taken for three weeks and the daily solar radiation were recorded. Table 4.2 in appendix C shows the three weeks data taken at the three sites. From Figure 4.3 drawn from Table 4.2, it can be seen that the average solar radiation for the three communities was high in the afternoon (between 11.00 and 15.00 GMT) than in the morning and evening and this indicate that there were enough solar energy during those periods to power the solar blender.

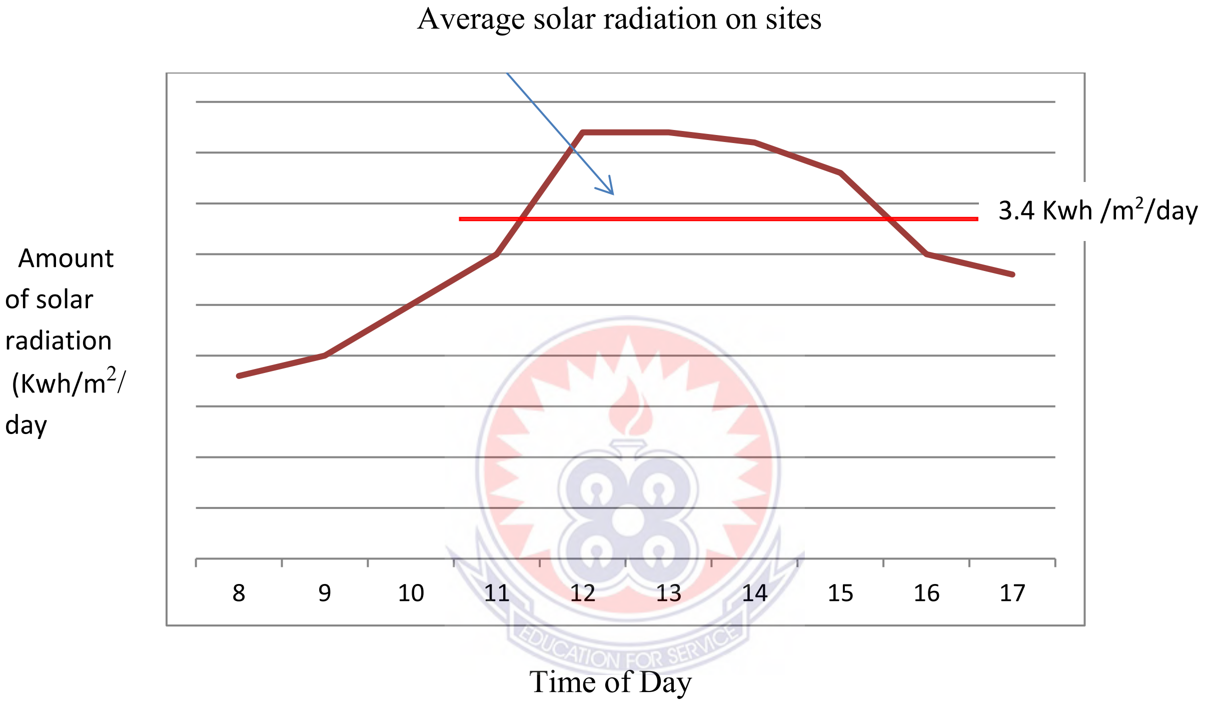

Figure 4.1. Average solar radiation recorded at Yorogo.

4.4. DAILY OPERATIONAL HOURS.

Various deductions were made from the analysis of the data to ascertain the operational period of the blender. In view of this the blender was made to run for 10 hours, and out of the 10 hours observed, the blender received 6 hours of continuous sun lights (9am – 3pm) which represented 60% of the total time of the day to power the solar blender for its operation (Albeit cloud cover)

4.5. POWER PRODUCED BY THE PANEL.

From Figure 4.3, it was realized that the solar energy was high in the afternoon than in the morning and evening in the three communities, thereby resulting in higher power produced in the afternoon by the solar module in all the sites. Figure 4.5 shows the power produced by the solar module during the peak sun hours.

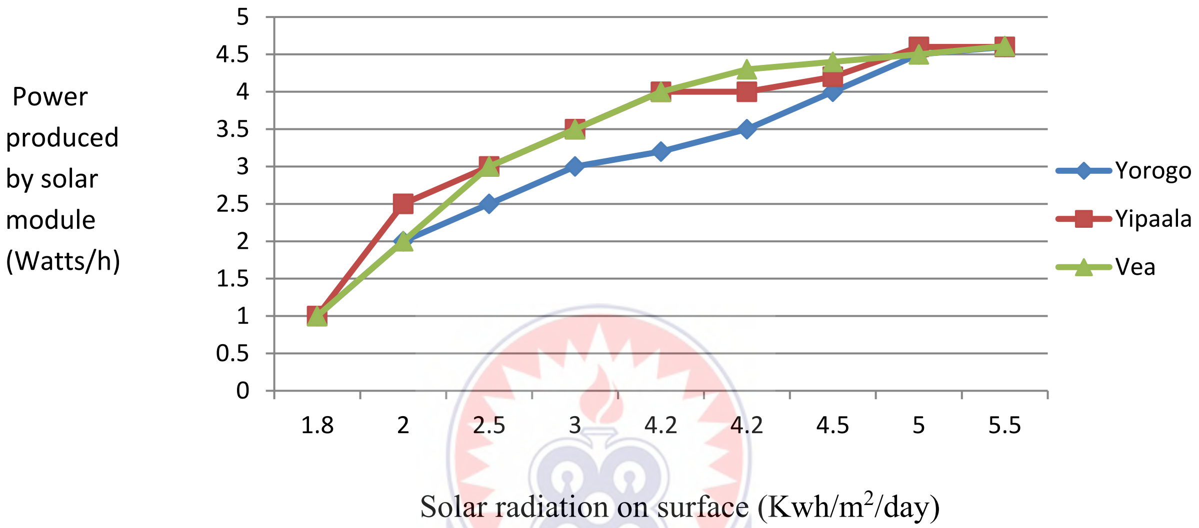

Figure 4.2: The amount of power produced by the solar panel on sites.

4.6. ECONOMIC ANALYSIS OF THE SOLAR BLENDER.

4.6.1 Production Cost

The cost of solar P.V varies depending on size and type of module. According to (KwasiOheneDwumfour Co. Ltd, 2013) 750 w / 24 v solar panel made of multi – crystalline silicon cells cost $35. (Ghc 140) and a DC motor rated at 750w/24v / 3200rpm also cost $ 25. (Ghc 100)

Therefore the production cost of the Blender was Ghc275 as shown in appendix F.

4.6.2. Payback Period

A trader who sells ken key on market days expressed interest in the design. She makes a profit of Ghp 50, and out of this she saves Ghp 30 every market day, there are ten market days in a month and she is expected to generate Ghc 108 per year for 3 years. The payback period for this trader is;

$$\text{Payback} = \frac{\text{Initial investment}}{\text{Cash inflow per period}}$$

The payback period 3 years and since the payback period is less than the targeted payback, it means the design will be good for this trader.

4.6.3. The Net Present Value (NPV)

The net present value of the design to this trader was determined by

$$NPV = \frac{Cash\ flow}{(1+0.03)^1} + \frac{Cash\ flow}{(1+0.03)^2} + \frac{Cash\ flow}{(1+0.03)^3} - (cost\ of\ design)$$

And was found to be 8 and since the NPV is positive it means the design is profitable and should be accepted by this trader.

4.6.5. `Life Cycle Cost (LCC).

The life cycle cost of the solar blender was determined as ;

Life Cycle Cost(LCC) = Initial capital costs (ICC) + projected life-time operating costs (OC) + projected life-time maintenance costs (MC) + projected disposal costs (DC) - projected residual value. (Solar energy Economics, 2000)

The life cycle cost was found to be 91, and this value is small and shows that the design is good for the three year period.

4.7. VIABILITY OF THE SOLAR BLENDER

The economic factors for the application of the solar blender as determined above shows that the savings in cost of energy as well as the time saving in using the solar blender when compared with alternative methods such as the manual way of grinding and other electrical appliancesshows that the design is viable and therefore there is the need to move from over dependence on hydro and grid energy to the use of solar appliance like this solar operated blender.

4.8. ENVERONMENTAL BENEFITS.

The design is environmentally friendly since solar power emits no fumes and creates no greenhouse gases or carbon emissions, making it one of the most environmentally friendly energy solutions available. In addition, solar power is silent, creating no noise pollution. The green house gas (GHG) according to (Retscreen, 2012) the net amount of reduction in GHG emission will occur if a proposed renewable energy project is implemented. The calculation is based on the gross annual GHG emission transaction fee. The Kyoto protocol adopted in 1997 in Kyoto at the third conference of parties (COP3), established three mechanisms. The Clean Development Mechanism (CDM), Joint Implementation (JI) and Emission Trading (ET) which allow project developers to pursue opportunities to cut GHG emission.

4.9. AFFORDABILITY

Taking into consideration the economic situation of the people in the three communities and comparing with the economic analysis as calculated above,, one can deduce that if a person can save Ghc3 a month he can get a payback period in 3 years for the design, and a payback period in 3 years means thatan average person can afford it and therefore one can confirm that the design is affordable.

4.10. `LIMITATION:

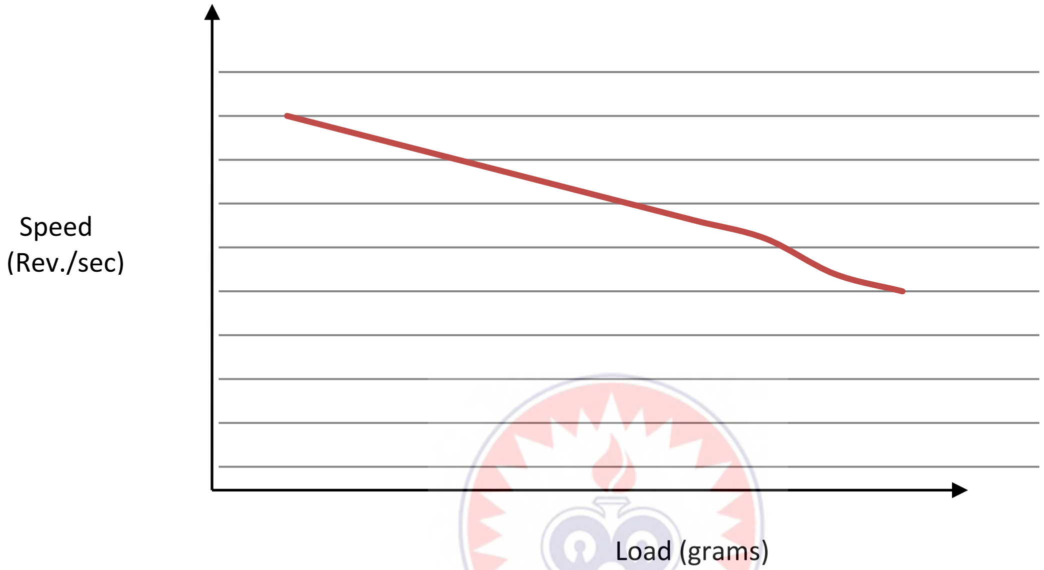

Figure 4.3: Speed and Load graph for a D.C motor

Because the motor used for the blender is a D.C motor, the speed of the blender reduced when the load is increased, as shown in Figure 4.4. In other to prevent this phenomenon the ingredients especially the tomatoes and onions will have to be slice in to pieces before it is put into the blender. Also the solar blender will only run when there is enough sun light, unless there is a battery tostore enough power for it to operate during raining or cloudy days. Improper positioning of the panel can also result in the blender not working or working intermittently.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATION

5.1. SUMMARY

A simple and inexpensive solar operated blender has been designed for the people of Yorogo, Yipaala and Vea communities in the Bolgatanga Municipality who have no electricity. A targeted population of 1150 representing 20 % of the entire people was used to gather information for the design. Daily solar radiation of 4.61 $Kwh/m^2/day$ for the month of August which is the least throughout the year was used as a reference for the P.V module sizing. A cable length of 20 m and 2.5 mm^2 cross sectional area and made of copper was used for the design taking into consideration the environmental and economic conditions of the three communities. The hourly variations of the temperature in these communities during the most hours of the day is between 11.00 and 15.00 hours local time and this was seen to be a good sun hours for the design of the solar blender. The solar blender shows sufficient ability to grind about 5 grams of tomatoes and other ingredients reasonably and rapidly. Also the materials used for the design are readily available in the local market.

The D.C motor which is powered by the solar P.V panel is housed in the base of the blender and has an average speed of 3000 rpm, maximum voltage of 24 volts and a maximum power of 750 watts. This motor was used because it is cheap and can be obtained in the local market, thereby making it affordable for the people since most of them are low income earners.Also the solar panel which receives the solar radiation and converts it into D.C for the motor to operate has maximum power of 270watts and voltage of 24 volts. The panel was used because it has the power to operate the motor for the blender to achieve the desire results.

5.2. CONCLUSION

The emergence and continuous increase in the dependence on solar energy provide evidence that solar appliance can become a leading domestic appliance in the future. The success of this technology depends mainly on the capability of meeting targets such as the enhancement of manufacturing procedures while at the same time, accomplishing increase demand and cost reductions. With the vast variety of PV technologies present in the market, it is important to design a blender that can operate on solar to help meet the electricity needs in the rural communities. The main purpose of the solar operated blender was to ascertain if the amount of solar radiation in three communities (Yorogo, Yipaala and Vea) was enough to power a D.C motor to operate the solar blender and to select the correct type and size of solar panel to produce the required power. Performance parameters which include the determination of the correct type of D.C motor to replace the existing A.C motor in the electric blender, determine the viability and or otherwise of the design and to design a solar operated blender for the 3 communities has been carried out. The outcome of the design also showed that these technologies have enormous potential even in areas with unreliable electricity supply.

5.3 RECOMMENDATION

I wish to make the following recommendation as lot still needs to be done to improve the operational performance of this type of blender.

i. A test under full loading condition should be carried out in order to know if all the design parameters have been met.

ii. Laboratory experiment should be carried out to know the effects on the nutritional values when solar operated blender is used to grind ingredients.

iii. As a matter of our economic situation, the government of Ghana and other individuals or cooperate organizations to take up a design of this nature as a business project and come out with mass production of such products for the rural communities without electricity, in other to help move our economy from import dependent to an industrial or a manufacturing economy and also help to reduce our overdependence on the national grid.

iv. Since the solar modules are expensive and the design requires two of them to operate the blender, I further recommend that cooperate bodies such as nongovernmental organization should have the design manufactured or produced and installed at the convenient location within the communities for commercial use at a minimum fees instead of the individual owning it for themselves.

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APPENDIX A

CONCEPTUAL DESIGN A

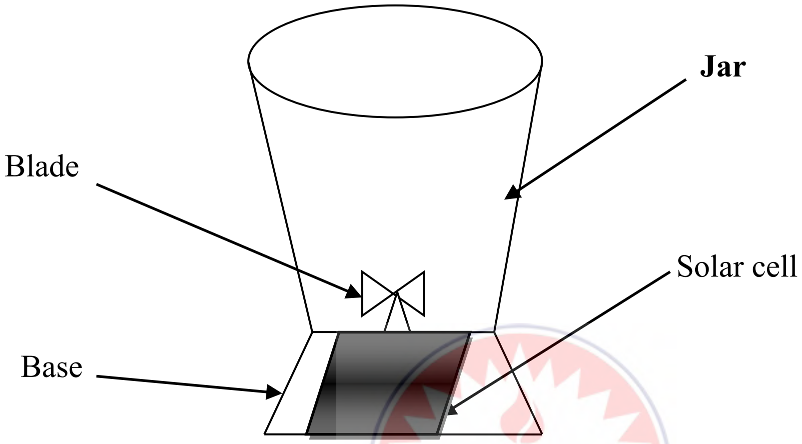

Figure 3.1: Solar operated blender with solar panel at the base

APPENDIX B

CONCEPTUAL DESIGN B

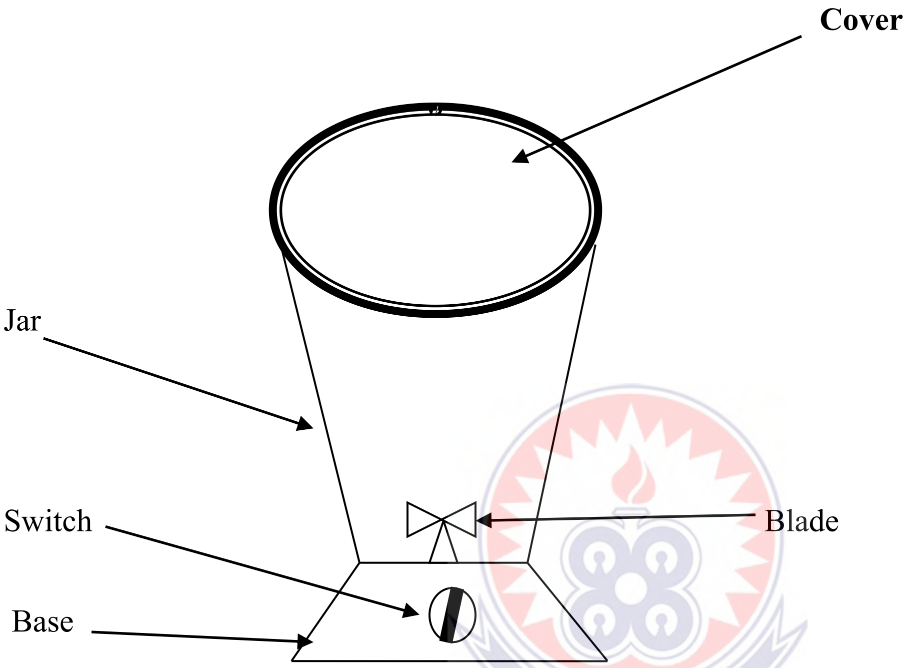

Figure 3.2: Solar operated blender with solar panel separated from the main unit

APPENDIX C

SET- UP

Figure 4.5: Set - up of the Solar operated blender.

APPENDIX D

Table 4.1: Weekly solar radiation on sites

SITE: YOROGO

WEEK	1	2	3
SOLAR RADIATION (Kwh/m2/day)	3.7	4.2	5

SITE: YIPAALA

WEEK	1	2	3
SOLAR RADIATION (Kwh/m2/day)	4	4.6	3.8

SITE: VEA

WEEK	1	2	3
SOLAR RADIATION (Kwh/m2/day)	4.5	4.5	2.8

APPENDIX E

Table 3.8: Daily operational hours of the blender

SITE: YOROGO

DAYS	1	2	3	4	5
RUNNING TIME (mins)	20	19	19	20	21

SITE: YIPAALA

DAYS	1	2	3	4	5
RUNNING TIME (mins)	20	20	19	20	20

SITE: VEA

DAYS	1	2	3	4	5
RUNNING TIME (mins)	18	20	20	19	20

APPENDIX F

CALCULATIONS

- **Calculating Peak Sun Hours**.

The solar radiation of 4.61 MJ/m^2 on the surface for the month of August was used to calculate the peak sun hours, using the following relation:

1 kWh = 3.6 MJ, or1 MJ = 1 / 3.6 KWh, then, 4.61 MJ/m^2would be equal to:

$$\frac{4.61\ \text{MJ/m}^2 \times 1\ \text{KWh}}{3.6\ \text{MJ}} = 1.28\ \text{KWh / m}^2$$

- **Determination of full load torque**;

To calculate motor full-load torque, apply this formula:

$$T = \frac{[Px\ 5252]}{rpm}.$$

Where;

T = torque (N.m)
P = power = 750 W
5252 = constant
Rpm = 300 rpm

∴ Torque (T) = [750 x 5252] / 3000 = 1.5 Nm

- **Voltage drop in Cables**

Since the supply voltage is 24 V, the value of allowable voltage drop should be;Allowable Voltage Drop = 24 x (2.5/100) = 0.6 mV, and that of sub circuit and final sub circuit allowable voltage drops is 0.3 mV (i.e. 0.5 of 0.6 mV).

- **Determination of the actual Cable size**

For the wiring of the solar blender, (from solar panel to the blender motor), the following condition were considered;

Load of 0.75 kW = 750 W

Total length of cable (from solar panel to blender motor) is assumed to be 5 meters.

Supply voltage = 24V

Ambient temperature is assumed to be 40°C.

Assuming 2% of additional load = $750 \text{ x } \left(\frac{2}{100}\right) = 15 \text{ W}$

Total Load = $750 \text{ W} + 15 \text{ W} = 765 \text{ W}$

Total Current = I = $\frac{P}{V} = \frac{765 \text{ W}}{24 \text{ V}} = 32 \text{ A}$

- Current rating (at 40°C) = 31 x 0.94 = 29.14 Amp. (Using Table 3.5)

- Actual Voltage drop (for 5 meter) = Voltage drop (mV) x Current carrying capacity at 40 ºC (I) x Length of cable (m) = mV x I x L = (7/1000) x 29.14 ×5 = 1 mV (Using Table 3.4)

- **Design Load Demand**

  The design load is the instantaneous load for which the power conversion, distribution and protection devices should be rated. It is calculated as follows:

$$S_d = S_p (1 + K_g) (1 + K_c)$$

Where

$S_d$is the design load (w)

$S_p$is the peak load = 765 w (from cable sizing)

K_g is a contingency for future load growth = 2% of 765 = 15 w

K_c is a design margin (for inaccuracies in load estimation) = 3% of 765 = 23 w. Therefore,

$S_d = 765 \text{ x } (1 + 15.) (1 + 23) = 294$ Kw

- **Design Energy Demand**

The design energy demand is used for sizing energy storage devices such as the battery; the total energy (in terms of Kwh) is calculated by assuming 2 hours operational time for the blender. It is calculated as follows;

$$E_d = E_t (1 + K_g) (1 + K_c)$$

Where;

E_d is the design energy demand (Kwh)

E_t is the total load energy, = 0.765 Kw x 2 = 1.53 Kwh

K_g is a contingency for future load growth as defined above (%)

K_c is a design contingency as defined above (%)

Therefore:

$$E_d = 1.53 \text{ x } (1 + 15) (1 + 23) = 588 \text{ Kwh}$$

- **To determine the maximum number of cells in series (N_{max}) is;**

$$N_{max} = \frac{V_{dc} (1 + V_{Lmax})}{V_c}$$

$$= \frac{24 \text{ x } (1 + 0.2)}{2} = 14 \text{ cells}$$

- **The minimum number of cells in series is:**

$$N_{min} = \frac{V_{dc}\,(1 - V_{lmin})}{V_{eod}}$$

$$= \frac{24 \times (1 - 0.1)}{1.8} = 12 \text{ cells}$$

- **rom the formulae**

$$C_{min} = \frac{E_d \times K_a \times K_c \times K_t}{V_{dc} \times K_{dod}}$$

$$= \frac{588 \times 1.25 \times 1.1 \times 0.956}{24 \times 0.8}$$

$= 40$ Ah cells

- **The effective PV cell temperature is determined by;**$(T\ pv) = T_{amb} + T_{stc}$

$= 40 + 25 = 65\ ^{o}C$

- **The power output of the solar P.V (P_{panel})** is;

$$P_{panel} = P_{peak} \times T_{stc} \times T_t \times f_{dirt}$$

$$= 270 \times 25 \times 0.05 \times 0.97$$

$$= 327 \text{ w}$$

- **Number of solar PV panels needed to power the DC motor**

Given an oversupply coefficient (f_o) of 4 and a PV sub-system efficiency of 85%, the number(N) of PV modules required is ;

$$N = \frac{Ed \times fo}{P\,(panel) \times Radiation \times \eta\,(pv)}$$

$$= \frac{588\ x\ 4}{327\ x\ 4.61\ x\ 0.85} = 1.8$$

- **Production Cost of the solar blender;**

Cost of solar panel = Ghc 140

Cost of DC motor = Ghc 100

Sub - total = Ghc 240

Cost of cables and fittings = Ghc 20

Operation and Maintenance cost = 1% of 240 = Ghc 2.4

Labour cost = 3% of 240 = Ghc 7.2

Miscellaneous cost = 2% of 140 = Ghc 4.8

Grand total = Ghc 274. 4

Therefore total Cost of the blender = Ghc 275

- **Payback Period**

$$\text{Payback} = \frac{\text{Initial investment}}{\text{Cash inflow per period}} = \frac{275}{108} = 2.55 \text{ years}$$

- **The Net Present Value (NPV)**

The net present value of the design to this trader was determined based on the following;

Cash inflow for year: 1 = Ghc 108

2 = Ghc 100

3 = Ghc 92

If the discount rate is 3%, then;

$$NPV = \frac{Cash\ flow}{(1+0.03)^1} + \frac{Cash\ flow}{(1+0.03)^2} + \frac{Cash\ flow}{(1+0.03)^3} - (cost\ of\ design)$$

$$= \frac{108}{1.03} + \frac{108}{1.06} + \frac{108}{1.09} - 275$$

$$= 283 - 275 = 8$$

- **Life Cycle Cost (LCC).**

The life cycle cost of the solar blender was determined as ;

Life Cycle Cost(LCC) = Initial capital costs (ICC) + projected life-time operating costs (OC) + projected life-time maintenance costs (MC) + projected disposal costs (DC) - projected residual value. That is; ICC = 275, OC = 15% of 275 = 41.25, MC = 2% of 275 =5.5, DC = 1% of 275 = 2.75, residual value = 85% of 274 = 233.75

Therefore;

LCC =275 + 41.25 + 5.5 + 2.75 – 233.75

= 91