Chapter One
Introduction

1.1 Renewable energy

Any energy resource that is naturally regenerated over a short time scale and derived directly from the sun (such as thermal, photochemical, and photoelectric), indirectly from the sun (such as wind, hydropower, and photosynthetic energy stored in biomass), or from other natural movements and mechanisms of the environment (such as geothermal and tidal energy). Renewable energy does not include energy resources derived from fossil fuels, waste products from fossil sources, or waste products from inorganic sources.

1.2 Renewable energies

- Hydroelectric energy
- Wind energy
- Solar energy
- Biomass
- Geothermal energy

1.3 The advantage of renewable energy

One major advantage with the use of renewable energy is that as it is renewable it is therefore sustainable and so will never run out.

Renewable energy facilities generally require less maintenance than traditional generators. Their fuel being derived from natural and available resources reduces the costs of operation.

Even more importantly, renewable energy produces little or no waste products such as carbon dioxide or other chemical pollutants, so has minimal impact on the environment.

Renewable energy projects can also bring economic benefits to many regional areas, as most projects are located away from large urban centre's and suburbs of the capital cities. These economic benefits may be from the increased use of local services as well as tourism.

It is easy to recognizes the environmental advantages of utilizing the alternative and renewable forms of energy but we must also be aware of the disadvantages [1].

1.4 Objectives

To design a mixed farm dependent entirely on renewable energy. Establishment of from using solar energy to pump water by solar cells and biogas for cooking and generation electricity and compost.

Chapter two
Solar energy

2.1 Solar Energy

It is The energy that Earth receives from the Sun, primarily as visible light and other forms of electromagnetic radiation.

2.2 Solar cells

A solar cell is an electrical device that converts the energy of light directly into electricity by the solar cells.

Solar cells are described as being photovoltaic irrespective of whether the source is sunlight or an artificial light. They are used as a photo-detector (for example infrared detectors), detecting light or other electromagnetic radiation near the visible range, or measuring light intensity.

2.2.1 The operation of a photovoltaic (PV) cell consists of

- The absorption of light, generating either electron-hole pairs.
- The separation of charge carriers of opposite types.
- The separate extraction of those carriers to an external circuit.

Multiple solar cells in an integrated group, all oriented in one plane, constitute a solar photovoltaic panel or solar photovoltaic module. Photovoltaic modules often have a sheet of glass on the sun-facing side, allowing light to pass while protecting the semiconductor wafers. Solar cells are usually connected in series in modules, creating an additive voltage. Connecting cells in parallel yields a higher current; however, problems such as shadow effects can shut down the weaker (less illuminated) parallel string (a number of series connected cells) causing substantial power loss and possible damage because of the reverse bias applied to the shadowed cells by their illuminated partners.

2.3 Theory of solar cells

2.3.1 The solar cell works in several steps

- Photons in sunlight hit the solar panel and are absorbed by semiconducting materials, such as silicon.
- These layers have different chemical electric charges and subsequently both drive and direct the current of electrons.
- An array of solar cells converts solar energy into a usable amount of direct current (DC) electricity.
- An inverter can convert the power to alternating current (AC).

The most commonly known solar cell is configured as a large-area p–n junction made from silicon.

2.4 Solar cell efficiency

Solar cell efficiency may be broken down into reflectance efficiency, thermodynamic efficiency, charge carrier separation efficiency and conductive efficiency. The overall efficiency is the product of these individual metrics.

A solar cell has a voltage dependent efficiency curve, temperature coefficients, and allowable shadow angles.

Due to the difficulty in measuring these parameters directly, other parameters are substituted by thermodynamic efficiency, quantum efficiency, integrated quantum efficiency, V_{OC} ratio, and fill factor. Reflectance losses are a portion of quantum efficiency under "external quantum efficiency". Recombination losses make up another portion of quantum efficiency, V_{OC} ratio, and fill factor. Resistive losses are predominantly categorized under fill factor, but also make up minor portions of quantum efficiency, V_{OC} ratio. Single p–n junction crystalline silicon devices are now approaching the theoretical limiting power efficiency of 33.7%, noted as the Shockley–Queisser limit in 1961. In the extreme, with an infinite number of layers, the corresponding limit is 86% using concentrated sunlight [2].

2.5 Types of solar cells

- Monocrystalline silicon

Monocrystalline silicon is the base material for silicon chips used in virtually all electronic equipment today. Mono-Si also serves as photovoltaic, light-absorbing material in the manufacture of solar cell.

- Polymer Solar cell

A polymer solar cell is a type of flexible solar cell made with polymers, large molecules with repeating structural units, that produce electricity from sunlight by the photovoltaic effect. Polymer solar cells include organic solar cells (also called "plastic solar cells"). They are one type of thin film solar cell, others include the more stable amorphous silicon solar cell.

- Thin –film solar cell

Thin-film technology has always been cheaper but less efficient than conventional c-Si technology. However, it has significantly improved over the years. The lab cell efficiency for CdTe and CIGS is now beyond 21 percent, outperforming multicrystalline silicon, the dominant material currently used in most solar PV systems.

- Dye-sensitized

A dye-sensitized solar cell (DSSC, DSC or DYSC) is a low-cost solar cell belonging to the group of thin film solar cells. It is based on a semiconductor formed between a photo-sensitized anode and an electrolyte, a photo electrochemical system. The modern version of a dye solar cell, also known as the Grätzel cell, was originally co-invented in 1988 by Brian O'Regan and Michael Grätzel at UC Berkeley and this work was later developed by the aforementioned scientists at the École Poly technique Fédérale de Lausanne until the publication of the first high efficiency DSSC in 1991. Michael Grätzel has been awarded the 2010 Millennium Technology Prize for this invention.

The DSSC has a number of attractive features; it is simple to make using conventional roll-printing techniques, is semi-flexible and semi-transparent which offers a variety of uses not applicable to glass-based systems, and most of the materials used are low-cost.

Chapter three
Biogas

3.1 Introduction

Biogas typically refers to a mixture of different gases produced by the breakdown of organic matter in the absence of oxygen. Biogas can be produced from raw materials such as agricultural waste, manure, municipal waste, plant material, sewage, green waste or food waste. It is a renewable energy source and in many cases exerts a very small carbon footprint.

Biogas can be produced by anaerobic digestion with anaerobic bacteria, which digest material inside a closed system, or fermentation of biodegradable materials.

Biogas is primarily methane CH_4, carbon dioxide CO_2, may have small amounts of hydrogen sulfide (H_2S), moisture and siloxanes. The gases methane hydrogen, and carbon monoxide (CO) can be combusted or oxidized with oxygen. This energy release allows biogas to be used as a fuel; it can be used for any heating purpose, such as cooking. It can also be used in a gas engine to convert the energy in the gas into electricity and heat.

3.2 Production

Biogas is produced as landfill gas (LFG), which is produced by the breakdown of biodegradable waste inside a landfill due to chemical reactions and microbes, or as digested gas, produced inside an anaerobic digester. A biogas plant is the name often given to an anaerobic digester that treats farm wastes or energy crops. It can be produced using anaerobic digesters (air-tight tanks with different configurations). These plants can be fed with energy crops such as maize silage or biodegradable wastes including sewage sludge and food waste. During the process, the microorganisms transform biomass waste into biogas (mainly methane and carbon dioxide) and digestate. The biogas is a renewable energy that can be used for heating, electricity, and many other operations that use a reciprocating internal combustion engine, such as GE Jenbacher or Caterpillar gas engines. Other internal combustion engines such as gas turbines are suitable for the conversion of biogas into both electricity and heat. The digestate is the remaining organic matter that was not transformed into biogas. It can be used as an agricultural fertiliser.

There are two key processes**:** mesophilic and thermophilic digestion which is dependent on temperature.

3.3 Composition

Typical composition of biogas

%	Formula	Compound
50–75	CH_4	Methane
25–50	CO_2	Carbon dioxide
0–10	N_2	Nitrogen
0–1	H_2	Hydrogen
0–3	H_2S	Hydrogen sulfide
0–0.5	O_2	Oxygen

The composition of biogas varies depending upon the origin of the anaerobic digestion process. Landfill gas typically has methane concentrations around 50%. Advanced waste treatment technologies can produce biogas with 55%–75% methane, which for reactors with free liquids can be increased to 80%-90% methane using in-situ gas purification techniques. As produced, biogas contains water vapor. The fractional volume of water vapor is a function of biogas temperature; correction of measured gas volume for water vapor content and thermal expansion is easily done via simple mathematics which yields the standardized volume of dry biogas.

In some cases, biogas contains siloxanes. They are formed from the anaerobic decomposition of materials commonly found in soaps and detergents. During combustion of biogas containing siloxanes, silicon is released and can combine with free oxygen or other elements in the combustion gas. Deposits are formed containing mostsssly silica (SiO_2) or silicates (Si_xO_y) and can contain calcium, sulfur, zinc, phosphorus. Such white mineral deposits accumulate to a surface thickness of several millimeters and must be removed.

Practical and cost-effective technologies to remove siloxanes and other biogas contaminants are available.

For 1000 kg (wet weight) of input to a typical biodigester, total solids may be 30% of the wet weight while volatile suspended solids may be 90% of the total solids. Protein would be 20% of the volatile solids, carbohydrates would be 70% of the volatile solids, and finally fats would be 10% of the volatile solids [3].

3.4 The Technology

Biogas is the gas resulting from an anaerobic digestion process. A biogas plant can convert animal manure, green plants, waste from agro industry and slaughterhouses into combustible gas.

Biogas can be used in similar ways as natural gas in gas stoves, lamps or as fuel for engines. It consists of 50-75% methane, 25-45% carbon dioxide, 2-8% water vapor and traces of O_2 N_2, NH_3 H_2, H_2S. Compare this with natural gas, which contains 80 to 90% methane. The energy content of the gas depends mainly on its methane content. High methane content is therefore desirable. A certain carbon dioxide and water vapor content is unavoidable, but sulphur content must be minimized - particularly for use in engines.

The average calorific value of biogas is about 21-23.5 MJ/m³, so that 1m³ of biogas corresponds to 0.5-0.6 l diesel fuel or about 6 kWh.

The biogas yield of a plant depends not only on the type of feedstock, but also on the plant design, fermentation temperature and retention time. Maize silage for example - a common feedstock in Germany - yields about 8 times more biogas per ton than cow manure. In Germany, cow manure and energy crops are the main forms of feedstock. About 2 live-stock units (corresponding to about 2 cows or 12 rearing pigs) plus 1 ha of maize and grass are expected to yield a constant output of about 2 kWel (48kWhel per day).

3.5 Gas production figures

If the daily amount of available dung (fresh weight) is known, gas production per day in warm tropical countries will approximately correspond to the following values:

- 1 kg cattle dung 40 liters biogas.
- 1 kg chicken droppings 70 liter biogas.

If the live weight of all animals whose dung is put into the biogas plant is known, the daily gas production will.

correspond approximately to the following values:

- cattle, buffalo and chicken: 1,5 liters biogas per day per 1 kg live weight.

3.6 Conversion to Electricity

Theoretically, biogas can be converted directly into electricity by using a fuel cell. However, this process requires very clean gas and expensive fuel cells. Therefore, this option is still a matter for research and is not currently a practical option. The conversion of biogas to electric power by a generator set is much more practical. In contrast to natural gas, biogas is characterized by a high knock resistance and hence can be used in combustion motors with high compression rates.

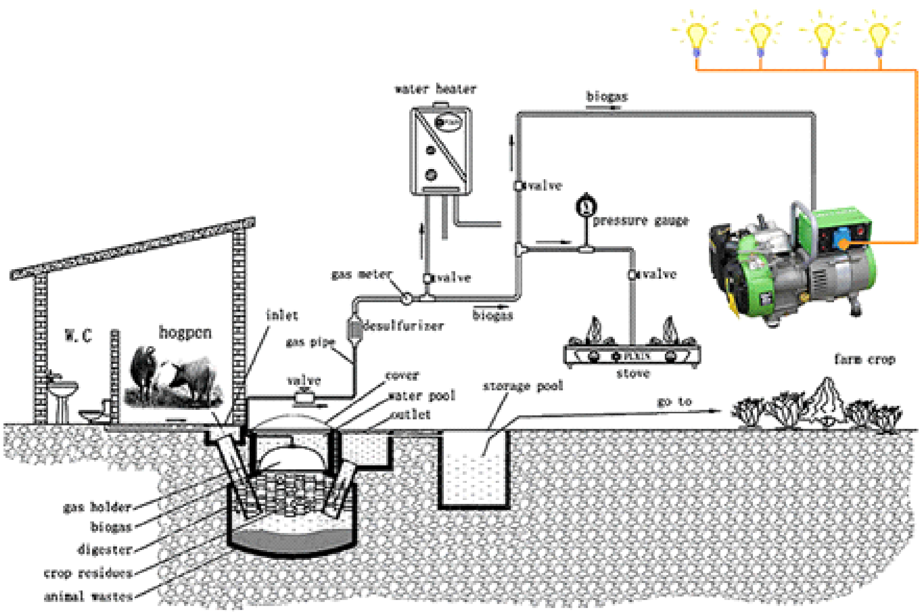

Fig (1)
Power generation

In most cases, biogas is used as fuel for combustion engines, which convert it to mechanical energy, powering an electric generator to produce electricity. The design of an electric generator is similar to the design of an electric motor. Most generators produce alternating AC electricity; they are therefore also called alternators or dynamos. Appropriate electric generators are available in virtually all countries and in all sizes. The technology is well known and maintenance is simple. In most cases, even universally available three-phase electric motors can be converted into generators. Technologically far more challenging is the first stage of the generator set: the combustion engine using the biogas as fuel. In theory, biogas can be used as fuel in nearly all types of combustion engines, such as gas engines (Otto motor) diesel engines, gas turbines and Stirling motors etc.

3.7 Appropriate Combustion Engine

3.7.1 External Combustion Engines (EC Engines)

- Stirling Motors

In such motors, biogas is combusted externally, which in turn heats the stirling motor through a heat exchanger. The gas in the stirling motor hence expands and thereby moves the mechanism of the engine. The resulting work is used to generate electricity. Stirling motors have the advantage of being tolerant of fuel composition and quality. They are, however, relatively expensive and characterized by low efficiency. Their use is therefore limited to a number of very specific applications.

In most commercially run biogas power plants today, internal combustion motors have become the standard technology either as gas or diesel motors.

3.7.2 Internal Combustion Engines

- Gas Motors

With spark ignition (Otto system) can operate on biogas alone. In practice, a small amount of petrol (gasoline) is often used to start the engine. This technology is used for very small generator sets (~

0.5-10 kW) as well as for large power plants. Especially in Germany, these engines have advantages as they do not need additional fossil fuels that would lead to lower feed-in tariffs according to the renewable energy law (EEG).

- Gas Turbines

Are occasionally used as biogas engines especially in the US. They are very small and can meet the strict exhaust emissions requirements of the California Air Resources Board (CARB) for operation on landfill and digester gases. Small biogas turbines with power outputs of 30-75 kW are available in the market. However, they are rarely used for small-scale applications in developing countries. They are expensive and due to their spinning at very high speeds and the high operating temperatures, the design and manufacturing of gas turbines is a challenging issue from both the engineering and material point of view. Maintenance of such a turbine is very different from well-known maintenance of a truck engine and therefore requires specific skills.

Today, experience of the use of combustion motors to produce electricity from biogas is extensive; this can be regarded as a proven standard technology. Over 4,000 biogas plants with internal combustion motors are in operation in Germany.

However, it has taken lengthy and determined effort to make this technology as durable and reliable as it is today. Internal combustion motors have high requirements in terms of fuel quality. Harmful components - especially hydrogen sulphide (H_2S) in the gas can shorten the lifetime of a motor considerably and cause serious damage [4].

Chapter Four
Mixed Farm

4.1 A solar system

It is assumed that the farm contains livestock as well as vegetables. Then farm is assumed to be completely dependent on renewable energy. Solar-powered pump is a pump running on electricity generated by photovoltaic panels pumps. The operation of solar powered pumps is more economical mainly due to the lower operation and maintenance .

4.1.1 A photovoltaic solar powered pump system has three parts

- the pump.
- the controller.
- solar panels.

The purpose of the controller is twofold. Firstly, it matches the output power that the pump receives with the input power available from the solar panels. Secondly, a controller usually provides a low voltage protection whereby the system is switched off, if the voltage is too low or too high for the operating voltage range of the pump. This increases the lifetime of the pump thus reducing the need for maintenance.

Voltage of the solar pump motors can be AC (alternating current) or DC (direct current) [5].

4.2 Biogas Applications

Biogas can be used for electricity production or for cooking. The generation of a combustible gas from anaerobic biomass digestion, is a well-known technology. There are already millions of biogas plants in operation throughout the world. Whereas using the gas for direct combustion in household stoves or gas lamps is common, producing electricity from biogas is still relatively rare in most developing countries.

In Germany, and other industrialized countries power generation is the main purpose of biogas plants; conversion of biogas to electricity has become a standard technology.

Biogas production depends on the availability of sufficient biomass feedstock, water and space for the digester. As the biogas cannot be transported over long distances, the digester has to be placed close to the home of its user this is more likely in rural areas. Yet, changing from a three stone wood fire to using a biogas stove requires complex changes for a rural household. Experiences particularly in African countries have shown that biogas is not always easily adopted by households.

Only if the prerequisites for the production of biogas (digester regular supply of water , feedstock daily care and maintenance) are met, can biogas be produced.

4.2.1 Some points to consider for the viability of biogas in an area

- The complex fermentation process in the biogas plant needs a continuous supply of suitable feedstock (preferably dung or other agricultural waste). This requires an appropriate farming system: a sufficient amount of livestock must be kept confined (no free-range grazing). The rule of thumb says that 3-4 cows are needed to make biogas production viable at household level. This may be a problem especially for poorer families.
- It requires a continuous supply of water all year round, which is a problem in arid areas or areas with a pronounced dry season.
- People must be able to afford the construction of a digester.
- There must be enough labor available for the daily feeding and maintenance of the digester.
- The economic viability increases if the slurry from the digester can be applied as fertilizer on fields close-by.

- Biogas might not be advisable in cultures where maintenance and preventive action is not a common habit.

4.3 Advantages

- Biogas burns very cleanly and produces less pollutants during cooking than any other fuel except electricity.
- Biogas provides instant heat upon ignition, no pre-heating or waiting time needed.
- In most biogas burners the flow-rate can be regulated to turn down fire-power from high heat to small low heat for simmering.
- Biogas can be used for lighting as well.
- The by-product from the digester is a good fertilizer.
- Biogas is a renewable fuel that is ‘carbon negative’: unless there are leakages in the system, burning biogas in a cook stove releases less greenhouse gases than if the dung was left on the ground to decompose naturally [6].

4.4 Conclusion

In this work energy self-sufficient farm was designed. Solar energy was used for lighting and water pumping. Biogas was used to generate electricity and for cooking.

4.5 Recommendation

An energy self-sufficient farm design depends on the location of the farm and the availability of agricultural and animal waste. The next work must be based on information from a real farm. The location determines the amount of solar energy. The available of agricultural and animal waste determines the amount of biogas.

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