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College of Engineering

Department of Electrical Power Engineering

Graduation Project

Modeling of hybrid micro grid renewable energy system with environment sense for rural development

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Modeling of hybrid renewable energy system(micro grid) with environment sense for rural development

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First, I would like to thank Allah, for His mercy during all our life, and praise the prophet Mohammad (peace be upon him!).We dedicate this work to our father's (Emad abuayyash ,Anwar Dwyyat), our mother's, our brothers and sisters. Furthermore, I greatly appreciate the support which I received from our supervisor Dr. Abed Alkareem Dawod , also thanks for Eng.Makawee Hriez , Dr .Sameer Hana, and every one who give us any support. I want to declare that this work was supported and funded by Deanship of Graduate Studies and Scientific Research (Palestine Polytechnic University).

Abstract

The Palestinian Territories depend on Israel for 100% of its fossil fuel and for 87% of its electricity. Total energy consumption in the Palestinian Territories is the lowest in the region and costs more than anywhere else in the world. The main renewable energy sources in the Palestinian Territories are solar, wind and biomass . Using the available renewable energy sources in the Palestinian Territories may significantly decrease the energy reliance on neighboring countries and improve the Palestinian populations access to energy. It is estimated that solar sources have the potential to account for 13% of electricity demand and wind energy for 6.6%. The conversion of animal waste into biogas has the potential to meet the needs of 20% of the rural population.

Using hybrid renewable energy systems for rural electrification has become an attractive solution for those areas. The purpose of this paper is design Hybrid system combines several energy systems together, therefore it can supply high reliable electricity rather than a PV/battery system or a wind/-battery system . But the most important thing is that the components in the hybrid system should be optimally sized .

The optimum combination of different energy systems is (bio-pv system) particularly in Palestine ,which can supply electricity to a rural community.

Biogas system consists Anaerobic digestion units called digester , which the biogas naturally produced by the fermentation of organic waste (dung) into anaerobic digesters, contains between 40 and 60% of methane, which gives it fuel character and its valorization allows energy conservation while protecting the environment by reducing the greenhouse gases emission. The photovoltaic generator (PV) and also methane generator will produce during the day enough electric power cover the requirements of the different loads in the farm while the excess power will injection to grid . The other case methane and solar generator are not able to cover the requirements of the different loads in the farm so the grid will provide the load energy requirements and the difference between production and consumption energy is called net metering technology by unidirectional metering.

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Chapter 1

Introduction

1.1 Problem statement

Our project has taken 'Arroub Technical college' case study. It suffer from shortage energy, continuous load interruption and have huge amount of animal dung.that will be very useful for our project we will help it to disposal from Cow and other animal dung with effective and special way that will give economic benefits with environment sense. On other hand it considered a big consumer of energy (heavy machine and engine ,pump ,lighting ,and a lot of load).For that ,hybrid renewable energy system (biogas with solar energy) would be designed especially for farm and rural area. Where existing a real able, effective and economic energy system with environment sense will be not easy[1].

The main components of photovoltaic-Biogas system with control system between them and main grid.Such a system includes a source of power(PV), a methane generator,in addition main grid.The system provides electrical energy continuously without interruption.

Photovoltaic power generation, which converts sunlight into electricity, and has many advantages, including the inexhaustible it's free and environment friendly and there is no moving parts[2].

Biogas system consists Anaerobic digestion units called digester, which the biogas naturally produced by the fermentation of organic waste(dung) into anaerobic digesters, contains between 40 and 60% of methane[3], which gives it fuel character and its valorization allows energy conservation while protecting the environment by reducing the greenhouse gases emission.

The photovoltaic generator (PV) and also methane generator will produce during the day enough electric power cover the requirements of the different loads in the farm while the e excess power will injection to grid.The other case methane and solar generator are not able to cover the requirements of the different loads in the farm so the grid will provide the load energy requirements and the difference between production and consumption energy is called net metering technology by unidirectional metering.

1.2 Objectives

The proposed project is assumed to achieve the following objectives:

- using hybrid renewable sources biogas and solar energy.
- the system will use biogas from Cow and other animal dung to produce energy that will give environment sense.
- Agricultural biogas fermentation not only produce energy but also treat agricultural wastes (faeces of poultry and livestock and straw), which increasingly was paid attention by state and society[4].
- The system should be able to produce enough and realable energy for all loads in the farm.
- The system should have the ability to connect on the main grid and exchange between tow system to satisfy high reliable.
- Ability to sell exceed energy to main grid so that will give a good economic benefits for the farm.
- The system will be controlled by SCADA system that mean more reliable ,economic ,effective system.

1.3 Motivations

- Energy system with environment sense that mean instead of pollution by organic substances like cow dung we disposal from it and produce energy.
- Isolated Micro-Grids With Renewable Hybrid Generation so renewable energy sources is the only solution to meet their future energy needs,design, and development of a standalone micro-grid supplied by a hybrid biogas-solar generating source. The goal of the project was to provide a reliable, continuous,sustainable, and good-quality electricity service to users, as provided in bigger consumer[1].

- Attractive solution by Using off grid hybrid renewable energy systems for rural electrification has become an attractive solution for those areas, where grid electricity is not feasible or cost of the grid extension is relatively large.

- More reliable Hybrid system with combines several energy systems together, therefore it can supply high reliable electricity rather than a PV/battery system or a wind/battery system.

- More economically system for example One cow can produce enough dung in one day to generate 3 kW.h of electricity, while we need 2.4 kW.h of electricity just to run 100 W bulb strongly for one day.

- Using Renewable energy as big businesses so the farm can investing in a clean energy by sells exceed energy from the system to traditional grid.However , investments grow increasingly appealing to big businesses such as Microsoft.

1.4 Project plan

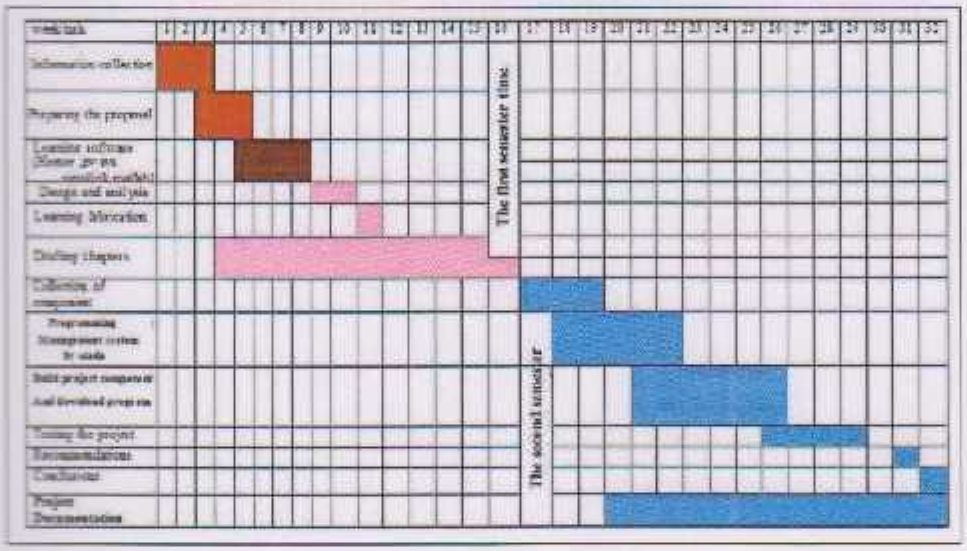

Figure 1.1: Project plan.

Chapter 2

Description and Modeling of Photovoltaic -Anaerobic digestion system

2.1 Description and Modeling of Photovoltaic system

2.2 Description and Modeling of Anaerobic digestion system

Chapter 2

Description and Modeling of Photovoltaic-Anaerobic digestion system

This chapter provides an overview of the main components and modeling of photovoltaic-Biogas system and also control system between them and also main grid Such a system includes a source of power (PV), a methane generator, in addition main grid The system provides electrical energy continuously without interruption.

Photovoltaic power generation, which converts sunlight into electricity. Biogas system consists Anaerobic digestion units called digester,which the biogas naturally produced by the fermentation of organic waste (dung) into anaerobic digesters, contains between 40 and 60% of methane gas ,which used as fuel for electric generation.

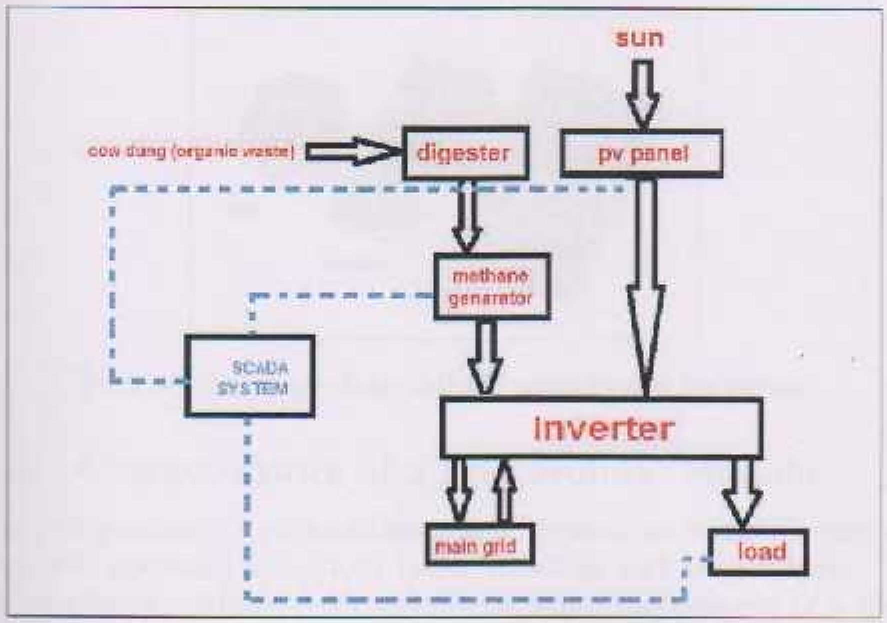

Figure 2.1: System Block Diagram.

2.1 Description and Modeling of Photovoltaic system

2.1.1 Photovoltaic Power Generation

Photovoltaic cells convert solar radiation directly into electrical energy, also known as solar cell. The photovoltaic word refers to 'photo' meaning light and 'voltaic' refer to generate electrical.

The cell is made up of semiconductor material such as silicon. It is composed of a P-type semiconductor and an N-type semiconductor.

Solar radiation emitting the photovoltaic cell produces two types of electrons, negatively and positively charged electrons, in the semiconductors.

The electric current flows through an external circuit between the two electrodes. Photovoltaic cells are connected electrically in series and/or parallel circuits to produce higher voltages, currents and power levels.

Photovoltaic modules consist of PV cell circuits. A photovoltaic array is the complete power-generating unit, consisting of a number of PV modules .A photovoltaic cell, PV module and array are shown in figure2.2.

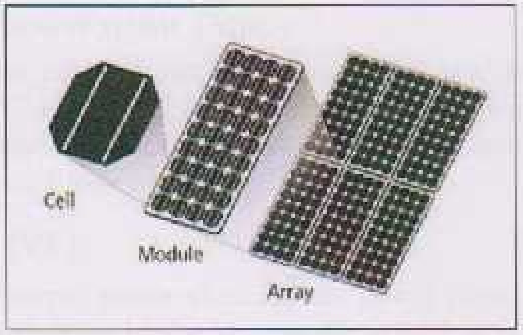

Figure 2.2: Photovoltaic cell,PV module and PV array.

2.1.2 Characteristics of a Photovoltaic Module

The performance of a photovoltaic module depends on manufacturing technology and operating conditions (solar radiation and temperature). The curve of current –voltage (I-V) which determines the behavior of a photovoltaic cell is represented in figure2.3.

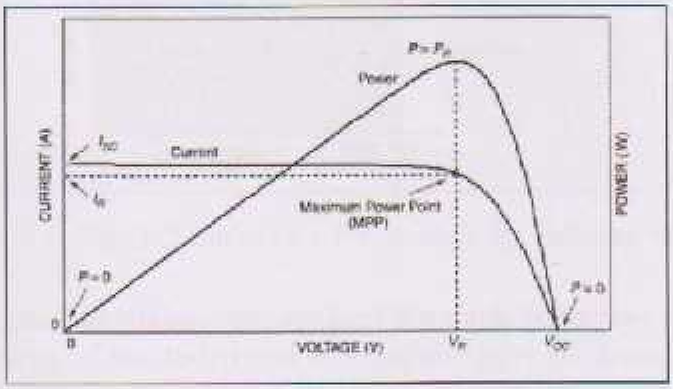

Figure 2.3: The I-V and P-V characteristics of typical PV module [5].

The main electrical parameters that describe the performance of a photovoltaic cell are:

1. **Short circuit current (Isc).**

   The value of (Isc) can be obtained by connecting the terminals of a module via an ammeter and measuring the current.The value of Isc changes in function of solar radiation and very little of temperature .

2. **Open circuit voltage (Voc).**

   It's the voltage of a PV module measured at its terminals at no load.

3. **Maximum power point (Mpp).**

   The maximum power point of a photovoltaic is a unique point on the (I-V) or (P-V) characteristics and the power supplied in this point is maximum, where measured in Watts (W).its value can be calculated by the product Vmax and Imax.

4. **Fill Factor (FF).**

   The ratio of output power at maximum power point to the power computed by multiplying Isc by Voc, as illustrated in figure2.4.

   The FF is obtained according the following equation:

   FF= Vmpp* Impp/Voc*Isc. . . . .(2.1).

   It is an important performance indicator.

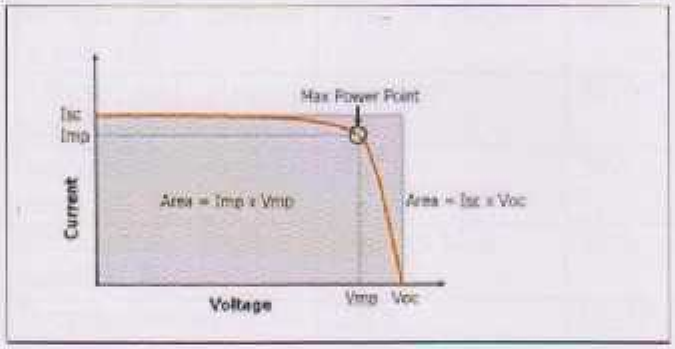

Figure 2.4: The I-V curve of a PV module for defining the FF.

Typically, crystalline silicon photovoltaic FF module is between 0.67 and 0.74 .If the I-V curves of two individual PV modules have the same values of Isc and Voc, the array with the higher fill factor (squarer I-V curve) will produce more power.Also, any impairment that reduces the fill factor will reduce the output power [6].

2.1.3 Maximum Power Point

To improve the efficiency of PV systems, various been performed. But, as solar energy is diffuse (less than 1 kW/m2), and photovoltaic cell efficiency is theoretically limited to 44%, efforts need to be strengthened on the energy transfer.This includes the design of the photovoltaic system and the energy management by seeking the Maximum Power Point (MPP).Large amount of publications can be 16 found on MPPT, and it is not easy to apprehend their differences and to estimate their performances [6].

The position of maximum power point is not known to determine this point used calculation models or by using a logarithms techniques, where vary in terms of complexity and simplicity, implementation, accuracy and the cost.Table (2.1) is shown the famous techniques used and simplicity in implementation[7].

Number	Methods of MPPT Techniques	cost (component, sensor, microcontoller)	Percentage of matching with theoretical value (100%)
1	Constant Voltage (cv)	Low	79.5
2	Short-cicuit pulse (sc)	Medium	90.7
3	Open Voltage (ov)	Near to meduim	94.6
4	perturb and observe (P and O a)	Near to meduim	98.9
5	perturb and observe (p and o b)	Near to meduim	99.3
6	perturb and observe (p and o c)	Medium	87.7
7	Incremental conductance (IC a)	High	98.7
9	Incremental conductance(IC B)	Near to high	99.5
10	Temperature methods	High	90-97

Table 2.1: Techniques of maxmium power point tracking.

2.1.4 Modeling of Photovoltaic cell

The equivalent electrical circuit of one-diode model consists of a real diode in parallel with a current source. The current source produces the current Iph and the current Id flows through diode. The current Ic which flows to the load is the difference between Iph and Id and it is reduced by the resistances Rs and Rp[8].

Two resistances, Rs and Rp, are included to model the contact resistances and the internal PV cell resistance respectively.

The values of these two resistances can be obtained from measurements or by using curve fitting methods based on the I-V characteristic of PV[9].

The equivalent electrical circuit for a PV cell or module is illustrated in figure2.5.

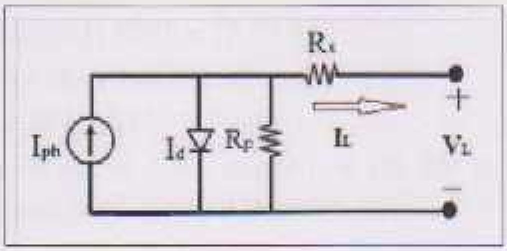

Figure 2.5: Equivalent circuit of PV.

The current source (Iph) depended on the solar radiation and the ambient temperature.The (I-V) characteristics of photovoltaic cell can be determined by the following equations[10].The terminal current of the model (IL) is given by:

$I_L = I_{ph} - I_d - I_p$ .... (2.1)

Where,

I_{ph}: photocurrent from photovoltaic cell [A].

I_d: is the current passing through none linear diode [A].

I_p: current through shunt resistance [A].

The photocurrent I_{ph} is a function of solar r radiation and temperature, it is determined from equation (3.2):

$_{ph} = [I_{sc} + k_I(T_c - T_r)]G/G_n$ .... (2.2)

Where,

I_{sc}: is the short-circuit of the cell at standard test condition (STC: G_n=1000W/m and T_r =298.15K) [A].

k_I: is the short-circuit current temperature co-efficient of the cell [A/ K].

T_c and T_r: are the working temperatures of the cell and reference temperature respectively.

G and G_n: are the working solar radiation and nominal solar radiation respectively [W/m].

The diode saturation current Id of the cell varies with the cell temperature, which is expressed in equation (2.3) as,

$I_d = I_o[e(q(V_L + I_{LR_s})A_{kT_c})1]$ .... (2.3)

I_o: reverse saturation current of the diode [A].

q: is the electron charge [1.6021 x 10-19 C].
V_L: output voltage of the photovoltaic cell [V].
R_s: series resistance of cell[Ω].
A: is the ideality constant of diode depend on the PV technology [1.2-3.3].
k: Boltzmann constant [1.38 10-23 J/K].

The shunt current Ip is given by equation (2.4):

$$Ip = (V_L + I_L R_s)/R_p \quad (2.4)$$

Where R_p [Ω] is parallel resistance .

2.1.5 Modeling of Photovoltaic module

A PV module is the result of connecting several PV cells in series in order to increase the output voltage. The characteristic has the same shape except for changes in the magnitude of the open circuit voltage[10], as shown in Figure 2.6:

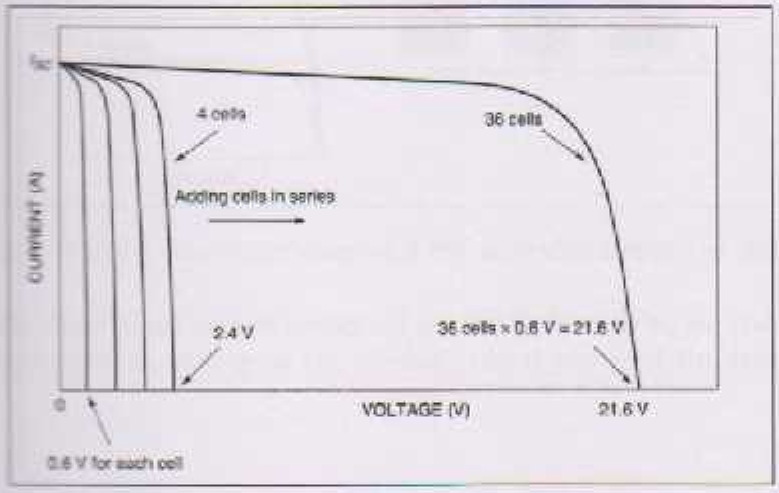

Figure 2.6: The I-V characteristics of a typical PV module consisting of 36 cells connected in series.

The output voltage of a PV module is calculated by:

$$V_{module} = n(V_d - ILR_s) \quad (2.5)$$

Where :

n: is the number of PV cells connected in series in the module. V_d: is the voltage of the diode of the equivalent circuit of the cell [v].

2.1.6 Modeling of Photovoltaic array

The PV Arrays are composed of some combination of series and parallel of PV modules. The modeling of PV arrays is the same as modeling of the PV module from the PV cells. Modules in series, the (I–V) curves are simply added along the voltage axis. The total voltage is just the sum of the individual module voltages .

For PV modules connected in parallel the total current is the sum of the currents of the modules whereby the total output voltage is equal to the voltage of one module, as shown in figure2.7:

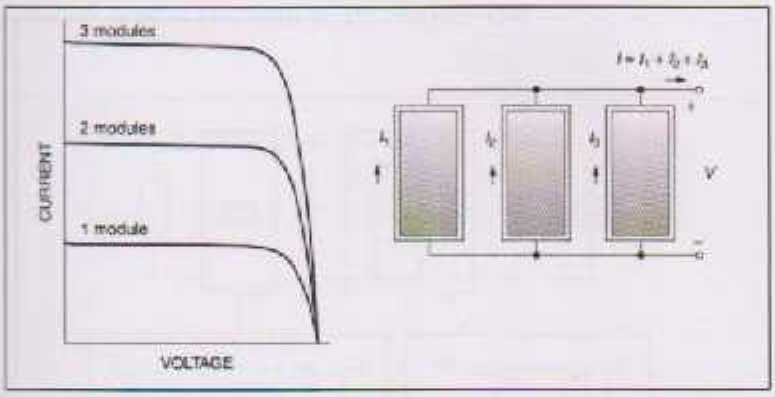

Figure 2.7: The I-V characteristics of 3 PV modules connected in parallel.

Practically the PV array will consist of a combination of series and parallel modules depending on the needed output power of the system is needed .

2.1.7 Inverter

Inverter Stages and Functions:

The inverter's main function is to convert variable-voltage DC from the PV panels or battery storage to a specific AC voltage and frequency for use by appliances and feedback to the grid. The AC output varies by region, with 60-Hz 115 VAC used in North America and 50-Hz 230 VAC in much of

Europe.

Applications also have different phase requirements, so one-, two- and three-phase inverters are available. Figure 3 shows the essential DC/AC conversion circuit, in which:

1. DC/DC conversion raises or lowers the incoming PV voltage, adjusting its output for greatest efficiency in the DC/AC conversion stage .
2. The capacitor provides further voltage buffering.
3. The MOSFETs in the bridge use a switching frequency in the range of 20 kHz to create an AC voltage.
4. The coils smooth the switched AC to a sinusoidal signal for use in generating a grid-frequency AC output [11].

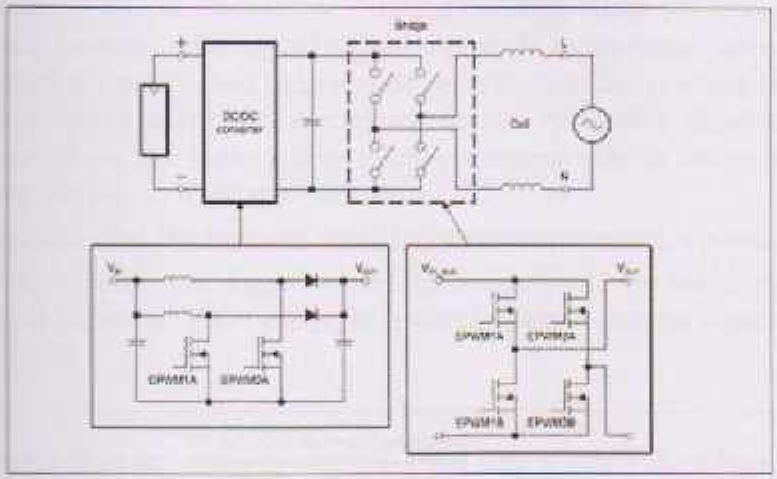

Figure 2.8: Transformerless DC/AC conversion circuit.

2.1.8 Important equation using in pv system design

$P_{dc} = p_{ac}/conversionefficiency$ .... (2.6)

$Area = p_{dc}/1kwh * \eta_{pv}$ .... (2.7)

$P_{peak} = p_{dc}/radiation$ .... (2.8)

$$Noofmodule = P_{peak}/peakpower \ldots\ldots (2.9)$$

$$InverterInputvoltage = Noofmodule*ratedvoltage \ldots\ldots ($$

$$Noofinverter = ((No.ofstring*shortcircuitcurrent))/Max.inputcurrentperstring) \ldots\ldots (2.11)$$

2.2 description of Anaerobic digestion system

2.2.1 Composition of the biogas

The biogas collected is flammable and this provides several options for utilization.Some common uses include flaring, heating (home, water, etc) and internal combustion (creating rotational power).In many cases, internal combustion engines are attached to electrical generators which produce electricity for on farm use or sale to an electric company. Anaerobic digestion is the degradation of organic materials by micro organisms able to utilize molecules other than oxygen as hydrogen acceptors.

More simplistically, the bacteria must be in an environment without oxygen. The process of anaerobic digestion on a molecular level involves many different kinds of bacteria. The process in general however can be summed up in Figure2.9 [12].

$$Organic\ Matter \xrightarrow{anaerobic\ microorganisms} CH_4 + CO_2 + H_2 + N_2 + H_2S$$

Figure 2.9: Anaerobic Molecular Process.

the biogas is about 70% methane (CH4) and 29% carbon dioxide (CO2) with insignificant traces of oxygen and sulfurated hydrogen (H2S) which gives the gas a distinct odor. (Although it smells like rotten eggs, this odor has the advantage of being able to trace leaks easily).

The basic gas producing reaction in the digester is:

carbon plus water = methane plus carbon dioxide

$$2C + 2H_2O = CH4 + CO2$$

The methane has a specific gravity of 0.55 in relation to air. In other words, it is about half the weight of air and so rises when released to the atmosphere. Carbon dioxide is more than twice the weight of air, so the resultant combination of gases, or simply bio-gas, when released to atmosphere, will rise slowly and dissipate[13].

Table(2.2):General Composition of Bio-Gas Produced From Farm Wastes

CH4	methane	54-70%
CO2	carbon dioxide	27-45%
N2	nitrogen	0.5-3%
H2	hydrogen	1-1%
CO2	carbon monoxide	0.1%
O2	oxygen	0.1%
H2S	hydrogen sufide	trace

Table 2.2: General Composition of Bio-Gas Produced From Farm Wastes.

2.2.2 Biogas Digester

A biogas digester, also known as a methane digester, is a piece of equipment which can turn organic waste into usable fuel. In addition to providing a source of renewable fuel, and they help to dispose of waste materials which would otherwise be discarded. The biogas digester relies on bacterial decomposition of biomass, waste material which is biological in origin, ranging from kitchen scraps to cow dung. The bacteria involved in the digestion process have many constraints for effective operation including temperature, pH and acidity, moisture, and substrate nutrients[14].

2.2.2.1 Temperature of the digester

Though there are many factors that affect the rate of biogas production in anaerobic digesters, one of the most influential is operating temperature. For the digesting bacteria to work at the greatest efficiency, a temperature of 95°F (35°C) is best.

Gas production can proceed in two ranges of temperature: 85-105°F (29-40°C) and 120-140°F (49-60°C). Different sets of acid-producing and methane bacteria thrive in each of these different ranges. Those active in the higher range are called heat-loving or "thermophilic" bacteria ,figure 2.10.

Some raw materials, like algae, require this higher range for digestion. But digesters are not commonly operated at this higher range because:

most materials digest well at the lower range,the Thermophilic Bacteria are very sensitive to any changes in the digester, the sludge they produce is of poor fertilizer quality, and it is difficult to maintain such a high temperature, especially in temperate climates.

The bacteria that produce methane in the "normal range" 90-95°F (32- 35°C) are more stable and produce a high quality sludge. It is not difficult to maintain a digester temperature of 95°F (35°C)[15].

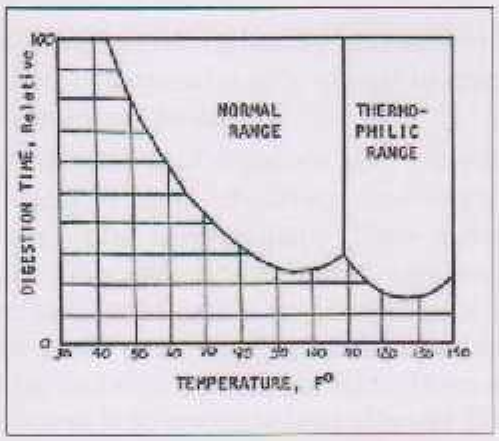

Figure 2.10: Digestion Time and Temperature.

The same mass of manure will digest twice as fast at 95°F (35°C) than it will at 60°F (15°C) (Fig2.10) and it produces nearly 15 times more gas in the same amount of time!
(Fig2.11) (See how the amount of gas produced improves with temperature in 80-100°F (27-38°C), where production is optimum).
In Fig(2.11)it can be seen how a different amount of gas is produced when the digester is kept at 60°F (15°C) than when it is kept at 95°F (35°C)[16].

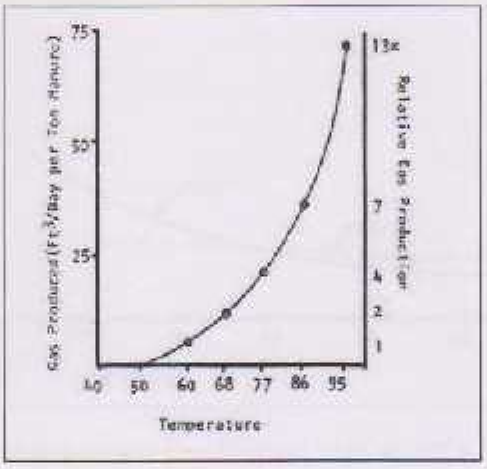

Figure 2.11: Gas production and temperature.

2.2.2.2 Heating Digesters

For the most efficient operation, especially in temperate climates, digesters should be supplied with an external supply of heat to keep them around 95°F (35°C); there are several ways to do this.

Methods which heat the outside of digesters (e.g., compost piles, light bulbs, and water jackets) could be more effectively used as insulation since much of their heat dissipates to the surroundings. (Since digesters should be constantly warmed rather than sporadically heated, compost "blankets" are not very practical unless you coordinate a regular program of composting with digestion.) Similarly, green houses built over digesters tend to overheat the digester during the day and cool it down at night. The most effective method of keeping digesters warm is to circulate heated water through pipes or coils placed within the digester. The water can be heated by solar collectors or by water boilers heated with methane.

Gas-heated water boilers are a good idea since they allow the digestion process to feed back on itself, thus increasing efficiency. One practical gas-heater design we have used .The thermostat in the water boiler is set at 140°F (60°C) because slurry will cake on surfaces (e.g., the water coils) warmer than this. The digester thermostat is set at the optimum 95°F (35°C). Until the digester begins producing methane, propane can be used as a fuel source for the water boiler [17].

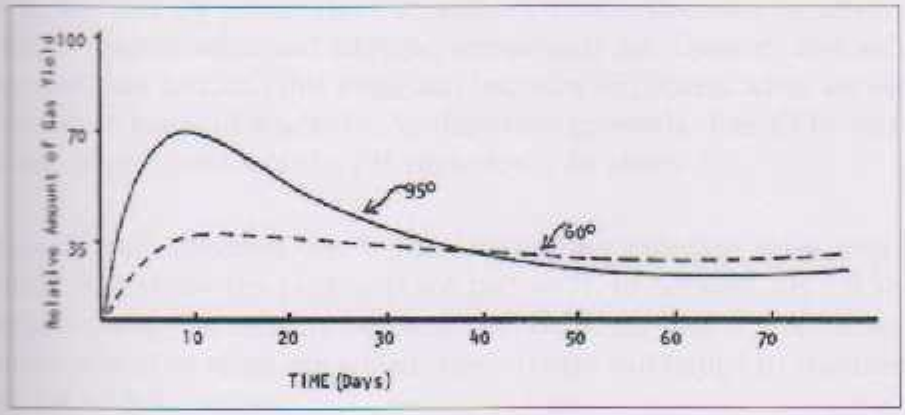

Figure 2.12: Comparison of gas production rate at 60°F and 95°F(Measured form time new sludge added to buffered digester).

2.2.2.3 PH and the Well-Buffered Digester

To measure the acid or alkaline condition of a material, the symbol "pH" is used.

A neutral solution has pH = 7; an acid solution has pH below 7; and an alkaline solution has pH above 7. The pH has a profound effect on biological activity, and the maintenance of a stable pH is essential to all life. Most living processes take place in the range of pH 5 to 9. The pH requirements of a digester are more strict (pH 7.5-8.5, Figure2.13).

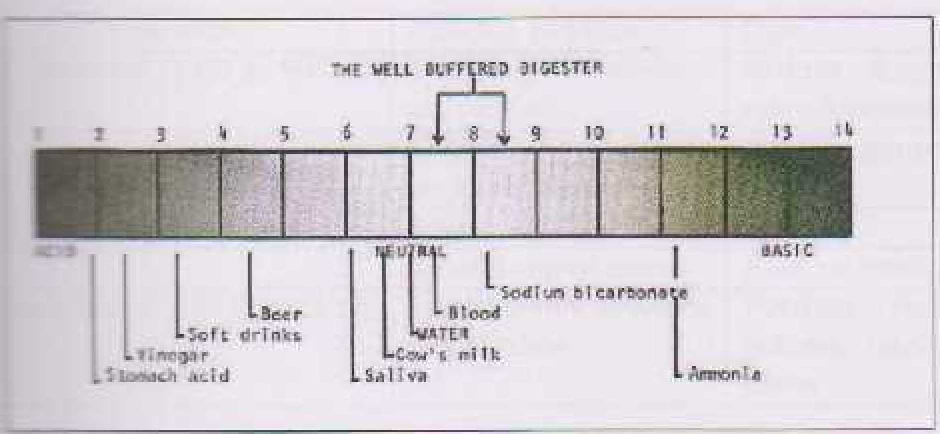

Figure 2.13: The ph scale.

During the initial acid phase of digestion, which may last about two weeks, the pH may drop to 6 or lower, while a great deal of CO_2 is given off.

This is followed by about three months of a slow decrease in acidity during which volatile acids and nitrogen compounds are digested, and ammonia compounds are formed (this ammonia becomes important when we consider the fertilizer value of sludge). As digestion proceeds, less CO2 and more methane is produced and the pH rises slowly to about 7.

As the mixture becomes less acid, methane fermentation takes over. The pH then rises above the neutral point (pH = 7), to between pH 7.5 and 8.5. After this point, the mixture becomes well buffered; that is, even when large amounts of acid or alkali are added, the mixture will adjust to stabilize itself at pH 7.5 to 8.5.

Once the mixture has become well buffered, it is possible to add small amounts of raw material periodically and maintain a constant supply of gas and sludge (continuous load digesters).
If you don't feed a digester regularly (batch-load digesters), enzymes begin to accumulate, organic solids become exhausted and methane production ceases.

After digestion has stabilized, the pH should remain around 8.0 to 8.5. The ideal pH values of effluent in sewage treatment plants is 7 to 7.5, and these values are usually given as the best pH range for digesters in general.
Table(2.3):Problem with Ph.

Condition	Possible Reasons	Cure
Too acid (PH6 or les)	1)Adding row materials too fast	Reduce feeging rate: Ammonia
	2)Wide temperature fluctuation	stabilize temperature
	3)toxic substances	
	4)build -up of scum	Remove scum
Too Alkaline (PH 9 or more)	1)Initial raw material too alkaline	Patience Never put acid into digester

Table 2.3: Problem with Ph.

If the pH in the continuous-load digester becomes too acidic Table(3), you can bring it up to normal again by adding fresh effluent to the inlet end, or by reducing the amount of raw material fed to the digester, or as a last resort, by adding a little ammonia.

If the effluent becomes too alkaline, a great deal of C02 will be produced, which will have the effect of making the mixture more acidic, thus correcting itself. Patience is the best "cure" in both cases. NEVER add acid to your digester. This will only increase the production of hydrogen sulfide[13].

2.2.3 conversion between biogas and electrical energy

Table (2.3): shows the potential biogas energy per year in the US from different animal manure.

Animal type	Animal unit (millionas)	Biogas energy per animal unit/day (thousand BTU	Biogas energy /year (trillion BTU)
Fattened cattle	9.6	25.7	89.9
Milk cows	12.3	20.6	92.4
Other beef and dairy cattle	58.8	23.3	497
Swine	8.5	39.8	124
Poultry	6.1	39.8	125
Total			928

Table 2.4: The potential biogas energy per year in the US from different animal manure.

Biogas potential is calculated by using the biogas energy that can be produced per animal unit and the number of the animal units in the US.

Each animal unit is defined as 1000 pounds of animal. There are about 95 million animal units in the country that could produce about 928 trillion BTU (about 1 quad) of renewable energy per year, which is approximately equal to 1% of the total US energy consumption. The US consumed about 1000 quads of energy in 2005.

Biogas when converted to electrical energy could produce up to 1.8 to 3% of annual electricity consumption in the US.

Table (2.5) shows possible electrical energy from biogas for each animal type. Larger and smaller generators with efficiencies 34-40% and 25% respectively are considered for the electricity generation.

Equation 3.6 provides a conversion between biogas and electrical energy production (biogas e) from each animal with an efficiency η [18].

$$e_{biogas} = E_{biogas}[BTU](0.00293)\left[\frac{Kwh}{BTU}\right]^{\eta} \quad (2.12$$

E_{biogas} is biogas energy production of each animal type.

Table(2.5):Potential electrical energy production from manure of each animal type .

Animal type	possibl electrical energy	form biogas (biollen kWh)
Fattened cattle	66	10.5
Milk cows	6.8	10.8
Other beef and dairy cattle	36.4	58.2
Swine	9.1	14.5
Poultry	9.2	14.7
Total	68	108.8

Table 2.5: The potential biogas energy per year in the US from different animal manure.

2.2.4 Modeling of the biogas generation system

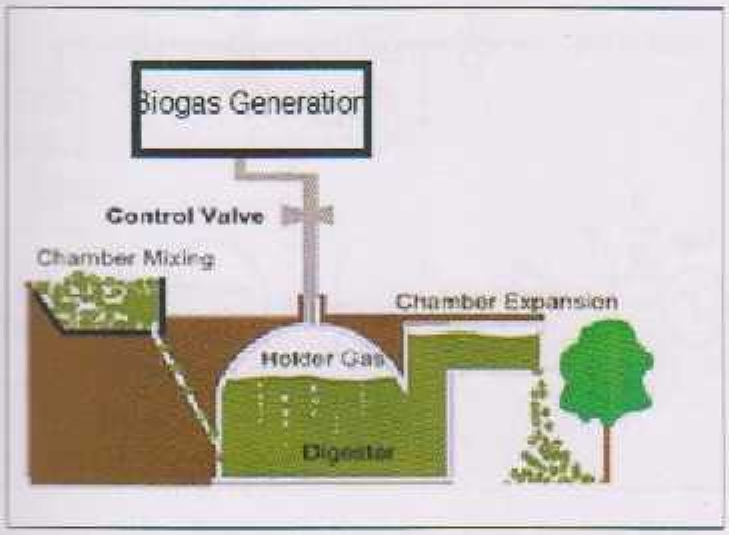

Figure 2.14: biogas system modeling.

General and abbreviations

GE,BGS: Gas engine and BGS.

IG, IM: Induction generator and induction motor.

P: Differential operator with respect to time (=d/dt).

P, Q: Real (active) power and reactive power.

v, i: Voltage and current.

X,Z: Reactance and impedance.

Subscripts

base: Base quantities of induction machine.

C: Quantities of ECB.

d,q: d- and q-axis quantities of induction machine.

s, r: Stator- and rotor-winding quantities of induction machine.

Biogas can used for commercial electricity generation and direct combustion. Commercial electricity generation systems that use biogas consist of an internal combustion engine, a generator, a control system, and an optional heat recovery system.

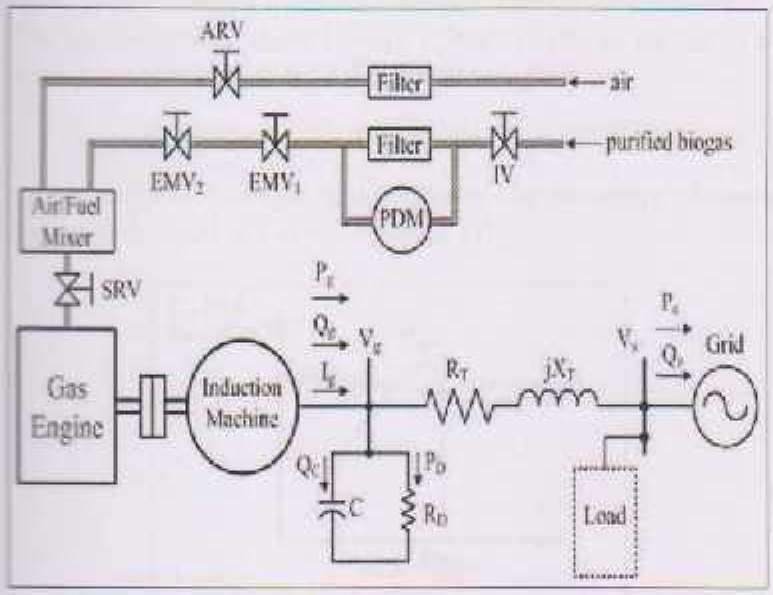

Figure 2.15: Schematic diagram of the studied BGS.

Configuration of the Studied BGS Figure2.15 shows the schematic diagram of the studied BGS [19] The airflow and purified biogas flow in pipelines in front of a gas engine (GE), a single-line equivalent circuit connected between the output terminals of an induction machine, and the power grid inside the large food mill are shown in Figure2.15 The normal operating procedure for starting up the GE-IG set is first to connect the stator windings of the IG to the distribution system through a manual-controlled electromagnetic switch.

When the switch is closed, the IG operates as both an induction motor (IM) and a GE starter, absorbing a large starting current to produce sufficient starting torque to drive the crank of the GE.

When the biofuel mixed with proper amount of air in the combustion chamber of the GE is ignited at correct instants, the GE can normally start up and maintain a sustained rotation to drive the shaft of the IG.

When the rotational speed of the IG is higher than its synchronous speed (1800 r/min), the slip of the IG becomes negative and the IG can deliver electrical power to the distribution system [20].

Biogas engine power output Pout and torque TShaft as a function of engine speed n The approximated shaft torque TShaft of prime-mover of biogas engine and speed is represented by a linear curve given as:

$T_{shaft} = K_1 - K_2 w_2$ .... (2.7)
where T_{shaft} is the shaft torque which shows the drooping characteristic of prime-mover and K_1 and K_2 are constants [21].

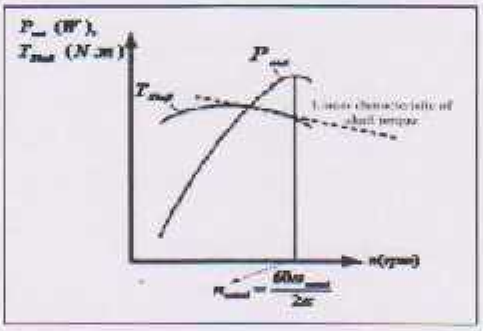

Figure 2.16: Biogas engine power output Pout and torque TShaft as a function of engine speed n.

Chapter 3

System protection, management and maintenance

Chapter 3

System protection, management and maintenance

Renewable energy sources may be distributed in different locations and can be employed as isolated sources to supply electrical energy in village without adding additional investment to transmission lines for connecting to the utility grid. If the utility grid and transmission lines are very far from the villages, it is more economic and convenient to utilize isolated Anaerobic digestion power system to supply required power energy.

Most of the published papers on hybrid systems focused on steady-state performance and Protection and the stability of the hybrid system and interactions did not be evaluated.

3.1 System protection

3.1.1 System ground-fault protection

Ground-fault detection and interruption circuitry perform ground-fault current detection, fault current isolation, and solar power load isolation by shutting down the inverter. This technology is currently going through a developmental process, and it is expected to become a mandatory requirement in future installations[22].So we use main DC and AC breaker, disconnecter to satisfy this goal[3].

For PV system figure 3.1 we put
combiner fuse (MCB DC)/string.MCB rating $=1.25*1.25*I_{sc}$ (pv) .... eq(3.1)

Array disconnector fuse > # of string *MCB rating /string .... eq(3.2)

Inverter fuse(utility disconector) > 1.25*(inverter output power /output voltage).. eq(3.3)

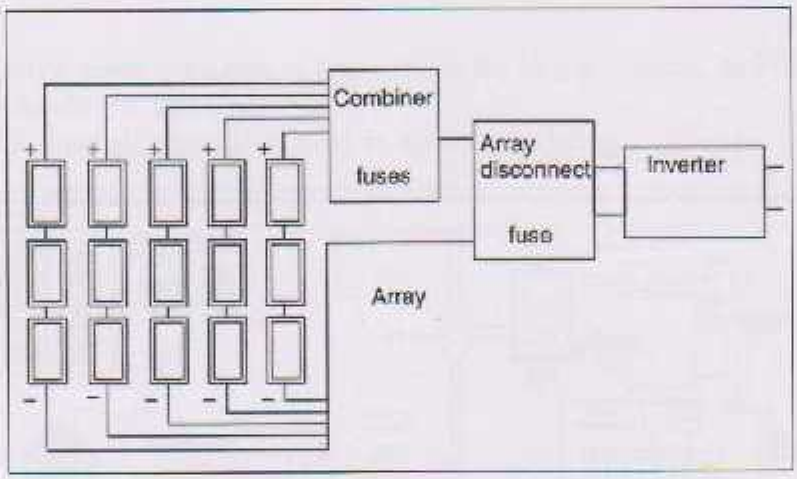

Figure 3.1: PV system protection devices.

For biogas system
Methane genarator MCB > $1.25*_{Irated(methanegenerator)}$ .... eq(3.4).

3.1.2 System Grounding

Grounded: Means that a conductor connects to the metallic enclosure of an electrical device housing that serves as earth.

*Grounded conductor: A conductor that is intentionally grounded. In PV systems it is usually the negative of the dc output for a two-wire system or the center-tapped conductor of an earlier bipolar solar power array technology.

*Equipment grounding conductor:A conductor that normally does not carry current and is generally a bare copper wire that may also have a green insulator cover.

The conductor is usually connected to an equipment chassis or a metallic enclosure that provides a dc conduction path to a ground electrode when metal parts are accidentally energized[22].

3.1.3 Lightning Protection

In geographic locations, such as Florida, where lightning is a common occurrence, the entire PV system and outdoor-mounted equipment must be protected with appropriate lightning arrestor devices an special grounding that could provide a practical mitigation and a measure of protection from equipment damage and burnout[22].**So we use surge arrestor to prevent the hazard**.

We set surge arrester on line to line voltage for biogas system. In PV system it exists inside PV inverter.
Figure3.2 show all protection need in system modeling.

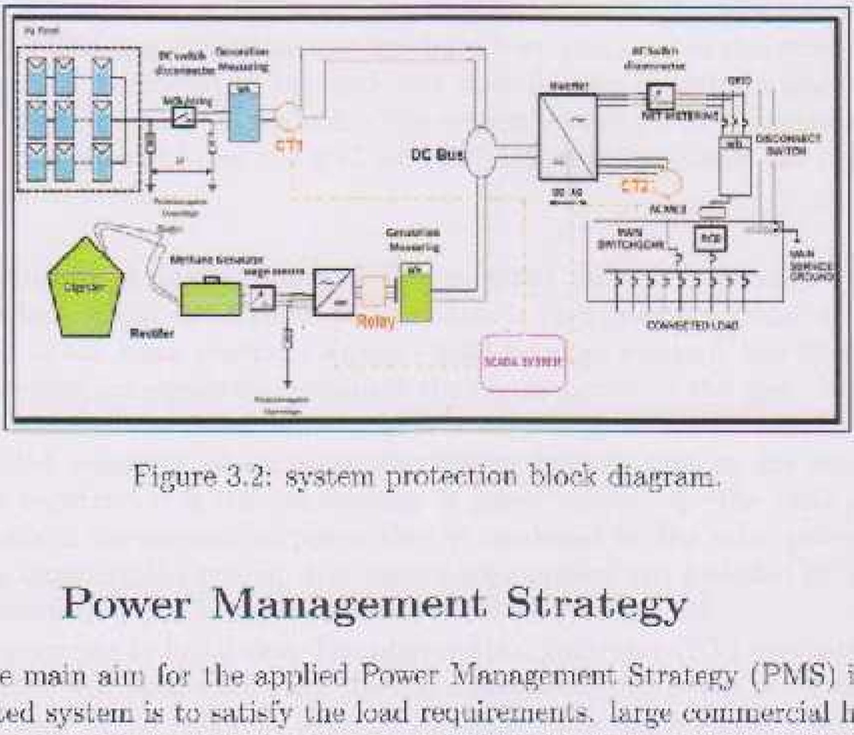

Figure 3.2: system protection block diagram.

3.2 Power Management Strategy

The main aim for the applied Power Management Strategy (PMS) in the adopted system is to satisfy the load requirements. large commercial hybrid power cogeneration systems, power production from the system is monitored by a central monitoring system that provides a log of operation performance parameters. The central monitoring station consists of a PC-type computer that retrieves operational parameters from a group of solar power inverters by means of an RS-232 interface, a power line carrier, or wireless communication system. Upon receipt of performance parameters, a supervisory software program processes the information and provides data in display or print format. Supervisory data obtained from the file can also be accessed from distant locations through Web networking.

Power condition unit that consist inverters,regulators ,control system and also net metering technology to make perfect management between consumption and generation from to Grid.

Small-scale renewable energy systems are becoming increasingly popular due to soaring fuel prices and due to technological advancements which reduce the cost of manufacturing. Solar and biogas energies, among other renewable energy sources, are the most available ones globally.The hybrid photovoltaic (PV) and biogas power system has a higher capability to deliver continuous power with reduced energy. storage requirements and therefore results in better utilization of power conversion and control equipment than either of the individual sources. Power conditioning units (p.c.u.) for such small-scale hybrid PV-biogas generation systems have been proposed in this study. The system was connected to the grid, but it could also operate in standalone mode if the grid was unavailable. The system contains a local controller for every energy source and the grid inverter. Besides, it contains the supervisory controller[23].

Net metering management: The essential difference between a grid-connected system and a stand-alone system is that inverters, which are connected to the main electrical service, must have an inherent line frequency synchronization capability to deliver the excess power to the grid. Net meters, unlike conventional meters, have a capability to record consumed or generated power in an exclusive summation format; that is, the recorded power registration is the net amount of power consumed—the total power used minus the amount of power that is produced by the solar power and biogas cogeneration system. Net meters are supplied and installed by utility companies that provide grid-connection service systems [22].
PMS principle in fig3.2 that The photovoltaic generator (PV) also methane generator will produce during the day enough electric power cover the requirements of the different loads in the farm while the e excess power will injection to grid .The other case methane and solar generator are not able to cover the all requirements of the different loads in the farm so the grid will provide the load energy requirements .The difference between production and consumption energy is called net metering technology by unidirectional meter.

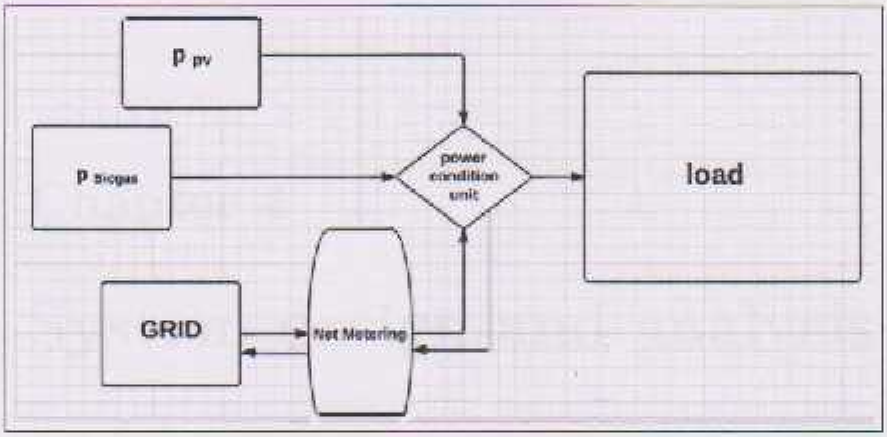

Figure 3.3: Logical block diagram .

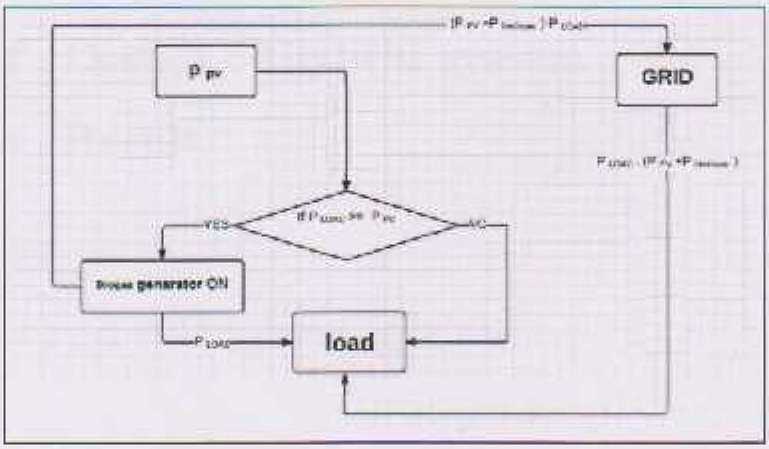

Figure 3.4: Power Management Strategy(PMS).

3.3 Maintenance

In general, solar power system maintenance is minimal, and PV modules often only require a rinse and mopping with mild detergent once or twice a year. They should be visually inspected for cracks, glass damage, and wire or cable damage. A periodic check of the array voltage by a voltmeter may reveal malfunctioning solar module . The same way will applied on biogas system[22].

Chapter 4

System design and analysis

4.1 Load analysis

4.2 Design of hybrid system

4.3 Result

Chapter 4

System Design And Analysis

4.1 Load analysis

We take a typical load 'Arroub Technical college'. the load consumption in 2013 as shown in table(4.1).

Month	Total consumption(kW.h)
January	25318
February	22244
March	21316
April	23444
May	22214
Jun	23246
July	21160
Augest	16540
September	20376
October	26430
November	26154
December	27566
Total	276008

Table 4.1: Load consumption in 2013

The monthly load curve is shown in figure4.1 represent Minimum load. The shown data is the consumed energy through year ,maximum demand in December as shown in figure 4.3 .

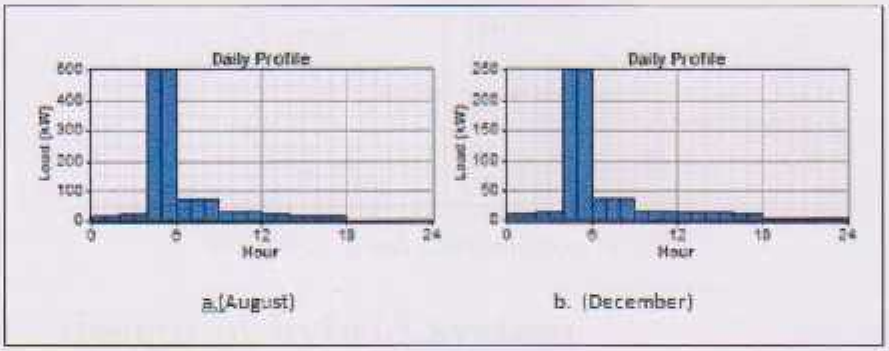

Figure 4.1: Load monthly curve(August and December).

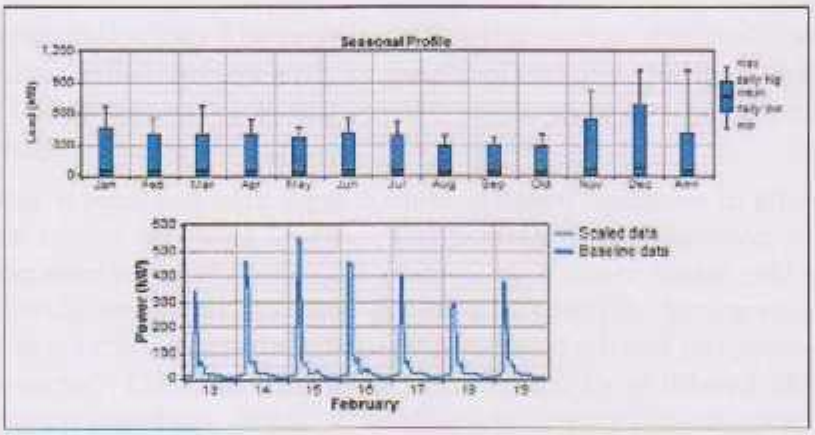

Figure 4.2: The monthly load consumption.

Some important factor for load in table[4.2].

Average (kWh/day)	1105
Average(kW)	300
Peak(kW)	500
load factor	0.63

Table 4.2: Load consumption in 2013

4.2 design of hybrid system

4.2.1 Biogas system design

Experimental set up The experimental setup used in this work consists of a bioreactor called digester with a capacity of 800 liters having a cylindrical shape (1.65 m high and 1.25 m diameter) and a gasometer bell used for biogas storage.

The latter is equipped with a gas counter installed upstream to allow quantification of the produced biogas. The heating of the digestion substrate to a temperature equal to 37°C is ensured by a water heater and a warm water circulation pump in closed circuit. In addition, homogenization of the substrate during experiments is done by hand stirrers introduced inside the bioreactor. Once the digester is fed with 440 kg of diluted (30%) and homogenized cow-dung, it has to be closed in order to create an anaerobic environment necessary for the anaerobic digestion process.

The fermentation of 440 kg of cow-dung in a 800 liter digester gave biogas production of 26.9 m3 with an average content of 61% in CH4, value considered optimal and energy equivalent to 592.8 MJ (164.5 kWh).

'Arroub Technical college' have a 41 cow and 50 sheep , 12 ton per year of cow-dung 50 kg per year of sheep-dung and digester with a capacity of (3.14*2*(1.5)2̂)=14.13m3 = 1413 liters ,having a cylindrical shape (3 m high and 1. 5 m diameter).

- 12ton/y*41=492 ton/y

- 50kg/y*50=2500 kg/y

- Total of the dung per year =492000kg+2500=494500 kg/y

- per day = 494500/365=1354.7 kg/day≈1354.7

- Every 10 days are fermentation process and biogas production

- 1355*10day=13550kg

Based on past experience 440 kg of cow-dung in .8m3 volume of digester to produce 164.5 kWh.

We choose methane generator with following specification Suitable gas: Biogas.

Gas consumption: 1.5m3/kW.h.

230V 50 Hz.

Running Power 1200W.

Peak Power1300W.

General Temperature Requirement: -5°C 40°C .

General altitude:(2000m(It may cause problem if the altitude level is higher than 2000 meters).

620 460 470mm/set 55kg/set .

HS CODE: 85022000.

Figure 4.3: The monthly load consumption.

440kg⟶8m3

Size of the digester=(13550kg*.8m3)/440kg=24.63m3 ≈25m3.

8m3⟶164.5 kW.h.

Energy= 25*164.5)/.8=5140.625kWh) .

kWh per month = 15421.875 kWh.

Digester existing in farm=14.13 m3.

New digester =25m3-14.13m3=10.87≈11m3 .

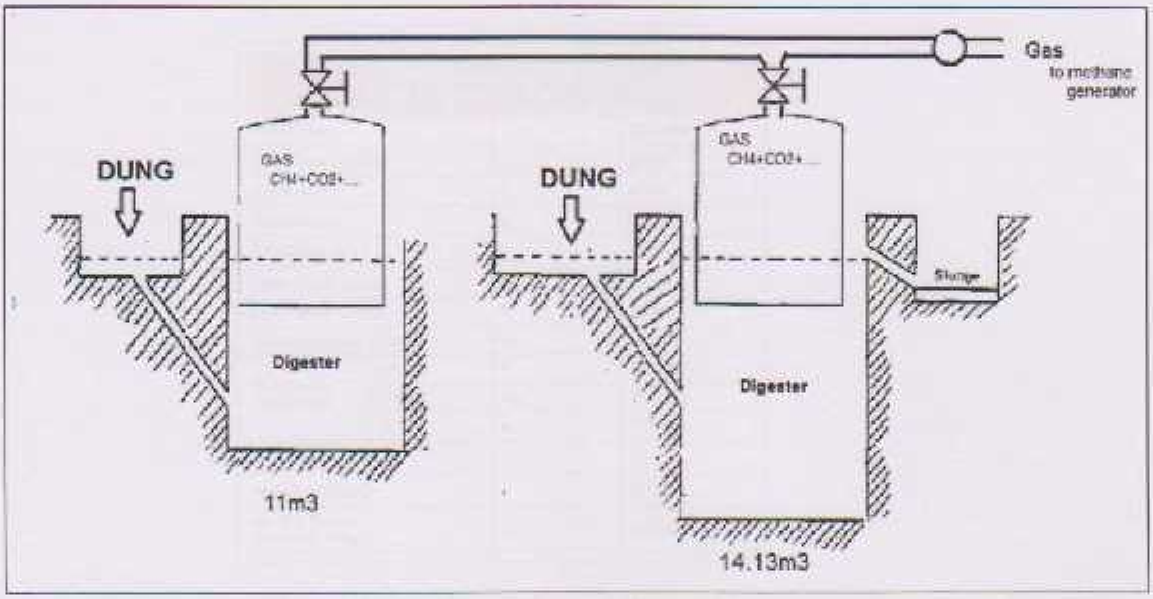

Figure 4.4: Two digester design in parallel.

Protection calculation

*MCB AC =1.25*I rated current

= 40*1.25

=50 A

*Surge arrestor= we setting it on line to line voltage=400v.

4.2.2 solar system design

Electrical Data Measured at Standard Test Conditions (STC): Irradiance 1000W/m², AM 1.5, and cell temperature 25°C			
Model Name			SER-228P
Peak Power (+5/-3%)		P_{mpp}	228 W
Efficiency		η	13.9 %
Rated Voltage		V_{mpp}	29.6 V
Rated Current		I_{mpp}	7.70 A
Open Circuit Voltage		V_{oc}	37.8 V
Short Circuit Current		I_{sc}	8.30 A
Maximum System Voltage		UL	600 V
Temperature Coefficients	Power	P	-0.45 %/K
	Voltage	V_{oc}	-0.35 %/K
	Current	I_{sc}	0.05 %/K
NOCT (±2°C)			45° C
Series Fuse Rating			15 A
Limiting Reverse Current (2strings)		I_r	10.4 A

Figure 4.5: photovoltaic datasheets.

Provisional Technical Data	Sunny Tripower 20000TL
Input (DC)	
Max. DC power (@ cos φ = 1)	20 450 W
Max. input voltage	1 000 V
MPP voltage range with a line voltage of 230 V / rated input voltage	580 V - 800 V / 580 V
Min. input voltage / start input voltage	570 V / 620 V
Max. input current	36 A
Max. input current per string	36 A
Number of independent MPP inputs / strings per MPP input	1 / 6

Figure 4.6: Inverter datasheet.

Minimum load=16540 kWh /month.

Maximum load= 28084 kWh /month .

Energy produce by biogas=15421.875 kWh /month .

We choose maximum load to calculate pv energy(worse case).

Energy produce by PV system =Energy (load)-Energy (methane gas)= 28084-15421.875=12662.125 kWh /month .

⟶Addition a correction factor to PV system + 10% .

Energy from PV system =12662.125+(10%*12662.125)=13928.3375 kWh /month ≈14000kwh.

Pac =(14000/30)/5=93.33kw .

From equation (2.6):

Pdc =93.33/.75=124.44kw

From equation (2.7):

Area =124.44/(1*13.9%)=895.283m2≈900m2

From equation (2.8):

Ppeak=466.66/5=93.332kW

From equation (2.9):

No of module=93.332/.228=409.35 between 400 or 401

From equation (2.10):

No of string =20*29.6=592v ,The inverter range of 570-620 v for the inverter picked, which fits nicely with MPPT range.

This suggests using an array with (20*4) ,So the number of array is=(400/80) =5 array a total of 400 module.

From equation (2.10):

No of inverter=(20*8.3) /36=4.6≈5 inverters.

Protection calculation

From eq(3.1) the combiner fuse (MCB DC)/ string.

MCB rating =1.25*1.25*8.3 =13 A

SO the number of the design MCB DC= 20 combiner fuse.

From eq(3.2) Array disconnector fuse # of string

*MCB rating /string =20*4=80A/Array.

Total number of disc fuse =5 MCB.

From eq(3.3) Inverter fuse(utility disconector) 1.25*(inverter output power/output voltage)

=1.25*(20 000 W/240)= 60A .

Chapter 5

Photovoltaic - Anaerobic digestion system

Chapter 5

Photovoltaic - Anaerobic digestion system

In this chapter, evaluation of the system components was performed (photo voltic system , Anaerobic digestion system).

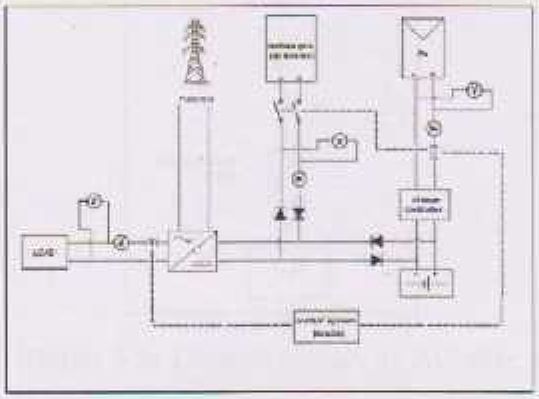

Figure 5.1: Model Power circuit.

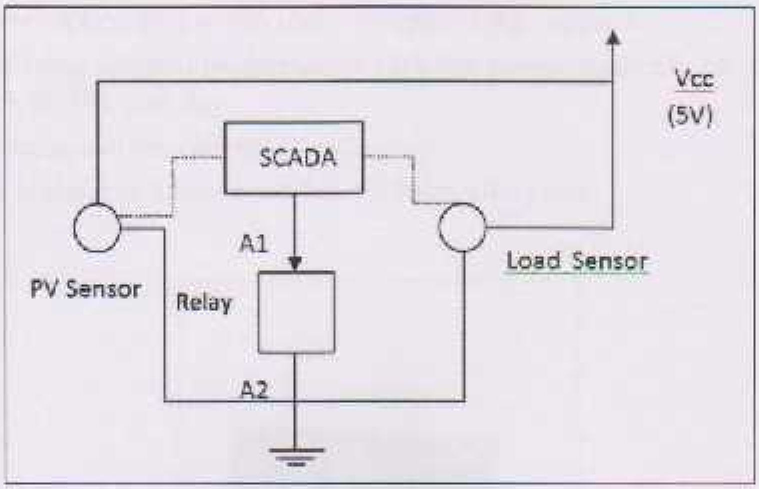

Figure 5.2: Control circuit at DC side.

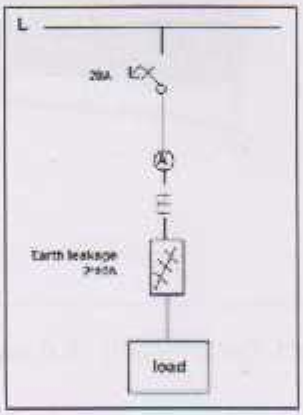

Figure 5.3: Control circuit at AC side.

5.1 Basic Specifications of the Photovoltaic Panel

The panel output is a DC voltage when illuminated by either sun or lamp Technical data:

Maximum nominal power: 66W.

Voltage at maximum power point (Vmpp): 17.8 V.

Current at maximum power point (Impp): 3.70 A.

Short-circuit current (Isc): 4.05 A.

Open circuit voltage (Voc): 22.25 V.

Dimensions: 660 x 35.5 x 780 mm. Weight: 3 Kg. approx.

Battery offering optimal performance with low power applications. Capacity: 32Ah with 96 Wh per day.

Set of interconnection cables.

Anodized aluminum framework for modules allocation.

Figure 5.4: Photovoltaic Panel.

5.2 Basic Specifications of the Methane Generator

We replace methane Generator by DC power supply on model(12 V DC) Obstacles :*High cost(1000$ for 1.2Kw Gen). Deal with methane generator very dangerous(Inflammable)

Figure 5.5: DC Power supply.

SPECIFICATIONS Fixed Output: 5V DC at 3 amps maximum line regulation of 0.2% load regulation of 1% with a % maximum ripple of 10mV p-p. Variable Output: +/- 1.5V DC to +/- 15V DC at 1 amp maximum, line regulation of 0.5%, load regulation of 1% with maximum ripple of 10mV p-p. Model 3040 With extra 30VAC OT output. Available only as a kit.

5.3 Basic Specifications for inverter

Figure 5.6: Pure sine Inverter.

- Model Number: PSE-1000VA
- Output Power: 500 - 1000W
- Size: 341x146x210
- Weight: 8.5Kgs
- Input Voltage: 12V
- Output Voltage: 220V
- Output Frequency: 45Hz-65Hz
- Output Current: 3.18A

5.4 Basic Specifications for ACS712 5A Hall Effect Current Sensor Module

This sensor takes current signals from PV and Load and transfer it to voltage then transfer voltage signal to PLC and SCADA system after that PLC make signal management and controlling and send command signal to methane relay (ON/OFF) .

Figure 5.7: ACS7125A Sensor.

5Amp Current Sensor Module based on the ACS712TELC-05B hall effect Sensor mount on a convenent board with termnial strip for connecting your load to monitor and header pins to interface with your Arduino or micro controller. Power: 5Vdc +-0.5V On board power LED Measures: positive to negitive 5Amps AC or DC Sensitivity: 185mV per Amp

5.5 Basic Specifications for battery ,relay ,load and charge controller

Figure 5.8: Battery.

- sage: UPS, Inverters and Solar Systems
- Voltage: 12v
- Sealed Type: Sealed
- Maintenance Type: Free
- Size: 483*170*239*241mm
- Weight: 12 kg
- Nominal Capacity: 150AH

Figure 5.9: DC relay.

- Coil Resistance: 1.15kohm
- Coil Type: -
- Coil Voltage: 24VDC
- Contact Configuration: DPDT
- Contact Current: 8A
- Contact Material: Silver Nickel
- Contact Voltage VAC: 250V
- Contact Voltage VDC: -
- Product Range: 40 Series
- Relay Mounting: Through Hole
- Relay Terminals: Solder
- Relay Type: Power

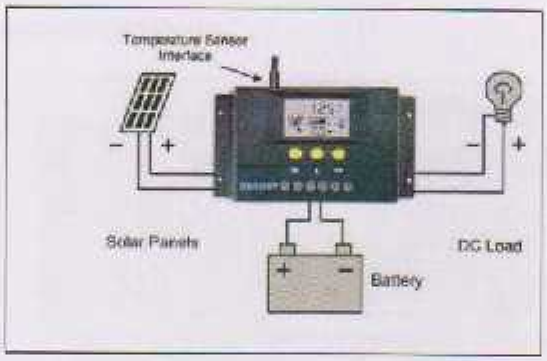

Figure 5.10: charge controller diagram.

Figure 5.11: loads Specifications.

PLC Unit with unitypro software

Figure 5.12: PLC Unit with unitypro software .

- Main functions
- Power supply dimensioning assistance(24 VDV)
- Management of 16 racks with their accessories and connections
- Links between racks management
- Fipio devices management
- Export to Unity Pro
- Layout drawing
- Preparation of a parts list to quote via link with the quotation tool Quick-Devis (TM)

5.6 Model Procedures

In the beginning we Connect the hardware component as shown in Fig 5.1,Fig5.2, Fig5.3 ,then program the load management and controlling on unitypro software ,connect two PLC's analog terminal (I/P) Pin for pv current sensor ,anther (I/P) Pin for load current sensor (O/P) digital Pin for methane Generator as shown in Fig (5.12).
PV ,load current sensors have sensitivity(185mV/1A)so when we turn on Led 30W ,Iled=(Power /220V)=0.136A, the sensor gives reading about 0.5 V (ps :there's a ratio between ac and dc current =18.333) , after that PLC take signals from load sensor and also from pv sensor and compare the signals if IPV¡ ILOAD then PLC send command to methane relay turn on anther case methane relay will be off :

Figure 5.13: Project image.

Project Obstacles:

*Buy methane generator (high cost)and need high safe deal (inflammable gas) we replace it by DC power supply as methane generator then control current signal simply. *Reverse current from methane generator to battery and from battery to methane Solve this problem was by using Diode (as rectifier and to get unidirectional current)as shown in Fig5.1. *Relay value first we chose relay with 12 V DC put it doesn't work because PLC voltage o/p signal 24 V DC so we replace it by 24V DC relay. *Finding current sensor suitable for model in the market it commercial and with high ratio we replace it by hole effect sensor ACS712 5A.

Chapter 6

Result and feasibility study

6.1 Result

6.2 Economic feasibility

Chapter 6

Result and feasibility study

6.1 Result

Some result and compression(on excel,PVsys software)

1. Figure 6.1 show the intervals where Embedded generation injection the grid also the intervals where the load consume from the grid.

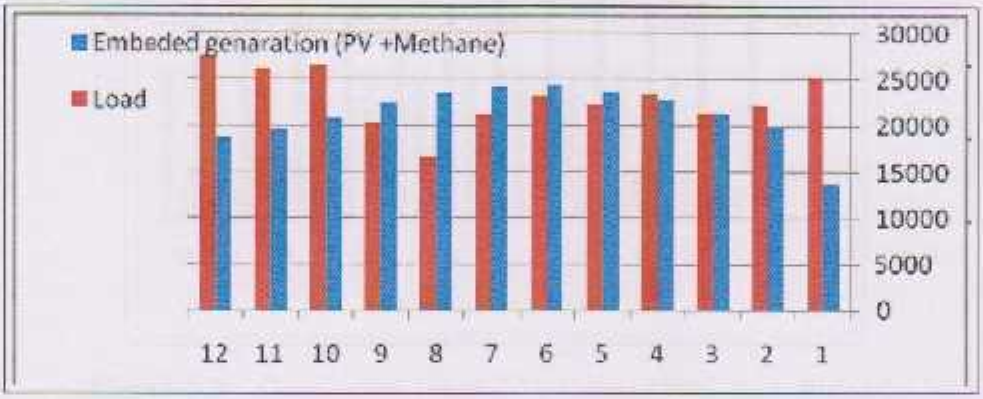

Figure 6.1: The load demand and the output power of the embedded generation.

In figure 6.2The photovoltaic generator (PV) also methane generator will produce during the day enough electric power cover the requirements of the different loads in the farm while the e excess power will injection to grid . the other case methane and solar generator are not able to cover the all requirements of the different loads in the farm so the grid will provide the load energy requirements .The difference between production and consumption energy is called net metering technology by unidirectional meter

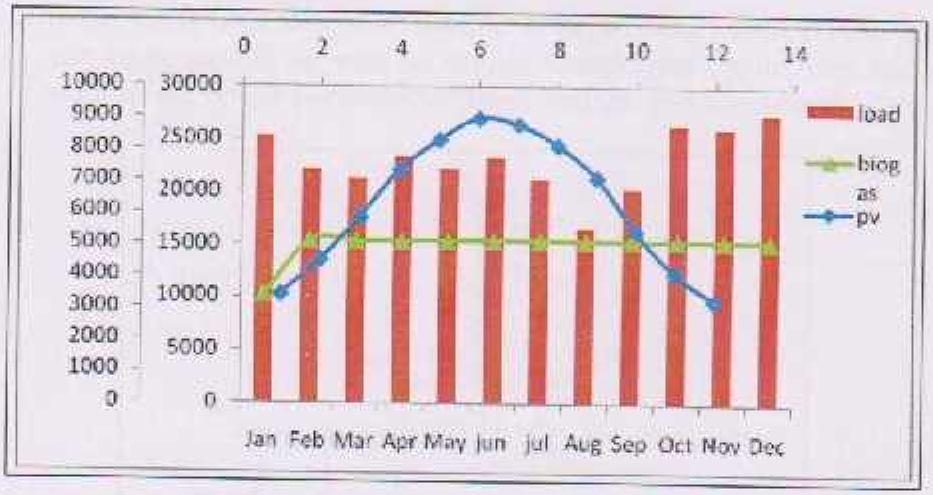

Figure 6.2: Show the three load curve for (PV, methane and load).

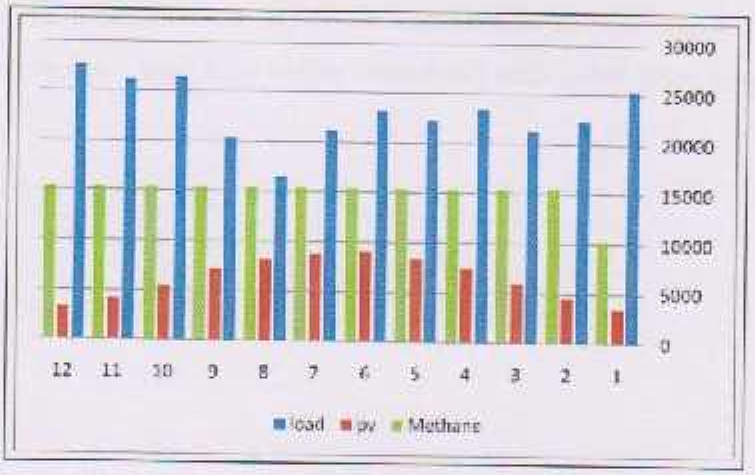

Figure 6.3: Genaration from(PV, mehane)and load dimand.

2. Some result Load flow analysis(from e-tap software) 2 We do this analysis to be sure if we want to change transformer ,cable from the net work to get better performance(fixed Voltage and frequency).

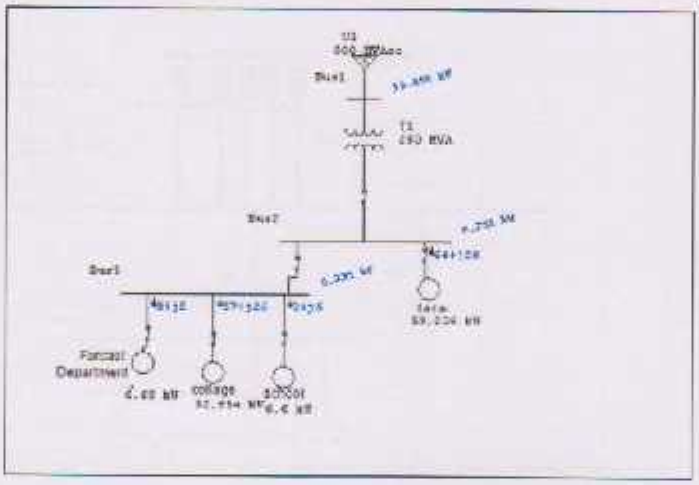

Figure 6.4: load flow before connected embedded generation.

The first caseload flow

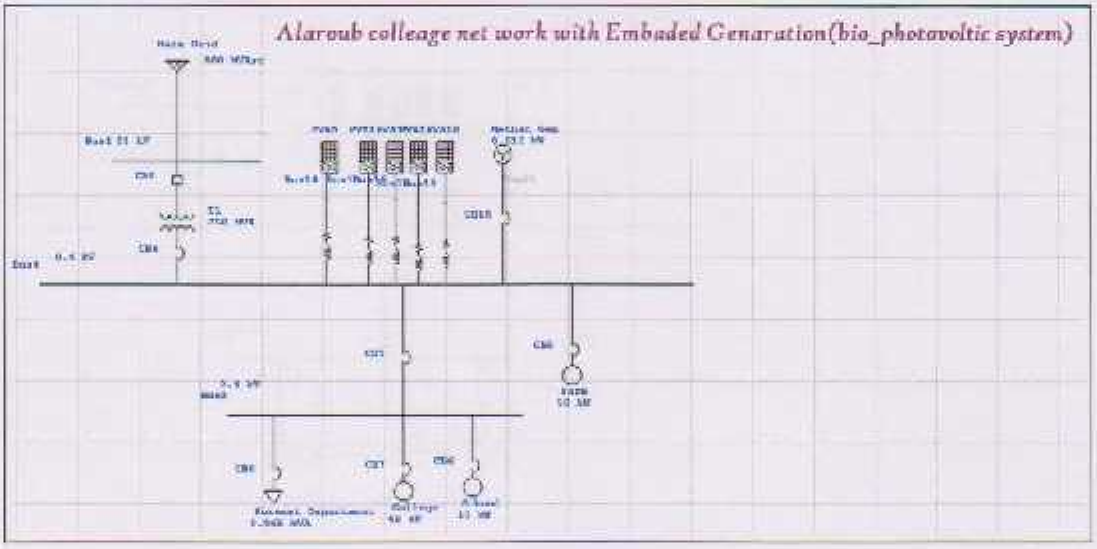

Figure 6.5: load flow after connected embedded generation.

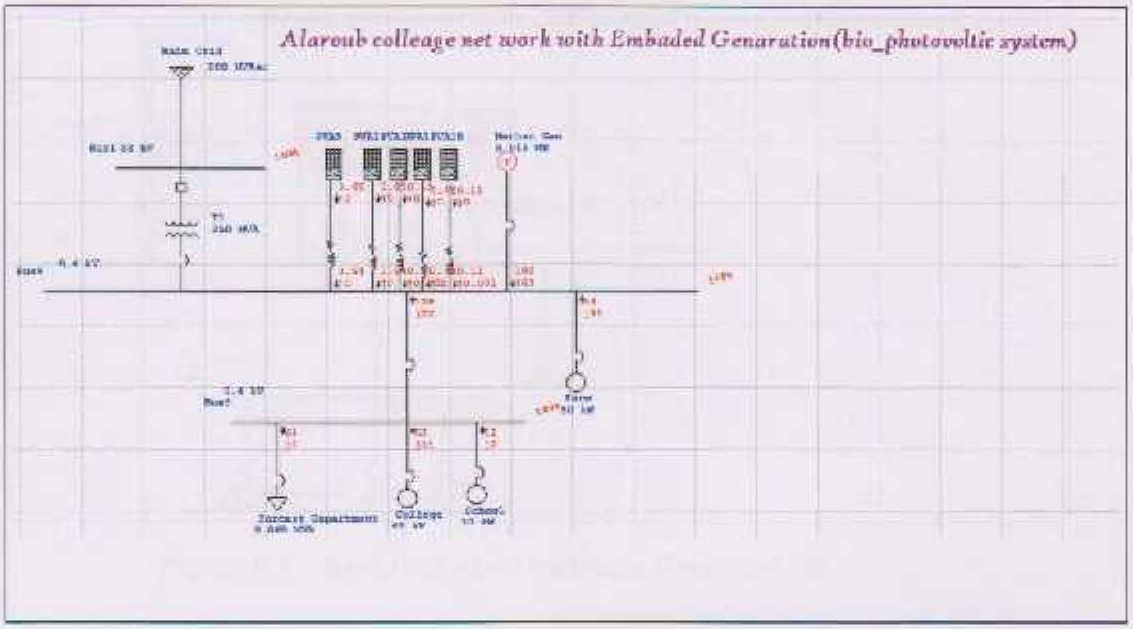

Figure 6.6: load flow after connected embedded generation.

Second case when methane genarator off :

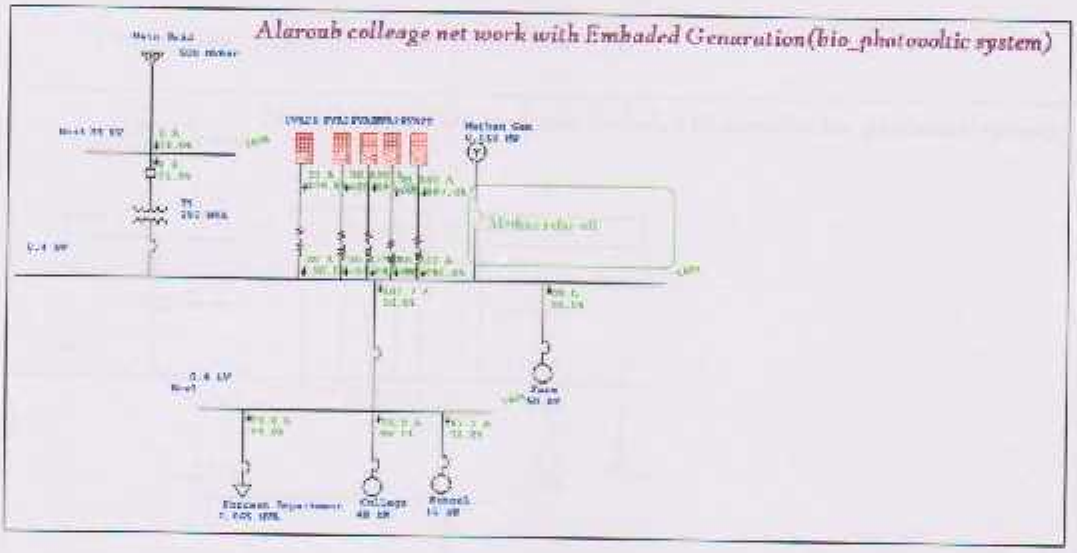

Figure 6.7: load flow when methane Generator off.

As you see the load demand has taken from PV system and the shortage demand has taken from grid .

Load Flow Result Analyzer

Study Reports

Ref.	Select	Reports
	☑	Untitled

ID	kW	kvar	Amp	% PF	% Lo
College	52.214	10.63	76.91	97.93	
Farm	54.301	40.725	97.97	80	
Forcast Department	64.347	9.169	93.82	99	
School	11.589	2.353	17.07	98	

Figure 6.8: load flow result analyzer without capacitor .

As you see theirs a problem in PF, so we insert capacitor bank to make PF correction.

Tharid case when methane genarator ON

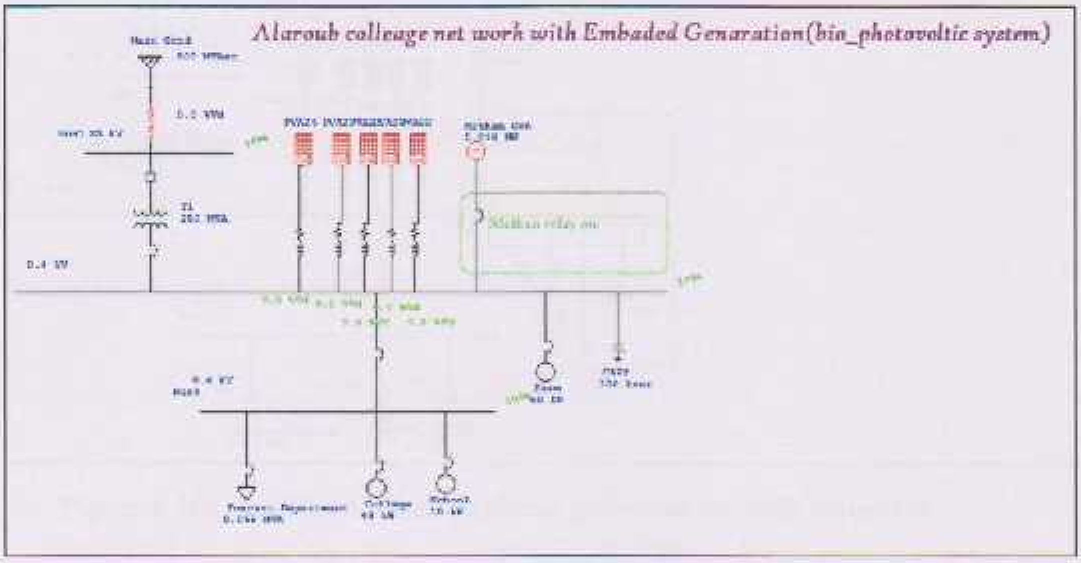

Figure 6.9: load flow with voltage drop value.

As you see there's no problem in net work (V drop) with range (0.9-1.1)

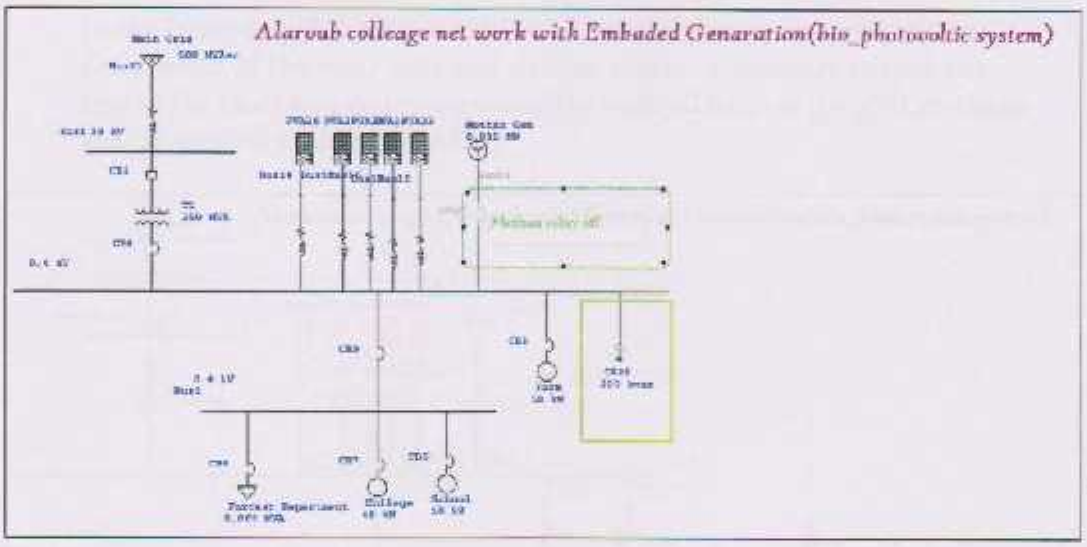

Figure 6.10: load flow when methane generator on with capacitor.

We notice when adding capacitor Improving the PF can maximize current-carrying capacity, improve voltage to equipment, reduce power losses.

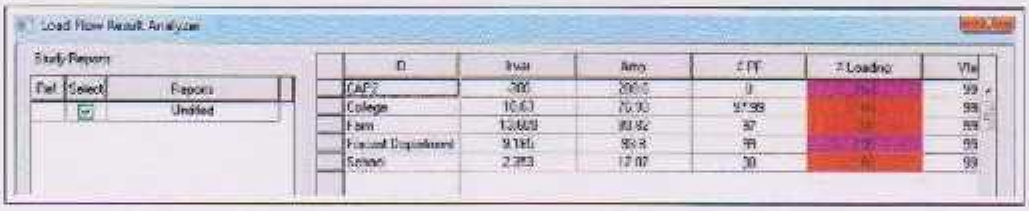

Figure 6.11: load flow result analyzer with capacitor .

In the latter case has been added to current sensor to measure the output current of the solar cells and current sensor to measure output current of the loads and do management between all sources (pv,grid,methane gen)by control system (SCADA).

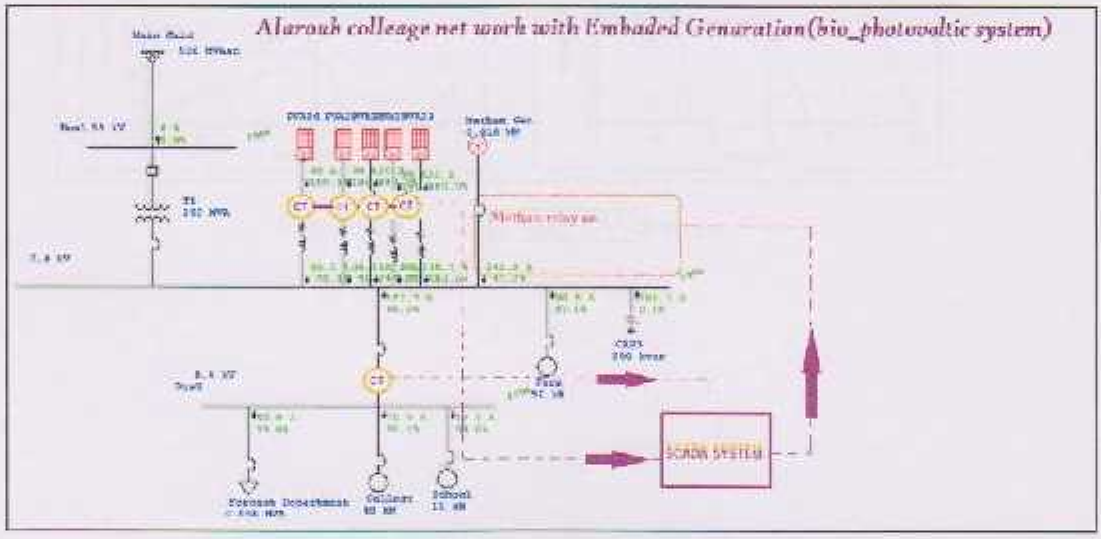

Figure 6.12: load flow when methane generator on with SCADA system .

As you see theirs no power withdraw from grid.

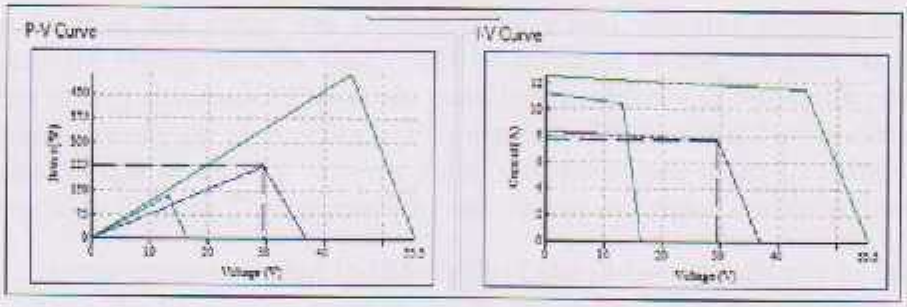

Figure 6.13: P-V and I-V curve .

6.2 Economic feasibility

The focus of the study was to determine a cost effective combination of alternative energy sources that could be installed at the complex to meet future energy demands. This study examines the merits of renewable energy technologies of solar photovoltaic (PV) arrays and biogas in a Alarub colleage. analyzing this possibility very carefully, the choice was made to reduce the life cycle to 25years The reasons why this choice was made are the following:

1. It was considered that the life cycle of the project should not be longer than the longest life cycle of any of the technologies implemented (PV has a 25 year life cycle).

2. 25 years allows the customer to reevaluate the technologies used in light of any technological developments throughout the project lifetime. Table (6.1): shows the final prices for solar systems and biogas system considered in this report. These prices include panel cost, inverter cost, Methane generator cost ,Protection Equipment cost ,Battery cost,and installation cost.

Equipment	number	cost	Cost
Pv	400	900 NIC	360000 NIC
Inverter	5	9000	45000
Methane generator	1	6000	6000
Protection Equipment		3000	3000
Battery	52	900	900
installation		5000	5000
Total		419900	

Table 6.1: Equipment cost for hybrid system.

6.2.1 Net cash flow

Net cash flow refers to the difference between a broject's cash inflows and outflows in a given period.

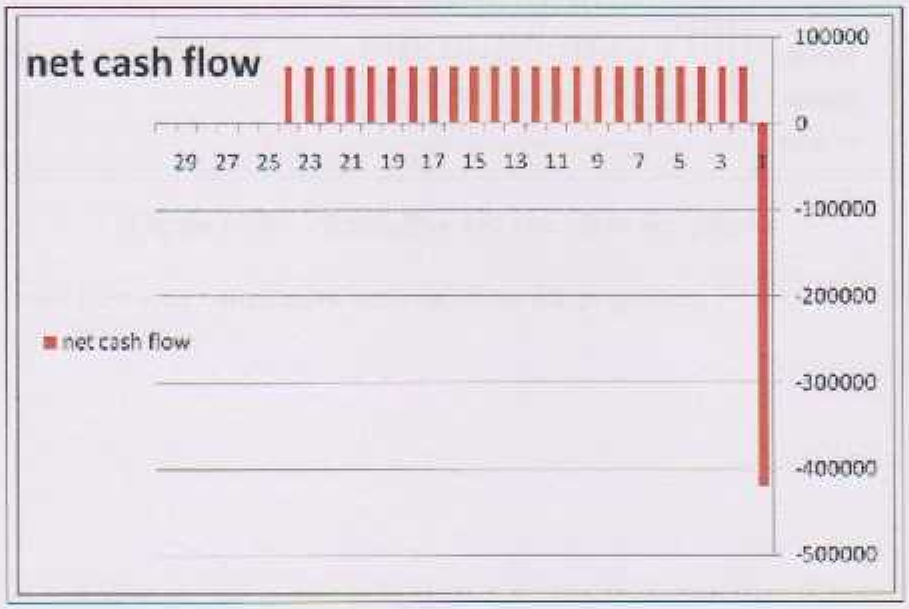

Figure 6.14: Net cash flow for broject.

6.2.2 Cumulative Cash Flow

Add the net cash flows from operations, investing and financing. The total equals the net cash flow for the period. A positive number indicates that your company generated more cash than it spent; a negative number indicates it spent more than it generated. As it is shown in fig 6.15 payback period for the project after 8 years.

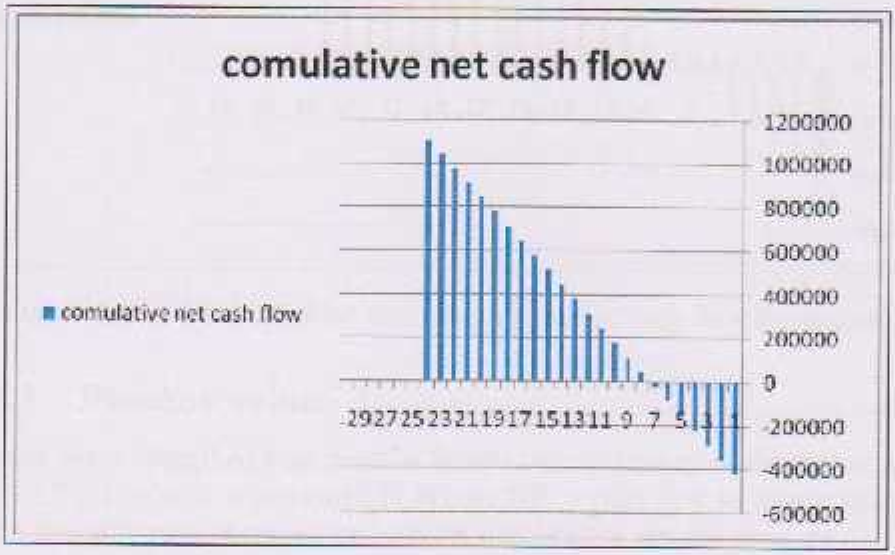

Figure 6.15: cumulative net cash flow for project.

net cash flow and cumulative net cash flow for project.

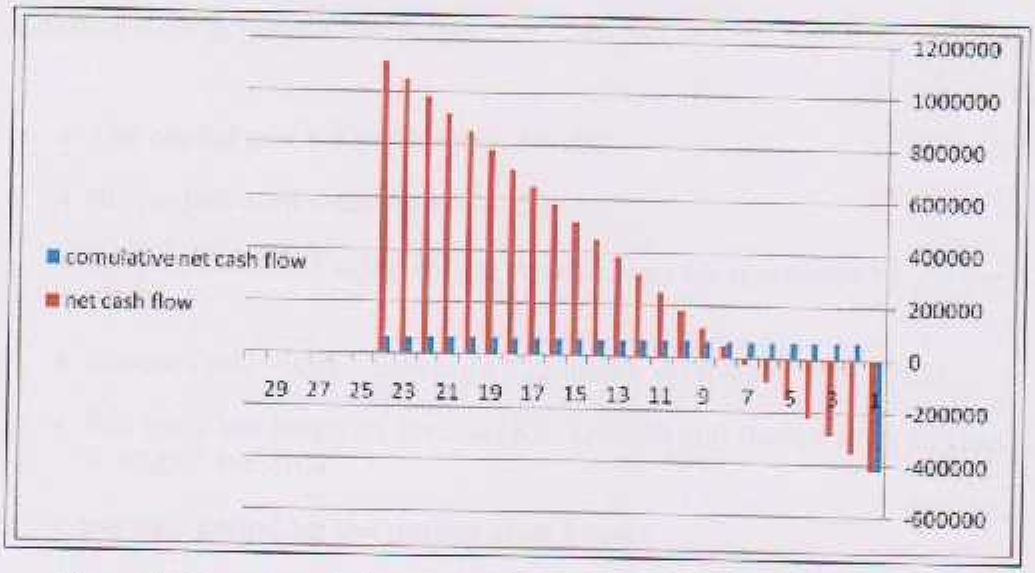

Figure 6.16: net cash flow and cumulative net cash flow for project

6.2.3 Present value

Present value describes how much a future sum of money is worth today. PV = CF/(1+r)n ... equation(6.1) Where CF = cash flow in future period r = the periodic rate of return or interest (also called the discount rate or the required rate of return) n = number of periods

Consideration in project evaluation

- The capital cost for a project = 419900
- the project need maintenance = 500
- per year and effect aging reduce the efficiency for equipment by 2% per year.
- Income /year =kwh* Sale price *12 month =14000*.4*12= 67200
- Efficiency loss based on module (20% after 20 yrs) Income after 20 year = 67200*.8=53760
- payback period for the project after 8 years.

Chapter 7

Conclusion and Recommendation

Chapter 7

Conclusion and Recommendation

Small-scale renewable energy systems are becoming increasingly popular due to soaring fuel prices and due to technological advancements which reduce the cost of manufacturing. Solar and methane energies, among other renewable energy sources, are the most available particularly in rural area . The hybrid photovoltaic (PV) and methane power system has a higher capability to deliver continuous power with reduced energy storage requirements and therefore results in better utilization of power conversion and control equipment than either of the individual sources. Power load management for such small-scale hybrid PV-methane generation systems have been proposed in this study. The system was connected to the grid, but it could also operate in standalone mode if the grid was unavailable. The system contains a local controller for every energy source and the grid inverter. Besides, it contains the supervisory controller. the system uses hybrid renewable sources biogas and solar energy. biogas from Cow and other animal dung to produce energy that will give environment sense . Main purpose of this project is to investigate electrification of 'Arroub Technical college for rural development area , consists of photovoltaic generators and methane generator . The advantage that energy system with environment sense , Isolated Micro-Grids With Renewable Hybrid Generation, More reliable Hybrid system with combines several energy systems together. The photovoltaic generator (PV) also methane generator will produce during the day enough electric power cover the requirements of the different loads in the farm while the e excess power will injection to grid . the other case methane and solar generator are not able to cover the all requirements of the different loads in the farm so the grid will provide the load energy requirements .The difference between production and consumption energy is called net metering technology by unidirectional

meter.
Finally The system have ability to connect on the main grid and exchange between tow system to satisfy high reliable and sell exceed energy to main grid so that will give a good economic benefits for the farm, so it will represent micro grid system far from traditional grid failure and loses.

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Appendix A

Appendix A

Grid-Connected System: Simulation parameters

Project : **Grid-Connected Project at Al-Arub College**

Geographical Site	**Jerusalem**		Country	Israel
Situation	Latitude	31.4°N	Longitude	35.1°E
Time defined as	Legal Time	Time zone UT+2	Altitude	790 m
	Albedo	0.20		

Meteo data : Jerusalem, Synthetic Hourly data

Simulation variant : **No shading effects**

Simulation date 23/04/15 14h34

Simulation parameters

Collector Plane Orientation	Tilt	30°	Azimuth	0°
Horizon	Free Horizon			
Near Shadings	No Shadings			

PV Array Characteristics

PV module Si-mono	Model	**SLK60M6L 228W**		
	Manufacturer	Siliken		
Number of PV modules	In series	8 modules	In parallel	51 strings
Total number of PV modules	Nb. modules	408	Unit Nom. Power	228 Wp
Array global power	Nominal (STC)	93 kWp	At operating cond.	86 kWp (50°C)
Array operating characteristics (50°C)	U mpp	217 V	I mpp	397 A
Total area	Module area	662 m²		
Inverter	Model	**G-332, three**		
	Manufacturer	Leonics		
Characteristics	Operating Voltage	165-300 V	Unit Nom. Power	21 kW AC
Inverter pack	Number of Inverter	4 units	Total Power	84 kW AC

PV Array loss factors

Thermal Loss factor	Uc (const)	20.0 W/m²K	Uv (wind)	0.0 W/m²K / m/s
=> Nominal Oper. Coll. Temp. (G=800 W/m², Tamb=20°C, Wind velocity = 1m/s.)			NOCT	56 °C
Wiring Ohmic Loss	Global array res.	9.1 mOhm	Loss Fraction	1.5 % at STC
Module Quality Loss			Loss Fraction	2.5 %
Module Mismatch Losses			Loss Fraction	2.0 % at MPP
Incidence effect, ASHRAE parametrization	IAM =	1 - bo (1/cos i - 1)	bo Parameter	0.05

User's needs : Unlimited load (grid)

Grid-Connected System: Main results

Project : **Grid-Connected Project at Al-Arub College**

Simulation variant : **No shading effects**

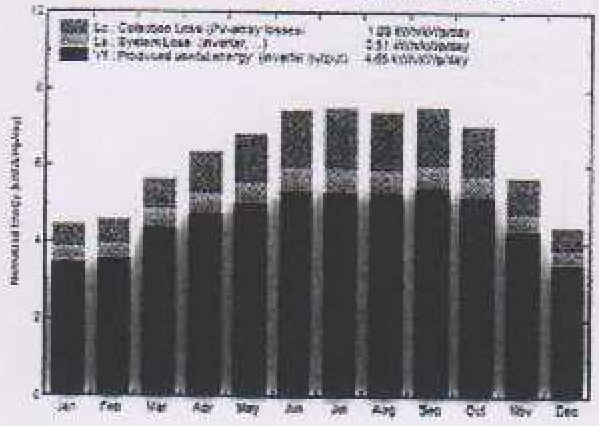
Main system parameters

	System type	**Grid-Connected**		
PV Field Orientation	tilt	30°	azimuth	0°
PV modules	Model	SLK60M6L 228W	Pnom	228 Wp
PV Array	Nb. of modules	408	Pnom total	**93 kWp**
Inverter	Model	G-332, three	Pnom	21 kW ac
Inverter pack	Nb. of units	4.0	Pnom total	**84 kW ac**
User's needs	Unlimited load (grid)			

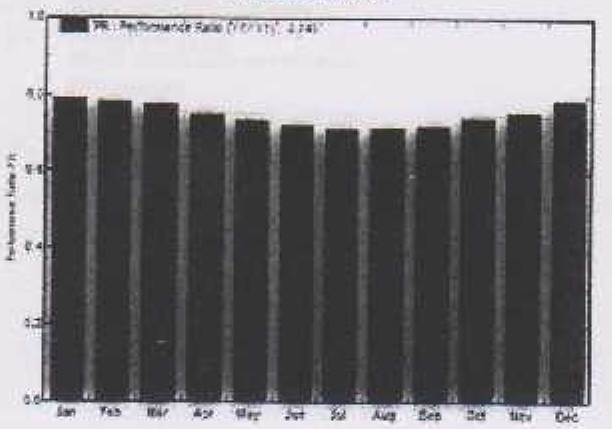
Main simulation results

System Production	**Produced Energy**	**158 MWh/year**	Specific prod.	1696 kWh/kWp/year
	Performance Ratio PR	74.3 %		

Normalized productions (per installed kWp): Nominal power 93 kWp



Performance Ratio PR



New simulation variant
Balances and main results

	GlobHor kWh/m²	T Amb °C	GlobInc kWh/m²	GlobEff kWh/m²	EArray kWh	E_Grid kWh	EffArrR %	EffSysR %
January	90.5	7.90	137.0	134.1	11223	10180	12.59	11.06
February	101.0	8.40	127.8	124.6	10340	9514	12.22	11.30
March	153.0	12.70	175.4	172.9	14232	12635	12.07	11.57
April	187.0	15.10	196.5	194.6	14730	13324	11.71	10.14
May	221.8	19.00	211.5	204.9	15704	14438	11.46	10.32
June	250.0	21.20	223.0	215.4	16002	14912	11.24	10.13
July	263.0	22.90	233.1	225.0	17163	15438	11.12	10.01
August	236.0	23.40	238.2	223.2	16996	15511	11.14	10.08
September	202.0	22.30	225.8	218.5	16765	15146	11.20	10.13
October	167.0	18.00	216.8	213.1	16677	15057	11.62	10.40
November	117.0	12.50	171.6	167.1	13068	12049	11.73	10.62
December	91.6	8.50	137.0	133.5	11194	10016	12.24	11.04
Year	2101.8	16.20	2262.1	2216.9	175123	157632	11.58	10.44

Legends:

GlobHor	Horizontal global irradiation	EArray	Effective energy at the output of the array
T Amb	Ambient Temperature	E_Grid	Energy injected into grid
GlobInc	Global incident in coll. plane	EffArrR	Effic. Eout array / rough area
GlobEff	Effective Global, corr. for IAM and shadings	EffSysR	Effic. Eout system / rough area

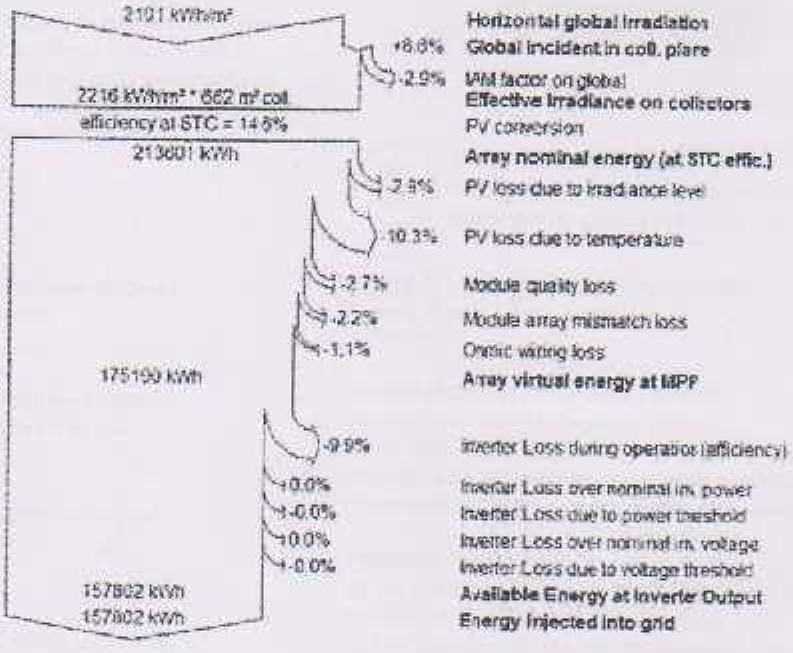
Grid-Connected System: Loss diagram

Project : **Grid-Connected Project at Al-Arub College**

Simulation variant : **No shading effects**

Main system parameters	System type	**Grid-Connected**		
PV Field Orientation	tilt	30°	azimuth	0°
PV modules	Model	SLK60M6L 228W	Pnom	228 Wp
PV Array	Nb. of modules	408	Pnom total	**93 kWp**
Inverter	Model	G-332, three	Pnom	21 kW ac
Inverter pack	Nb. of units	4.0	Pnom total	**84 kW ac**
User's needs	Unlimited load (grid)			

Loss diagram over the whole year



CanadianSolar

MAX POWER
CS6X-305 | 310 | 315P

High quality and reliability in all Canadian Solar modules is ensured by 14 years' experience in module manufacturing, well-engineered module design, stringent BOM quality testing, an automated manufacturing process and 100 % EL testing.

25 years insurance-backed warranty non-cancellable, immediate warranty insurance linear power output warranty

10 years product warranty on materials and workmanship

KEY FEATURES

- Excellent module efficiency up to 16.42%
- Outstanding low irradiance performance > 96.0%
- +5Wp: Positive power tolerance up to 5 W
- No.1 PTC: High PTC rating up to 91.97%
- IP67 junction box for long-term weather endurance
- Heavy snow load up to 5400 Pa wind load up to 2400 Pa
- Salt mist and blown sand resistance, for seaside and desert environments

MANAGEMENT SYSTEM CERTIFICATES*

ISO 9001: 2008 / Quality management system
ISO/TS 16949: 2009 / The automotive industry quality management system
ISO 14001: 2004 / Standards for environmental management system
OHSAS 18001: 2007 / International standards for occupational health & safety

PRODUCT CERTIFICATES*

IEC 61215 / IEC 61730: VDE / MCS / CE / SII / CEC AU / CQC / INMETRO
UL 1703 / IEC 61215 performance: CEC listed (US)
UL 1703: CSA / IEC 61701 ED2: VDE / IEC 60068-2-68: SGS
PV CYCLE (EU) / UNI 9177 Reaction to Fire: Class 1

* As there are different certification requirements in different markets, please contact your local Canadian Solar sales representative for the specific certificates applicable to the products in the region in which the products are to be used.

CANADIAN SOLAR INC. is committed to providing high quality solar products, solar system solutions and services to customers around the world. As a leading manufacturer of solar modules and PV project developer with about 9 GW of premium quality modules deployed around the world since 2001, Canadian Solar Inc. (NASDAQ: CSIQ) is one of the most bankable solar companies worldwide.

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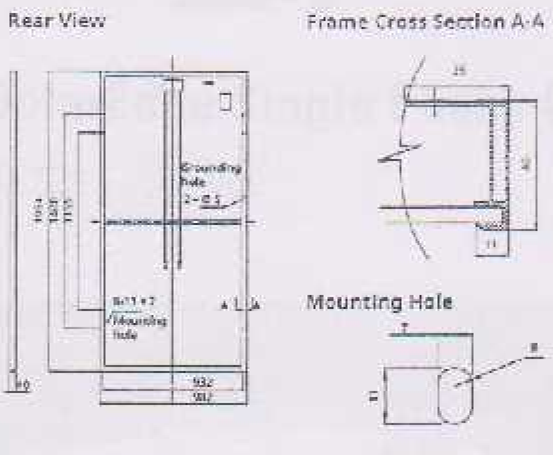
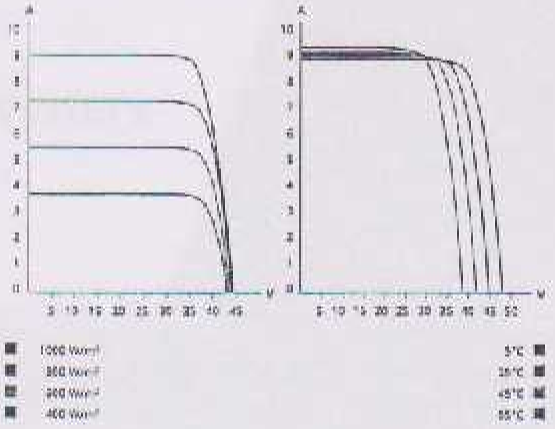
MODULE / ENGINEERING DRAWING (mm)



CS6X-310P / I-V CURVES



ELECTRICAL DATA / STC*

Electrical Data CS6X	305P	310P	315P
Nominal Max. Power (Pmax)	305 W	310 W	315 W
Opt. Operating Voltage (Vmp)	36.3 V	36.4 V	36.6 V
Opt. Operating Current (Imp)	8.41 A	8.52 A	8.61 A
Open Circuit Voltage (Voc)	44.8 V	44.9 V	45.1 V
Short Circuit Current (Isc)	8.97 A	9.08 A	9.18 A
Module Efficiency	15.90%	16.16%	16.42 %
Operating Temperature	-40°C ~ +85°C		
Max. System Voltage	1000 V (IEC) or 1000 V (UL)		
Module Fire Performance	TYPE 1 (UL 1703) or CLASS C (IEC 61730)		
Max. Series Fuse Rating	15 A		
Application Classification	Class A		
Power Tolerance	0 ~ + 5 W		

* Under Standard Test Conditions (STC) of irradiance of 1000 W/m², spectrum AM 1.5 and cell temperature of 25°C.

ELECTRICAL DATA / NOCT*

Electrical Data CS6X	305P	310P	315P
Nominal Max. Power (Pmax)	221 W	225 W	228 W
Opt. Operating Voltage (Vmp)	33.1 V	33.2 V	33.4 V
Opt. Operating Current (Imp)	6.68 A	6.77 A	6.84 A
Open Circuit Voltage (Voc)	41.2 V	41.3 V	41.5 V
Short Circuit Current (Isc)	7.27 A	7.36 A	7.44 A

* Under Nominal Operating Cell Temperature (NOCT), irradiance of 800 W/m², spectrum AM 1.5, ambient temperature 20°C, wind speed 1 m/s.

PERFORMANCE AT LOW IRRADIANCE

Industry leading performance at low irradiation, +96.0 % module efficiency from an irradiance of 1000 W/m² to 200 W/m² (AM 1.5, 25°C).

The specification and key features described in this Datasheet may deviate slightly and are not guaranteed. Due to on-going innovation, research and product enhancement, Canadian Solar Inc. reserves the right to make any adjustment to the information described herein at any time without notice. Please always obtain the most recent version of the datasheet which shall be duly incorporated into the binding contract made by the parties governing all transactions related to the purchase and sale of the products described herein.

Caution: For professional use only. The installation and handling of PV modules requires professional skills and should only be performed by qualified professionals. Please read the safety and installation instructions before using the modules.

MODULE / MECHANICAL DATA

Specification	Data
Cell Type	Poly-crystalline, 6 inch
Cell Arrangement	72 (6 × 12)
Dimensions	1954 × 982 × 40 mm (76.93 × 38.7 × 1.57 in)
Weight	22 kg (48.5 lbs)
Front Cover	3.2 mm tempered glass
Frame Material	Anodized aluminium alloy
J-BOX	IP67, 3 diodes
Cable	4 mm² (IEC) or 4 mm² & 12 AWG 1000V (UL), 1150 mm (45.3 in)
Connectors	MC4 or MC4 comparable
Stand. Packaging	24 pcs, 608 kg (quantity & weight per pallet)
Module Pieces per Container	528 pcs (40' HQ)

TEMPERATURE CHARACTERISTICS

Specification	Data
Temperature Coefficient (Pmax)	-0.43 % / °C
Temperature Coefficient (Voc)	-0.34 % / °C
Temperature Coefficient (Isc)	0.065 % / °C
Nominal Operating Cell Temperature	45±2°C

PARTNER SECTION

SolarEdge Single Phase Inverters

SE2200 - SE6000

Specifically designed to work with power optimizers

- Superior efficiency (97.6%)
- Small, lightweight and easy to install
- Built-in module-level monitoring
- Internet connection through Ethernet or Wireless
- IP65 – Outdoor and indoor installation
- Fixed voltage inverter, DC/AC conversion only

solaredge

Single Phase Inverters
SE2200 - SE6000

	SE2200	SE3000	SE3500	SE4000	SE5000	SE6000	
OUTPUT							
Rated AC Power Output	2200	3000	3500	4000	5000	6000	VA
Maximum AC Power Output	2200	3000	3500	4000	5000	6000	VA
AC Output Voltage (Nominal)	220 /230						Vac
AC Output Voltage Range	184 - 264.5						Vac
AC Frequency (Nominal)	50 / 60 ± 5						Hz
Maximum Continuous Output Current	12	16.5*	19.5*	22*	27	27	A
Residual Current Detector / Residual Current Step Detector	300 / 30						mA
Utility Monitoring, Islanding Protection, Country Configurable Thresholds	Yes						
INPUT							
Recommended Maximum DC Power** (Module STC)	2750	3750	4350	5000	6250	7500	W
Transformer-less, Ungrounded	Yes						
Maximum Input Voltage	500						Vdc
Nominal DC Input Voltage	350						Vdc
Maximum Input Current	8.5	11.5	13.5	15.5	19.5	23	Adc
Reverse-Polarity Protection	Yes						
Ground-Fault Isolation Detection	600kΩ Sensitivity						
Maximum Inverter Efficiency	97.6						%
European Weighted Efficiency	97.6	97.6	97.5	97.5	97.4	97.4	%
Nighttime Power Consumption	< 2.5						W
ADDITIONAL FEATURES							
Supported Communication Interfaces	RS485, RS232, Ethernet, Zigbee (optional)						
STANDARD COMPLIANCE							
Safety	IEC-62103 (EN50178), IEC-62109						
Grid Connection Standards	VDE 0126-1-1, VDE AR-N-4105, AS-4777, RD-1663, DK 5940						
Emissions	IEC61000-6-2, IEC61000-6-3, IEC61000-3-11, IEC61000-3-12, FCC part15 class B						
RoHS	Yes						
INSTALLATION SPECIFICATIONS							
AC Output	Cable Gland - diameter 9-16						mm
DC Input	1 MC4 pair			2 MC4 pairs			
Dimensions (HxWxD)	540 x 315 x 172			540 x 315 x 191			mm
Weight	20.2			21.7			kg
Cooling	Natural Convection						
Noise	<25						dBA
Operating Temperature Range	-20 - +50 (M40 version -40 - +50)						°C
Protection Rating	IP65 - Outdoor and Indoor						
Bracket Mounted (Bracket Provided)							

* For inverters with an AC current limit of 16A please refer to the "[illegible]" datasheet

** Limited to 135% of AC power

CE SUNSPEC

Product Detail

Report Suspicious Activity

Quick Details

Place of Origin: Guangdong, China (Mainland)

Brand Name: PUXIN

Model Number: PX-3KW

Place of Origin:: Guangdong, China (Mainland)

Brand Name :: PUXIN

Model Number :: PX- 1.2KW

Output Type :: AC Single Phase

Speed :: 1500R/M

Frequency:: 50HZ

Rated Power :: 1200W

Rated Voltage :: 230V

Gas consumption :: 0.55m3/h

Suitable gas:: Biogas/LPG

Packaging & Delivery

Packaging Details:	Cartons per piece
Delivery Detail:	15~30 days normally

Specifications

1. small size biogas generator
2. clean,
3. enviroment friendly,
4. hight return,
5. low operation

1.2kw small size biogas generator

Suitable gas: Biogas
Gas consumption: 0.55~0.65m3/kW.h
230V 50 Hz
Running Power 1200W
Peak Power 1300W
General Temperature Requirement: -5°C~40°C
General altitude: 2000m (It may cause problem if the altitude level is higher than 2000 meters)
620×460×470mm/set 55kg/set
HS CODE: 85022000

Email to this supplier

Related Products

1200W Biogas engine generator

1.2KW biogas engine generator

Biogas engine generator