AVAILABILITY AND ESTIMATION OF RENEWABLE ENERGY FOR HABITANTS LIVING IN REMOTE PLACES

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for the award of the degree of
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STUDENT'S DECLARATION

I hereby declare that the work in this project is my own except for quotations and summaries which have been duly acknowledged. The project has not been accepted for any degree and is not concurrently submitted for award of other degree.

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Dedicated:

Father: Md Yusoff b Hj Majid

Mother: Rohani bt Hassan

Sister: Nur Izzati and Nur Adlina

Younger Brother: Muhammad Farhan dan Ahmad Hanif

and all my friends

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ABSTRACT

Today, the world has been relying on fossil fuels as its primary source of energy. This unsustainable energy source is not going to last long. Thus, the green renewable energy should be practice from now on. Malaysia is gifted with many natural renewable energy resources. It is because it has a long coast line, good rainfall with rivers flowing for greater part of the year. In Malaysia also there are 82% of the remote places in Malaysia have electricity in their place but sometime this electricity is not functional because of the some problem. And for the other 12%, there are not facilities for them. The electricity is very important for our daily life for the cooking, lighting and the others activity. This thesis is presented the research to determine the suitable renewable energy use in remote places which in Malaysia. After some research, there are potential of renewable energy that can be used that is biomass energy, solar energy and wind energy. Based on the parameter in the remote place, the case study has been done for design the system for that habitant to generate the electricity. With the animal dung and excrement, biogas digester can be use. The biogas produce can generated the electricity for that place. But, the number of the animal available is less than number of animal needed for generates the whole place. After that, solar photovoltaic is the one way of the solution for this problem. Solar photovoltaic system can be use with the biogas digester. In other hand, wind turbine also can be one of the alternative ways beside the solar photovoltaic. So, this paper is discussed about the best solution for the remote place to choose the suitable renewable energy either biogas-solar photovoltaic or biogas-wind turbine.

ABSTRAK

Pada masa ini, penduduk dunia terlalu bergantung kepada bahan bakar fosil sebagai sumber tenaga utama. Sumber tenaga dari bahan bakar ini tidak akan bertahan untuk selama-lamanya kerana sumber tenaga ini tidak berkekalan. Oleh sebab itu, kita harus mula untuk menerokai sumber tenaga baru. Seperti yang kita ketahui, Malaysia telah dianugerahkan dengan pelbagai sumber tenaga baru. Ini kerana kedudukan Malaysia yang strategik, menerima jumlah hujan tahunan yang baik dengan sungai yang mengalir sepanjang tahun. Di Malaysia juga, sebanyak 82% kawasan pedalaman telah menerima sambungan elektik dari kerajaan. Walaubagaimanapun, sistem ini tidak dapat berfungsi kerana berlaku beberapa masalah yang tidak dapat dielakkan. Untuk 12% penduduk di kawasan pedalaman yang lain tidak mendapat kemudahan untuk mereka. Sistem elektrik adalah sangat penting dalam kehidupan pada masa sekarang. Dengan elektrik, penduduk dapat melakukan aktiviti masing-masing seperti memasak dan sebagainya. Tesis ini adalah mengenai kajian untuk menentukan penggunaan sumber tenaga baru yang paling sesuai untuk digunakan di kawasan pedalaman di Malaysia. Melalui beberapa kajian, potensi sumber tenaga baru yang dapat digunakan di Malaysia ialah tenaga biojisim, tenaga suria dan tenaga angin. Berdasarkan parameter daripada kawasan pedalaman, satu kajian kes telah dijalankan untuk merekabentuk satu sistem yang paling sesuai untuk menghasilkan tenaga di kawasan pedalaman. Melalui bahan buangan daripada haiwan ternakan di kawasan pedalaman, satu "biogas digester" telah dihasilkan. Melalui biogas yang keluar akan digunakan untuk menghasilkan tenaga elektrik. Namun, jumlah haiwan ternakan di kawasan itu tidak cukup untuk memberi tenaga kepada semua penduduk. Oleh itu, "solar photovoltaic" adalah salah satu sumber tenaga yang boleh digunakan bersama biogas. Selain daripada "solar photovoltaic", tenaga daripada angin juga boleh digunakan. Oleh itu, kertas ini akan membincangkan tentang jalan yang terbaik untuk menghasilkan elektrik di kawasan pedalaman.

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P	Power
V	Voltage
I	Current
$\prod$	Combustion efficiency
H_b	Heat of combustion of biogas
H_m	Heat of combustion of methane
F_m	Fraction of methane in biogas
V_b –	Volume of biogass, m^3
C	Biogas yield per unit dry mass
m_o	Mass of dry input
V_f	Volume flow rate of fluid per day, m^3/day
P_m	Density of dry matter in the fluid
T_r	Retention time in the digester, days
E	Efficiency of rotor
ρ	Density of air
r	Radius of rotor
v	Velocity of wind

LIST OF ABBREVIATIONS

GDP	Gross Domestic Product
USD	United State Dollar
SREP	Small Renewable Energy Power Program
PTM	Pusat Tenaga Malaysia
MTBE	Methyl Tertiary Butyl Ether
ETBE	Ethyl Tertiary Butyl Ether
UKM	University Kebangsaan Malaysia
PV	Photovoltaic
UiTM	Universiti Teknologi MARA
FIT	Feed-in Tariff

CHAPTER 1

INTRODUCTION

1.0 PROJECT BACKGROUND

The Malaysian population of about 28.5 million is spread over an area of 329,759 sq.km comprises of thirteen states and has an average population density of 86 per square kilometer. About 18% of the populations live in remote places and does not have electrical connection from the main grid. About 75% of the land is covered with rainforests with population density spread as shown in Figure 1 makes it highly uneconomical to lay transmission lines in certain locations. The occupation of the people living in these remote places are mostly farming, fishing and others activity. These animals and trees provided most of their energy requirements.

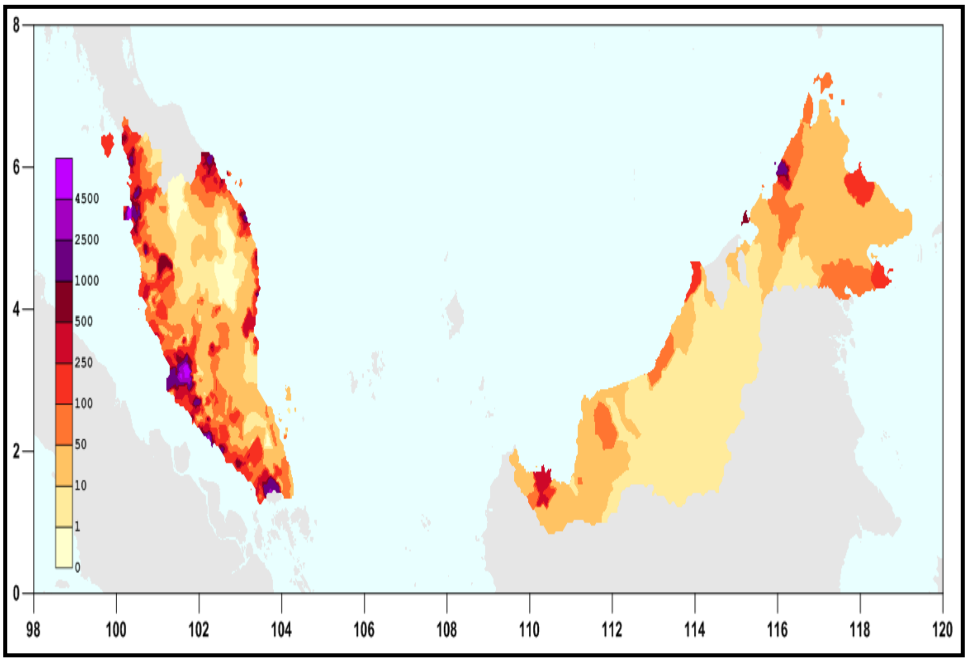

Figure 1.1: Average population density for Malaysia

Malaysia is gifted with many natural renewable energy resources as shown in Figure 1.1. It has a long coast line, good rainfall with rivers flowing for greater part of the year. As it is located near the equator it has high solar insolation prevailing for most part of the year. However, the renewable resources are not utilized to a large extent due to the availability of crude petroleum and palm oil in sufficient quantities.

Malaysia ranks 56 in the world with a GDP of USD13, 315 per capita and plans to upgrade as a developed nation by the year 2020. In line with these objectives and rising concerns of global warming it is important to promote the use of renewable energy to enhance the living standards of its people, especially in remote places.

2.0 WORLD RENEWABLE ENERGY RESOURCES.

The world energy demands are basically met by fossil fuels such as oil, coal and natural gas. The foreseeable depletion of these fossil fuel reserves within the next 40–50 year and the expected environmental damages due the global warming have catalyzed the world to shift towards the use of renewable energy resources. There is a need to explore these renewable energy sources like solar, wind, hydro, biomass, etc for sustainable growth. Table 1.1 is shown the current used as technical and theoretical potentials for renewable energy. These resources have an advantage that makes it uniquely suited to certain applications. Also the resources do not release gaseous or liquid pollutants during their operation. The use of renewable energy will steer the energy policy of nations in the direction of sustainability and lead to better energy security.

Table 1.1: Current use (2004) as well as technical and theoretical potentials for various renewable energy sources (in term of primary energy) at global scale

Global theoretical and technical potentials (Unit: EJ)			
Resource	Current use (2004)	Technical potential	Theoretical potential
Solar energy	0.2	1600	3,900,000
Wind energy	0.2	600	6000
Hydropower	10	50	150
Ocean energy	-	-	7400
Geothermal energy	2	5000	140,000,000
Biomass energy	50	250	2900
Total	62.4	7500	143,916,450

Source: IEA (2007b), Johansson et al. (2004) and Rogner et al. (2004)

2.1 SOLAR POWER

The sun has produced energy for billions of years. Solar energy is the sun's rays (solar radiation) that reach the Earth. This energy can be converted into other forms of energy, such as heat and electricity. Usually the people used the Sun for drying clothes and food for thousands of years, but only recently have use it for generating power. The Sun is 150 million kilometers away, and amazingly powerful. Just the tiny fraction of the Sun's energy that hits the Earth (around a hundredth of a millionth of a percent) is enough to meet all our power needs many times over. In fact, every minute, enough energy arrives at the Earth to meet our demands for a whole year - if only it harness it properly. Solar power is the generation of electricity from sunlight. Solar energy is radiant light and heat from the sun, has been harnessed by humans since ancient times using a range of ever-evolving technologies.

Solar energy can be used for heat and electricity. When solar was converted to thermal energy, it can be used to heat water and heat spaces. Usually, heat water heater is for use in home, building or swimming pools and heat spaces is usually used inside homes, greenhouses and other buildings. For electricity, solar energy can be converting in two ways. First is photovoltaic (PV) or in other name is solar cell. This process can change sunlight directly into electricity. Individual PV cells are grouped into panels and arrays of panels that can be used in a wide range of applications ranging from single small cells that charge calculator and watch batteries, to systems that power single homes, to large power plants covering many acres. The other way is concentrating solar power plant to generate electricity by using the heat from solar thermal collectors to produce steam that is used to power the generator.

2.2 WIND POWER

The power from wind have been harnessing for hundreds of years. Wind energy harnesses the power of the wind to propel the blades of wind turbines. The rotation of turbine blades is converted into electrical current by means of an electrical generator. In the older windmills, wind energy was used to turn mechanical machinery to do physical work, like crushing grain or pumping water. Wind turbines, like windmills, are mounted on a tower to capture the most energy. At 100 feet (30 meters) or more aboveground, they can take advantage of the faster and less turbulent wind. Turbines catch the wind's energy with their propeller-like blades. Usually, two or three blades are mounted on a shaft to form a rotor. A blade acts much like an airplane wing. While the wind blows, a pocket of low-pressure air forms on the downwind side of the blade. The low-pressure air pocket then pulls the blade toward it, causing the rotor to turn. This is called lift. The force of the lift is actually much stronger than the wind's force against the front side of the blade, which is called drag. The combination of lift and drag causes the rotor to spin like a propeller, and the turning shaft spins a generator to make electricity.

Now, electrical currents are harnessed by large scale wind farms that are used by national electrical grids as well as small individual turbines used for providing electricity to isolated locations or individual homes. Wind power is renewable and produces no greenhouse gases during operation, such as carbon dioxide and methane.

2.3 HYDRO POWER

Hydropower is power that is derived from the force or energy of moving water, which may be harnesses for useful purpose. Since water is about 800 times denser than air even a slow flowing stream of water, or moderate sea swell, can yield considerable amounts of energy. There are many forms of water energy like hydroelectric, ocean, rain, tidal and steam.

Hydro power is depends on the water cycle. Water cycle describes the continuous movement of water on, above and below the surface of the earth. Water can change states among liquid, vapour and ice at various places in the water cycle. From the Figure 1.2, solar energy heats water on the surface, causing it to evaporate. Then, this water vapor condenses into clouds and falls back onto the surface as precipitation like rain, snow and etc.). Lastly, the water flows through rivers back into the oceans, where it can evaporate and begin the cycle over again.

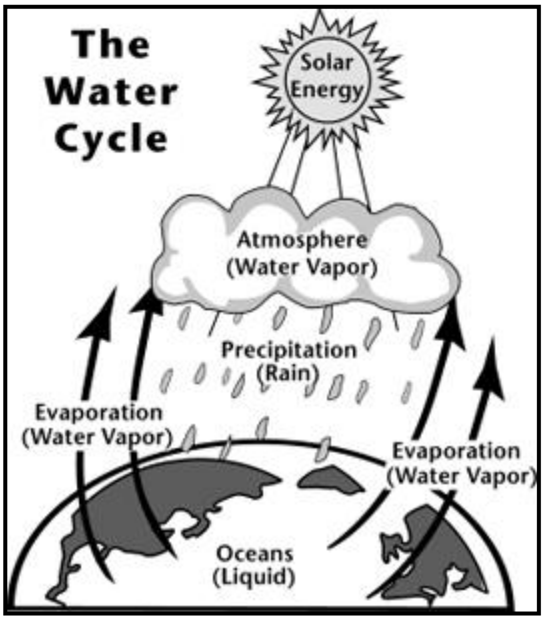

Figure 1.2: Process of water cycle

Source: National Energy Education Development Project (Public Domain)

Flowing water creates energy that can be captured and turned into electricity. This is called hydroelectric power or hydropower. Mechanical energy is harnessed from moving water. The amount of available energy in moving water is determined by its flow or fall. Swiftly flowing water in a big river, like the Rajang River that located in Sarawak, carries a great deal of energy in its flow. Water moves rapidly from a very high point. It also has lots of energy in its flow. In either instance, the water flows through a pipe, or penstock, then pushes against and turns blades in a turbine to spin a generator to produce electricity. In a run-of-the-river system, the force of the current applies the needed pressure, while in a storage system, water is accumulated in reservoirs created by dams as shown in Figure 1.3, then released as needed to generate electricity.

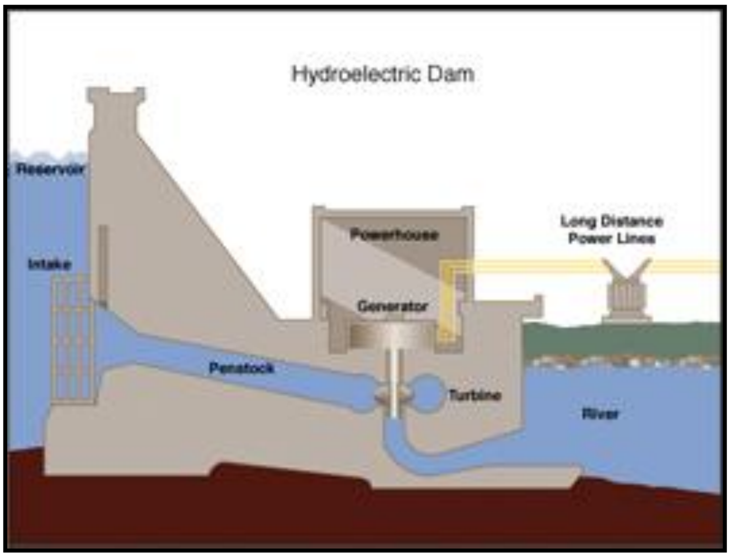

Figure 1.3: Dam system

Malaysia is a country mostly surrounded by water. In Malaysia, there are a few dams that are being used to generate the electric. For example, Kenyir dam in Terengganu. It generates 1600 GW per year. Kenyir dam is a biggest dam in Peninsular Malaysia. Others include Pergau dam in Kelantan with installed capacity of 150 MW from 4 turbines..

2.4 ENERGY FROM OCEANS

The Ocean can produce two types of energy that thermal energy from the sun's heat, and mechanical energy from the tides and waves. Oceans cover more than 70% of Earth's surface, making them the world's largest solar collectors. The sun's heat warms the surface water a lot more than the deep ocean water, and this temperature difference creates thermal energy. Just a small portion of the heat trapped in the ocean could power the world. In tropical regions, the surface water can be much warmer than the deep water as shown in Figure 1.4. This temperature difference can be used to produce electricity. Ocean thermal energy is used for many applications, including electricity generation. There are three types of electricity conversion systems namely closed-cycle, open-cycle, and hybrid. Closed-cycle systems use the ocean's warm surface water to vaporize a working fluid, which has a low-boiling point, such as ammonia. The vapor expands and turns a turbine. The turbine then activates a generator to produce electricity. Open-cycle systems actually boil the seawater by operating at low pressures. This produces steam that passes through a turbine or generator. Hybrid systems combine both closed-cycle and open-cycle systems.

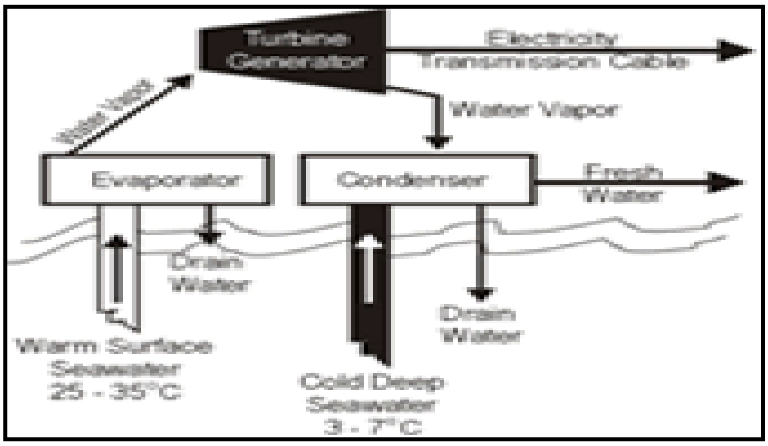

Figure 1.4: Diagram of ocean system

Tidal Power, sometimes also called tidal energy, is a form of hydropower that converts the energy of tides into electricity or other useful forms of power. Although not yet widely used, tidal power has potential for future electricity generation. Tides are more predictable than wind energy and solar power. Tides are caused by the gravitational pull of the moon and sun, and the rotation of the Earth. Near shore, water levels can vary up to 40 feet due to tides. A simple generation system for tidal plants involves a dam, known as a barrage, across an inlet. Sluice gates (gates commonly used to control water levels and flow rates) on the barrage allow the tidal basin to fill on the incoming high tides and to empty through the turbine system on the outgoing tide, also known as the ebb tide. There are two-way systems that generate electricity on both the incoming and outgoing tides. Tidal fences can also harness the energy of tides. A tidal fence has vertical axis turbines mounted in a fence. All the water that passes is forced through the turbines. Tidal fences can be used in areas such as channels between two landmasses. Tidal fences are cheaper to install than tidal barrages and have less impact on the environment than tidal barrages, although they can disrupt the movement of large marine animals.

Wave have a lots of energy. Waves are caused by the wind blowing over the surface of the ocean. There is tremendous energy in the ocean waves. One way to harness wave energy is to bend or focus the waves into a narrow channel, increasing their power and size. The waves can then be channeled into a catch basin or used directly to spin turbines. Many more ways to capture wave energy are currently under development. Some of these devices being developed are placed underwater, anchored to the ocean floor, while others ride on top of the waves. Waves are generated by wind passing over the surface of the sea. As long as the waves propagate slower than the wind speed just above the waves, there is an energy transfer from the wind to the waves. Both air pressure differences between the upwind and the side of a wave crest, as well as friction on the water surface by the wind, making the water to go into the shear stress causes the growth of the waves.

In general, larger waves are more powerful but wave power is also determined by wave speed, wavelength, and water density. Oscillatory motion is highest at the surface and diminishes exponentially with depth. However, for standing waves near a reflecting coast, wave energy is also present as pressure oscillations at great depth, producing microseisms. These pressure fluctuations at greater depth are too small to be interesting from the point of view of wave power.

The waves propagate on the ocean surface, and the wave energy is also transported horizontally with the group velocity. The mean transport rate of the wave energy through a vertical plane of unit width, parallel to a wave crest, is called the wave energy flux or on other name wave power.

2.5 GEOTHERMAL ENERGY

Literally, geothermal means earth heat. Geothermal energy harnesses the heat energy present underneath the Earth. Geothermal energy is a renewable energy source because the heat is continuously produced inside the Earth. Hot rocks under the ground heat water to produce steam. When holes are drilled in the region, the steam that shoots up is purified and is used to drive turbines, which power electric generators. Geothermal energy is generated in the Earth's core. Temperatures hotter than the sun's surface are continuously produced inside the Earth by the slow decay of radioactive particles, a process that happens in all rocks. People around the world use geothermal energy to heat their homes and to produce electricity by digging deep wells and pumping the heated underground water or steam to the surface. The stable temperatures near the surface of the Earth can be use to heat and cool buildings. Geothermal power plants use hydrothermal resources that have two common ingredients that is water (hydro) and heat (thermal). Geothermal plants require high temperature (300°F to 700°F) hydrothermal resources that may come from either dry steam wells or hot water wells. These resources can be use by drilling wells into the Earth and piping the steam or hot water to the surface. Geothermal wells are one to four kilometer deep. There are four types of geothermal plants. First, dry steam plants use steam piped directly from a geothermal reservoir to turn the generator turbines. The first geothermal power plant was built in 1904 in Tuscany, Italy, where natural steam erupted from the Earth. Second is flash steam plants take high-pressure hot water from deep inside the Earth and convert it to steam to drive the generator turbines. When the steam cools, it condenses to water and is injected back into the ground to be used over and over again. Most geothermal power plants are flash steam plants.

The hot dry rock: The heat recovered from subsurface rocks is used to generate electricity. The system proposed for extracting heat from the rock and converting it to electricity is comprised of two distinct subsystems at very different stages of their technological evolution. The two subsystems are the power plant (on the surface) and the HDR reservoir (deep beneath the surface), which are connected by deep wells. The wells and reservoir are thought of as a single system, often referred to as the well field system or reservoir system. The power plant system is largely identical to commercial binary hydrothermal electric plants. The technology for the reservoir system is much less mature. Lastly, binary cycle power plants transfer the heat from geothermal hot water to another liquid. The heat causes the second liquid to turn to steam which is used to drive a generator turbine.

In Malaysia, Tawau has an electricity generation potential of up to 67 MW from geothermal resources following the discovery of a geothermal site in Apas by a study by the Mineral and Geosciences Department. The study also found a reservoir about 2,000 to 3,000m below the earth's surface with water at temperatures of 220 to 236 degrees Celsius which was more than enough heat to generate electricity.

2.6 BIOMASS ENERGY

Biomass, a renewable energy source, is biological material derived from living, or recently living organisms, such as wood, waste, and alcohol fuels. Biomass is commonly plant matter grown to generate electricity or produce heat. Biomass energy or bioenergy was used for thousands of years, ever since people started burning wood to cook food or to keep warm. Today, wood is still our largest biomass energy resource. But many other sources of biomass can now be used, including plants, residues from agriculture or forestry, and the organic component of municipal and industrial wastes. Even the fumes from landfills can be used as a biomass energy source. The use of biomass energy has the potential to greatly reduce our greenhouse gas emissions. Biomass generates about the same amount of carbon dioxide as fossil fuels, but every time a new plant grows, carbon dioxide is actually removed from the atmosphere. The net emission of carbon dioxide will be zero as long as plants continue to be replenished for biomass energy purposes. These energy crops, such as fast-growing trees and grasses, are called biomass feedstock. The use of biomass feedstock can also help increase profits for the agricultural industry. Burning biomass is not the only way to release its energy. Biomass can be converted to other useable forms of energy, such as methane gas or transportation fuels, such as ethanol and biodiesel.

Methane gas is the main ingredient of natural gas. Smelly stuff, like rotting garbage, and agricultural and human waste, release methane gas are also called "landfill gas" or "biogas." Crops like corn and sugar cane can be fermented to produce ethanol.

Biodiesel, another transportation fuel, can be produced from left-over food products like vegetable oils and animal fats. For environment, biomass pollutes the air when it is burned, but not as much as fossil fuels do. Burning biomass fuels does not produce pollutants such as sulfur that can cause acid rain. When burned, biomass releases carbon dioxide, a greenhouse gas. But when biomass crops are grown, a nearly equivalent amount of carbon dioxide is captured through photosynthesis. The different forms and uses of biomass impact the environment in a different way.

There are three major biomass energy technology applications that are biofuels, biopower and bioproducts. Biofuels is conversion process of biomass into liquid for transportation. Biopower is burning biomass directly or convert it into gaseous fuel or oil to generate electricity. Lastly, bioproducts convert biomass into chemicals for making products that typically are made from petroleum.

3.0 RENEWABLE ENERGY POTENTIAL IN MALAYSIA

In Malaysia, there is several of renewable energy that has potential to use like biomass, solar, hydro, wind, and etc. The most potential renewable energy in Malaysia is biomass, solar and hydro as shown in Table 1.2.

Table 1.2: Shown the status of approved Small Renewable Energy Power Program (SREP)

Type Of Renewable Energy	No Of Approved Application	Capacity MW
Biomass	14	105
Biogas	2	5
Minihydro	1	2
Wind and Solar	0	0
Total	17	112

Source: EC-ASEAN COGEN PROGRAMME

Malaysia has very substantial potential for biomass energy utilization given its equatorial climate that is ideal for dense tropical forest growth and agricultural vegetation. There are five major sectors contributing wastes to biomass energy in Malaysia that is forestry (wood products), rubber cultivation, cocoa cultivation, sugar cane cultivation and oil palm cultivation as shown in Table 1.3. Based on Figure 1.5 total potential biomass based on generate capacity is 3700MWe.

Table 1.3: Shown the potential of biomass in Malaysia

Type of Industry	Production (Thousand Tonne)	Residue	Residue product ratio (%)	Residue Generated (Thousand Tonne)	Potential Energy PJ	Potential Electrical MWe
Oil Palm	74 272	EFB	21.14	15 701	74	714
		Fiber	12.72	9 447	140	1 353
		Shell	5.67	4 211	71	683
	Total			29 360	285	2 750
	Others (POME)			51 990	30	428
Paddy	2 141	Rice Husk	22	471	7.6	72
		Paddy Straw	40	856	8.8	80
Sugar	1 111	Bagasse	32	356	356	314
Wood	2 937 679 m^3	Sawn Timber	0.5-0.6	1 692 718 m^3	5.2	50
	523 336 m^3	Plywood and veneer	0.18-0.65	121 000 m^3	0.374	4
	147 813	Moulding	0.2-1.0	75 600 m^3	0.232	2

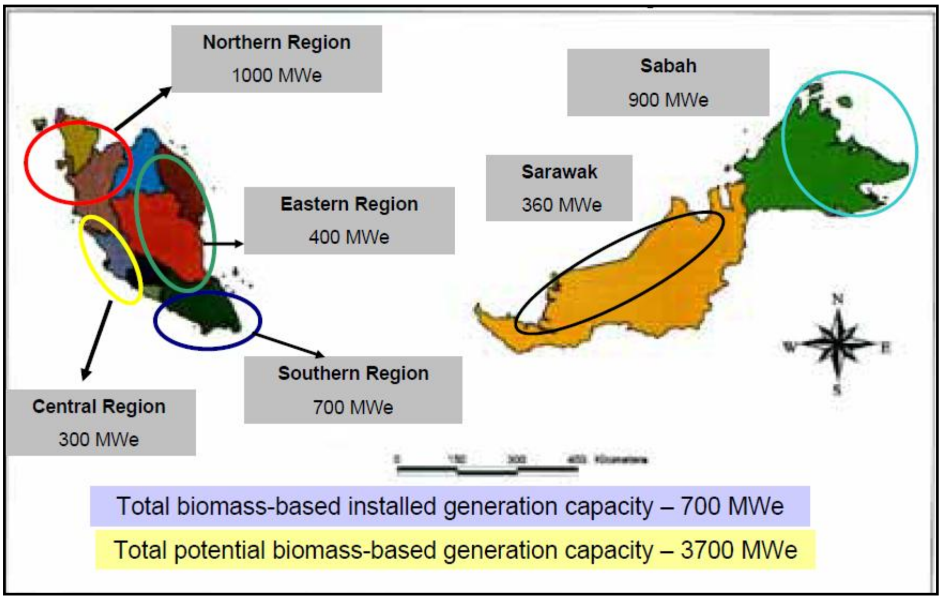

Figure 1.5: Shown a generation capacity and potential biomass generation capacity for Malaysia

Source: Malaysia Energy Centre (PTM)

There are three major biomass energy technology applications that are biofuels, biopower and bioproducts. Biofuels is the converting biomass into fluid fuels. The two most common types of biofuels are ethanol and biodiesel. Ethanol is an alcohol, the same found in beer and wine. It is made by fermenting any biomass high in carbohydrates (starches, sugars, or celluloses) through a process similar to brewing beer. Ethanol is mostly used as a fuel additive to cut down a vehicle's carbon monoxide and other smog-causing emissions. But flexible-fuel vehicles, which run on mixtures of gasoline and up to 85% ethanol, are now available. Biodiesel is made by combining alcohol (usually methanol) with vegetable oil, animal fat, or recycled cooking greases. It can be used as an additive to reduce vehicle emissions (typically 20%) or in its pure form as a renewable alternative fuel for diesel engines. Other biofuels include methanol and reformulated gasoline components. Methanol, commonly called wood alcohol, is currently produced from natural gas, but could also be produced from biomass. There are a number of ways to convert biomass to methanol, but the most likely approach is gasification. Gasification involves vaporizing the biomass at high temperatures, then removing impurities from the hot gas and passing it through a catalyst, which converts it into methanol. Most reformulated gasoline components produced from biomass are pollution-reducing fuel additives, such as Methyl Tertiary Butyl Ether (MTBE) and Ethyl Tertiary Butyl Ether (ETBE).

Biopower or biomass power is the use of biomass to generate electricity. There are six major types of biopower systems that is direct-fired, co-firing, gasification, anaerobic digestion, pyrolysis, and small, modular. Most of the biopower plants in the world use direct-fired systems. They burn bioenergy feedstock directly to produce steam. This steam is usually captured by a turbine, and a generator then converts it into electricity. Gasification systems use high temperatures and an oxygen-starved environment to convert biomass into a gas (a mixture of hydrogen, carbon monoxide, and methane). The gas fuels what's called a gas turbine, which is very much like a jet engine, only it turns an electric generator instead of propelling a jet.

Whatever products that can make from fossil fuels, it also can make by using biomass. These bioproducts, are not only made from renewable sources, they also often require less energy to produce than petroleum-based products. Researchers have discovered that the process for making biofuels by releasing the sugars that make up starch and cellulose in plants. It also can be used to make antifreeze, plastics, glues, artificial sweeteners, and gel for toothpaste. Other important building blocks for bioproducts include carbon monoxide and hydrogen. When biomass is heated with a small amount of oxygen present, these two gases are produced in abundance. Scientists call this mixture biosynthesis gas. Biosynthesis gas can be used to make plastics and acids, which can be used in making photographic films, textiles, and synthetic fabrics. When biomass is heated in the absence of oxygen, it forms pyrolysis oil. A chemical called phenol can be extracted from pyrolysis oil. Phenol is used to make wood adhesives, molded plastic, and foam insulation.

Hydropower is the only renewable energy technology that is commercially viable on a large scale. It has four major advantages. First, it is renewable. Second, it produces negligible amounts of greenhouse gases. Third, it stores large amounts of electricity at low cost and lastly it can be adjusted to meet consumer demand. For mini hydro in Malaysia in 2005, total installed capacity for power station is 121.3MW from Table 1.4.

Table 1.4: Shown the installed capacity power for biomass and mini-hidro in Malaysia

	Total Installed (MW) for RE (palm oil waste, paddy husk, wood waste)	Total installed capacity (MW) for mini-hydro power station (<50 MW)	Total electricity Generation (Gwh/year) by RE
Peninsular Malaysia	251.4	104.1	354.43
Sabah	127.2	9.9	89.44
Sarawak	360.0	7.3	1903.00
Total	702.6	121.3	2337.87

Source: Malaysia Energy Centre (PTM)

Based on the table 1.4, power installed capacity for mini hydro are 104.1 MW in Peninsular Malaysia, 9.9MW in Sabah and 360.0 in Sarawak. So the total installed capacity for mini hydro power station is 121.3MW.

In Malaysia, hydropower is used for water supply, flood control, irrigation and recreation purposes. These are based on run-of- the-river systems ranging from 500 kW to 1000 kW capacity. Mini-hydro technology is proven and the in-country expertise to build, operate and maintain plants is sufficient. Some of the major hydropower plants here like Kenyir Sultan Mahmud Power Station with 400MW installed capacity, Pergau, Kelantan Hydroelectric Power Station with 600MW installed capacity, Temenggor Hydroelectric Power Plant with 348MW installed capacity and etc.

Sourcing energy from the sun is a sensible decision. Capturing sunlight with solar collectors or photovoltaic cells to use in water heaters or to make electricity takes advantage of a relatively free energy source. Solar energy applications are viable for domestic, industrial and agricultural applications. In Malaysia, most of the photovoltaic systems are being applied for rural electrification and telecommunication. Other minor applications being promoted include street and garden lighting and recently for powering parking ticket dispensing machines municipalities. This photovoltaic technology uses semiconductor material to convert sunlight directly into electricity. The advantages of a photovoltaic (PV) system are numerous like non-polluting, there are no moving parts, operates silently and requires little maintenance. Photovoltaic power can also be stored in deep-cycle batteries for evening or back-up use. The most important disadvantage of the photovoltaic system is its cost. Photovoltaic generated electricity costs as much as twenty times the cost of electricity generated by conventional plants. Solar technology is already a mainstay option in Malaysia. In fact solar applications were first used for rural electrification and telecommunication.

4.0 TECHNOLOGIES OF RENEWABLE ENERGY IN MALAYSIA

Based on the several of renewable energy in Malaysia, it appears that Malaysia has a large of potential in Biomass, Hydro and Solar energy.

4.1 BIOMASS ENERGY

In Malaysia, biomass resources are mainly from palm oil mill residues, rice husks and wood-processing and forest residues. Sourced in a variety of forms like empty fruit bunches, fibers, shells, palm trunks, fronds and mill effluents .Each of these biomass source contains different levels of energy, depending on caloric value, moisture content, among other parameters. Currently, a great deal of these residues is disposed through incineration and dumping. Only a small portion is used as fuel for heat and power. Applying biomass technology is both a business necessity and an environmental benefit, since it rids of slurries, waste and refuses on a local scale and reduces global carbon dioxide content in the atmosphere. Biomass fuel obtained from energy crops and forest and agricultural waste can be used in power plants and is very competitive in price and 0 where biomass productivity is high. As such the country can capitalize on this natural energy resource so that biomass supplements limited petroleum and coal reserves. Many companies have taken the challenge to use Malaysia's fifth fuel and support biomass production and utilization through the following means:

4.1.1 Biomass Energy Conversion Power is energy from biomass can be converted via two general categories that is thermo chemical and biological conversion. The predominant thermo chemical conversion processes are gasification and pyrolysis. Biological means include anaerobic digestion and fermentation.

4.1.2 By gasification, fuel gas can be produced from biomass and related materials by either partial oxidation to give a mixture of carbon monoxide, carbon dioxide, hydrogen and methane or by steam or pyrolytic gasification.

4.1.3 Pyrolysis is thermal decomposition occurring in the absence of oxygen. It is the first step in combustion and gasification processes, followed by total or partial oxidation of the primary products.

4.1.4 Direct Combustion is a heat generated from direct combustion can be used directly or as an energy source. Combusting biomass for industrial applications is highly automated and can meet emission standards. And both dry matter and green material can be burnt.

4.1.5 Anaerobic digestion is microbial conversion of organic materials to methane and carbon dioxide with typically around 60% or more of methane. This can take place in landfill sites or purpose built digesters that are particularly suitable for materials with high moisture content since drying is not required. Gas outputs can then be used for heat with minimal processing or for power generation in engines, turbines and fuel cells.

4.1.6 Fermentation is suitable for materials with high moisture content, commercial technology is available to convert cellulose and hemicellulose to sugars prior to fermentation and both enzyme and acid hydrolysis is employed for this purpose. Carbohydrates such as starch also require hydrolysis. Only the cellulose in biomass is converted to ethanol.

4.2 HYDRO ENERGY

When flowing water is captured and turned into electricity, it is called hydroelectric power or hydropower. There are several types of hydroelectric facilities. They are all powered by the kinetic energy of flowing water as it moves downstream. Turbines and generators convert the energy into electricity, which is then fed into the electrical grid to be used in homes, businesses, and by industry. There are two main types of hydro turbines, impulse and reaction. The type of hydropower turbine selected for a project is based on the height of standing water-referred to as "head"-and the flow or volume of water at the site. Other deciding factors include how deep the turbine must be set, efficiency and cost.

The impulse turbine generally uses the velocity of the water to move the runner and discharges to atmospheric pressure. The water stream hits each bucket on the runner. There is no suction on the down side of the turbine and the water flows out the bottom of the turbine housing after hitting the runner. An impulse turbine is generally suitable for high head, low flow applications.

A reaction turbine develops power from the combined action of pressure and moving water. The runner is placed directly in the water stream flowing over the blades rather than striking each individually. Reaction turbines are generally used for sites with lower head and higher flows than compared with the impulse turbines.

Now, still under the project is Bakun dam that located in Sarawak. Based on their purpose, Bakun hydroelectricity dam in Sarawak will complete on stream in 2011 and the ability of the plant to transfer electricity to the Peninsular Malaysia from 2015 onwards, these projects are major milestones towards increasing the share of green energy in the country’s fuel mix. This dam, which comes with an electricity-generating capacity of 2,400MW to be supplied to Peninsular Malaysia, Sabah and Sarawak, Brunei and Kalimantan, is touted to be Southeast Asia’s largest power project.

4.3 SOLAR ENERGY

In 2005, University Kebangsaan Malaysia (UKM) has reported that solar photovoltaic stand-alone systems were introduced as part of a social rural electrification programmed. Today, technological developments worldwide are looking to grid connected photovoltaic systems. In Malaysia, there are several installations on trial. First, Six 3kW systems have been installed and operated by Tenaga Nasional Research and Development Sdn. Bhd. One of the earliest is the 5.6kW single phase installation operated by the Solar Energy Research Group in University Kebangsaan Malaysia funded by IRPA. And other include two 8 kW systems at BP petrol pumping stations. There are many advantages of the photovoltaic energy system. The most important of which is that it is a clean energy source. The most important disadvantage of the photovoltaic system is its cost.

Photovoltaic generated electricity, whether stand alone or grid connected, is electricity generated at point of use. So one megawatt of photovoltaic generated electricity is equivalent in fuel saving to about four megawatts of conventional electricity once generation and transmission losses of the conventional system are factored in. Another advantage of using the photovoltaic system is that in diversifying energy sources, it slows down the rate of increase of conventional fuels usage. This would, perhaps defer putting up of new conventional plants.

It may be quite feasible to set a target of about 10 MW of grid connected photovoltaic system for Malaysia. Another area of interest would be the use of passive solar designs to enhance natural ventilation for cooling. The basic knowledge of using these features would be very attractive to architects and landscape architects. In addition, landscaping can improve a building's energy performance. Trees and bushes can provide shading or block a prevailing wind. A typical solar hot water system will reduce the need for conventional water heating by about two-thirds. Medium-temperature solar water heaters can provide energy- efficient hot water and hot water heat for large commercial and industrial facilities. There are huge potential for the use solar hot water heating in hotels where almost of quarter of the total energy consumption is for water heating. Other promising applications include the use of solar industrial process heat in textile factories large commercial, industrial facilities and other manufacturing facilities.

5.0 THE NEED FOR ELECTRICITY AVAILABILITY

Remote people are normally settled in small villages comprised in 15 to 25 families. A few bigger villages up to 100 families also can be found. As we know, there are many activities that villagers need to do like cooking and for daily life activities. For daily life activities, they must need lighting or more. So, the electricity is very important for their activities. Providing electricity for remote communities is highly desirable. With electricity, people in remote areas can ease their daily chores by using some of electrically powered appliances long enjoy by urban dwellers. Besides cooking and lighting, regeneration is necessary in remote areas. Because wild meat and others wild food supplies have decreased drastically in deep jungles due to logging activities and commercial farming, people rely on refrigerator to preserve food.

Electricity also enables remote communities to set up village industries. Processing agricultural products such as rice milling, corn and more can be done using electrical machine. Power tools can also be used to build furniture and other wood based products. By this, it saves a lot of time and energy. In fact remote villagers can produce products of value to the urban population. Therefore, providing electricity in an appropriate and sustainable manner eventually improve the socio-economic standard of remote communities.

6.0 CASE STUDY

Electricity is a basic need in everyone's daily life, but there are some people that cannot get the electricity. For examples in Kampung Dala, Gerik, there has a community that lives deep inside the jungle. So, to extending grid wires hundreds of kilometers through difficult terrain and thick jungle just to serve a small remote village are not practical in economic terms. Besides that, the cost of stepping down the power to serve these tiny communities is very expensive.

Therefore, local authorities usually resort to temporary measures such as installing small diesel-powered generators and solar panels in certain remote villages. But, for diesel generator, it cost is expensive to operate. Then, the fuels also are difficult to get because of the location of village in the jungle. Solar panels and their electronic components also prove to be too fragile and prone to corrosion in hot and wet countries. Despite the efforts in remote area electrification, progress and success rates remain low because of

(1) the harsh operating conditions in remote settlements
(2) limited resources
(3) poor planning
(4) lack of research (in problems and technology used)
(5) negligence

On the other hand, remote peoples' dependency on rivers as source of water supply, food and transport result in most remote villages being situated in close proximity to rivers. This flow river also could be used to generate electricity to ease life in the jungle.

While micro hydro is gaining popularity for rural or remote electrification in hilly country, less research and development work has been geared towards generating power from the kinetic energy in rivers in flat country where many remote villages are located. There have been some field trials using small turbines similar to wind turbines for harnessing energy from the natural flow of rivers, but there are problems with floating debris and weeds.

Wind energy also has a potential to use in remote places. Wind energy depends on availability with varies locations. In remote areas, we can put the wind turbine in a highest place to get the maximum wind speed. Wind energy is considered a green power technology because it has only minor impact on the environment. Wind energy power plants produce no air pollutant or greenhouse gasses.

6.1 CURRENT METHOD OF REMOTE COMMUNITY ELECTRIFICATION

Diesel generators are commonly used for remote electrification. This is because they are low cost, easy to install and easy to operate. Diesel generators used in remote villages are mostly in the range of 3–7.5 kW. Generators operating on village funds usually provide about four to 6 hours of electricity in1 day, mainly for lighting at night. This again depends on the availability of fuel which is normally transported using motor boats or off-road vehicles from the nearest town. In the highlands of Sarawak, diesel fuel costs ten times the normal price because it is normally flown in using a special airplane. There is diesel generator supplied by the local government to some remote village but has been abandoned due to the lack of funds for buying diesel. Generally, diesel generators widely used in electrifying remote villages bring little improvement to the remote communities but it is limited. Besides for lighting, the limited hours of operation do not allow any significant activity to be carried out in order to improve their socioeconomic standard. To a certain degree, the maintenance and operation cost of a diesel generator is seen to be an extra burden for them. Furthermore, the low cost diesel generators are noisy, produce toxic fumes and require regular maintenance which is often neglected in a less technologically literate society.

Usually solar photovoltaic energy systems supplied to remote communities comprise two 75W panels, two 6 V 36 Ah deep cycle batteries, an inverter cum charge controller and two or three energy-efficient light globes. Power outlet points for a radio and a small TV are also available. Panels are often installed on a high pole to get clear access to the sunlight but this causes problems when it comes to cleaning. In hot and wet countries, moss and even grass grows on the panels in a short time. Surrounding trees also grow quickly and will shade the panels, thus resulting in poor operation. Panels mounted on high poles are also found to attract lightning strikes that send destructive voltage spikes to the electronic control system, destroying electronic components in the inverter cum charge controller. Some systems have ceased operation shortly after installation due to this. Electrical connections on photovoltaic arrays corrode away and the bypass diodes mounted in the termination box under each panel usually crack, probably due to high humidity, short circuiting and heat. Besides that, the panel also sensitive to the wet and hot weather, frequent downpours and a normally loudy sky give limited operating hours for the panels to charge batteries.

Mini-hydro is gaining popularity in many developing countries. Most turbines require a static head of 10 m or more, although some operate from 3 m. now, with the mini hydro system, the village enjoys 24 hours electricity supply, enabling them to use electric rice cookers, heaters, refrigerators, satellite TVs, phone, iron, radio etc. The good news was soon heard by some villagers who had left the village, and have now come back to enjoy the change. Since the micro-hydro started its operation in May 2007, not a single cent has been spent on diesel fuel for electric generation in this village. Even though mini-hydro power is proven and has gained favour in remote electrification, a micro hydro is site specific and still very expensive to construct, factors which hinder micro-hydro development in many remote area settlements. Also conventional micro hydro is not possible in flat country.

In this remote village, the numbers of villager were assumed around 30 persons. The villagers have a farm and cattle as their daily activities. The cattle in this village are like cows, buffalos, chickens, duck, sheep's, goats and more. The energy was generated by the biogas with the used of cattle waste. So that, the villagers will not have difficulties to transported long distance to get the fuel for generate the diesel generator.

The organic material, particularly from human, animal and plant wastes can be degraded by microbes and converted to methane and carbon dioxide. The decaying process in absence of the air is called as anaerobic digestion or fermentation. The gas produce from this process is known as biogas. The cattle waste from the village like cow dung, chicken dung and more, the biogas plant digester was used to provide the biogas. This gas can be used for cooking, heating as well as generating electricity for lighting, refrigeration and running motor. If the energy produces by a biogas digester is less than the energy requirement for 30 people, the other alternatives ways were use a solar photovoltaic or a wind turbine. After do the research, the hybrid system will be used either biogas-solar or biogas-wind.

1 m^3 of biogas is approximately to 6 kWh/m^3. With this amount of biogas, it can be used to operate each one of this below;

i. Can cook 3 meals for family of 4 person
ii. Can illuminate mantle lamp equivalent to 60 Watt for about 7 hours
iii. Can generate 1.25 kW of electricity
iv. Can run 2 horse power engines for one hour
v. Can run 300 litre refrigerator for 3 hours

7.0 PROBLEM STATEMENT

In order to easy their life in remote places, a research will be done to design a hybrid system to produce the energy that can be use for cooking, heating and generating the electricity for lighting. The cattle waste will be used to produce the biogas. With anaerobic digestion process the biogas will be produce. In that remote places also got the solar radiation from the sun. The solar photovoltaic also can be used to produce the energy. The other energy is wind energy. The extraction from the wind can be used to produce the power. A research will be evaluate the quantity of renewable energy available based on the local resources. The economic aspect of providing biogas or solar photovoltaic energy will be analyzed.

8.0 PROJECT OBJECTIVES

a. To determine the suitable renewable energy resource that can use in Malaysia for people living in remote places
b. To estimate the quantity of energy required

9.0 PROJECT SCOPES

a) Study of the potential of renewable energy in remote places
b) Analyzed the most suitable of renewable energy that can be used in remote places
c) Estimated the quantity of energy required for people living in remote places in Malaysia
d) Depending on the power requirement as biogas, solar and wind, hybrid power can also be used

10.0 PROJECT FLOW CHART

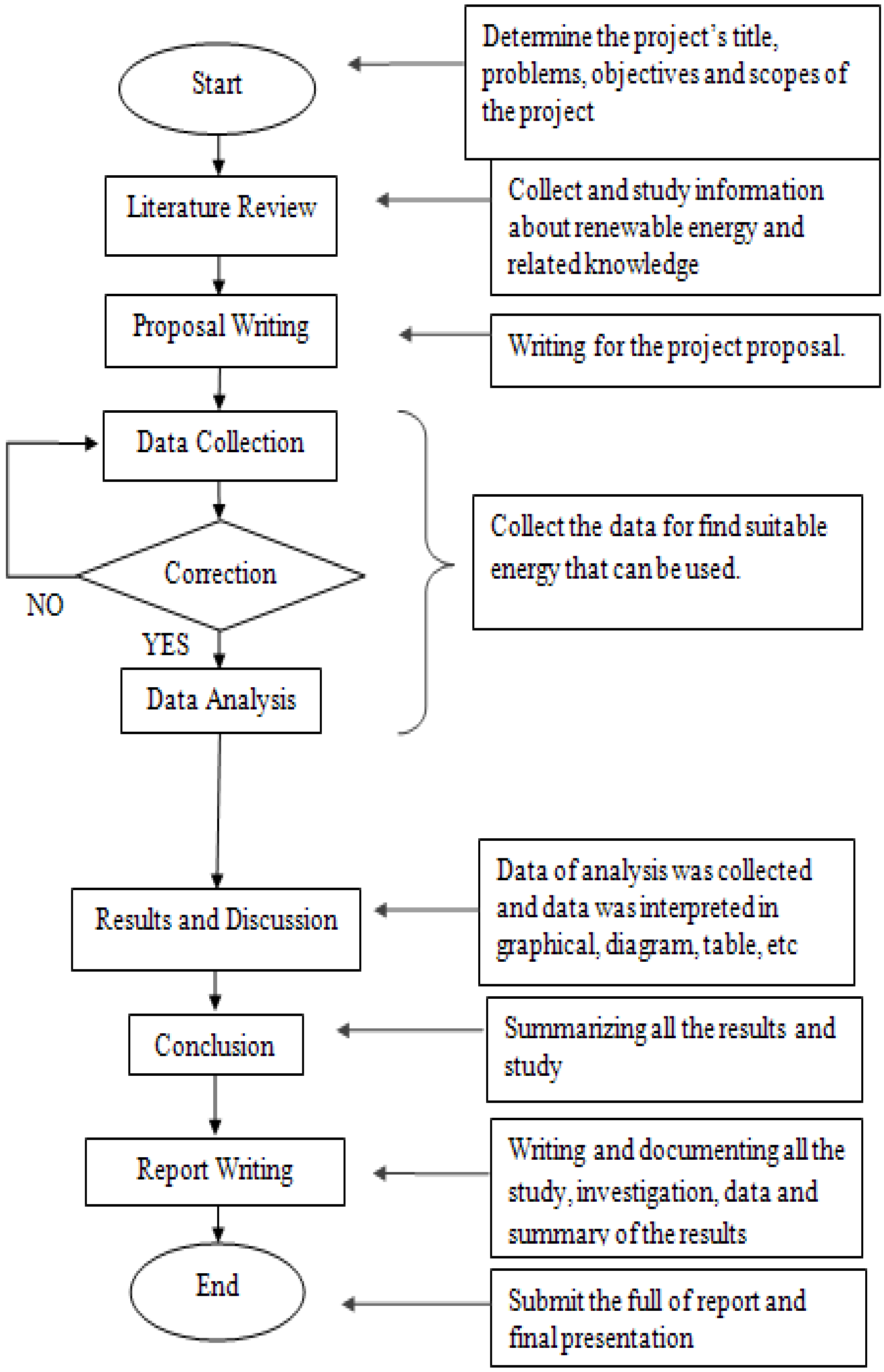

Figure 1.6: Flow chart of the overall methodology

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

This chapter will discuss about the previous related study on renewable energy and provide additional information and relevant fact. It cover are of interested terms such as biomass energy, biogas, anaerobic digestion, solar energy, sustainability and other energy resource.

2.2 BIOMASS RENEWABLE ENERGY

Sumathi et al {1} in Utilization of Oil Palm as a Source of Renewable Energy in Malaysia states that Malaysia produced about 47% of the world`s supply of palm oil. One of the major attentions from this journal is bio-diesel from palm oil. In Malaysia, bio-diesel implementation is important because of environment protection and energy supply security reason. From this journal also said that the palm oil bio-diesel is biodegradable, non-toxic and has significantly fewer emissions than petroleum-based diesel when burned. Palm oil is also well known plant for its others source of renewable energy. Sumathi et al also stated that oil palm has created many opportunities and social benefits for the local. The objective of this journal is to give a concise and up-to-date picture of the present status of oil palm industry enhancing sustainable and renewable energy. It also aims to identify the prospects of Malaysian oil palm industry toward utilization of oil palm as a source of renewable energy.

Tock et al [2] in Banana Biomass as Potential Renewable Energy Resource: A Malaysian case study states the unsustainable energy source is not going to last long and thus, gradual shift towards green renewable energy should be practiced. These journals also say that Malaysia has been well endowed with natural resource in areas such as agriculture and forestry. Beside the oil palm as the top of biomass source in Malaysia, new source should be sought after as to avoid the over dependency on single source. This paper was discussed on its potential as a new biomass resource. Banana plant is chosen as the subject due to its availability, high grows rates and carbon neutrality. This journal also state that conversion of the biomass to energy can be done via combustion, supercritical water gasification and digestion to produce thermal energy and biogas.

Koh and Hoi {3} in Sustainable Biomass Production for Energy in Malaysia have addressed issues on sustainable biomass production for energy in Malaysia. These three biomass demand scenarios that were incremental biomass demand, sustainable biomass demand and full biomass demand. In order to meet these demands, two surplus land availability scenarios are introduced. By subjecting these lands to different forestry and productivity options, it can estimate the sustainable biomass production for energy. This journal also discusses about the barriers and policy options for energy plantations and recommends some strategies to promote them.

Evans et al {4} in Sustainability Consideration for Electricity Generation from Biomass states as global populations increased, the electricity demand continues to grow. With limited fossil fuel reserved and their volatile prices, renewable fuels can provide increased energy security and stable price profiles. From this journal also say the biomass is organic, plant derived material that may be converted into other form of energy. It is easily produced in almost any environment, regenerated quickly and has a long history of use for direct heating applications. It also states that biomass could help to ensure global energy security and help to mitigate carbon pollution. For the combustion based conversion of biomass into electricity, there are three primary technologies that can be use that is pyrolysis, gasification and direct combustion.

Lim and Teong {5} in Opportunity and Challenges of Biodiesel in Malaysia states that renewable energy from biodiesel has been touted as one of the most promising substitutions for petroleum-derived diesel. The combustion of biodiesel as fuel is more environment friendly while retaining most of the positive engine properties of petroleum-derived diesel. This journal also say the huge potential of biodiesel coupled with the abundance of palm oil which is one of the most cost effective feedstock for biodiesel is responsible for the pledging of Malaysia to become the leading producer of high quality biodiesel in this region. In this journal discuss about Malaysia’s previous and current position in global biodiesel market, its future potential towards the prominent leading biodiesel status and major disrupting obstacles.

Yong et al {6} in Potential of Hydrogen from Oil Palm Biomass as a Source of Renewable Energy Worldwide states that renewable energy provides an effectiveness option for the provision of energy services from the technical point of view. In this context, biomass appears as one important renewable source of energy. In this journal also say that biomass has been major source of energy in the world until before industrialization when fossil fuel become dominant and researches have proven from time to time its viability for large scale production. So, the race to the end line must begin with the proof of biomass ability to sustain in a long run as a sustainable and reliable source of renewable energy. The aim of this journal also to present the potential availability of oil palm biomass that can be convert to hydrogen through gasification reaction in supercritical water, as a source of renewable energy to policy makers.

Walsh et al {7} in Utilization of Biogas has comprehensive study of the systems and equipment required to convert biogas into useful thermal or electrical energy. Based on this journal, biogas is a product of microbiological degradation process. Actually, the primary sources of biogas are wastewater or sludge treatment systems and solid waste landfills which are rely upon anaerobic microorganism to convert waste material to methane and carbon dioxide. Before, biogas was considered a waste product of sludge digesters and landfills. However, in recent years, it has been recognize that biogas is not simply a nuisance by product of anaerobic treatment, but a valuable source of energy. This journal also has a selection of a system for converting biogas into thermal or electrical energy. So, to choose the best process of converting biogas, the user must have knowledge of the technological option available for utilization of the fuel on-site or for sale to an off-site user. Then, a knowledge of the physical, chemical and combustion characteristic of the fuel is needed to determine what changes to conventional equipment are needed to efficiency burn the fuel. Lastly, the utilization technology selected and the biogas fuel characteristic determined the system needed for transport, clean up, compression and storage.

2.3 SOLAR RENEWABLE ENERGY

Muhida et al (8) in A Simulation Method to Find the Optimal Design of Photovoltaic Home System in Malaysia states to stop air pollution there must develop clean energy resource. This paper concerns an analysis to integrate photovoltaic as an architecture feature of a detached house in Putrajaya. The analysis was undertaken using calculation and simulation tools to optimized performance of Building Integrate Photovoltaic (BIPV) home system. The simulation and calculation was done with consideration of PV panels tilt and direction, shading effect and economical consideration. In this case study, they use 60 PV modules with power output of 2.7 kW giving an average of PV electricity output is 255kWh/month.

Klien et al {9} in Design Procedure for Solar Air Heating System states extension of the design method for solar heating systems which heat air and store the energy in a packed bed. In this paper, a solar air heating system incorporating a flat plate air heater and packed bed thermal storage is described and simulation model for the systems is developed. The result of many simulations of the air heating system are use to establish the relationship between system performance and the system design. The results are presented in several widely different climates.

Bilgen and Bakeka {10} in Solar Collector Systems to Provide Hot Air in Rural Applications was evaluated the thermal performance by a simple solar system. A mathematical model and a code are developing based on monthly average meteorological data. There are two kind of solar collector field are considered that is collector field for which the ground is used as absorber and with glazing. The other one is collector field for which roofing sheet is used as absorber as absorber without glazing. In a case study, the system is used to provide thermal energy for drying tobacco in an existing propane burning heating plant.

Denholm and Margolis{11} in Supply Curves for Rooftop Solar PV-Generated Electricity for the United States was examined several possible methods for generating PV supply curves based exclusively on rooftop deployment. They begin by introducing a framework methodology for a basic supply curve based on estimated distribution of population and buildings, rooftop availability and orientation, and geographical variation in resource. Then, they also discuss limitations to this basic methodology and introduce alternative supply curves that consider additional factors like changes in PV efficiency and configuration, rooftop availability and grid limitations. Finally, the resulting curves potentially could be used as inputs to other models or as stand-alone results.

Damanhuri et al {12} in System Design and Cost Analysis Simulation of Small Scale Dual-Tariff Solar Photovoltaic (PV) System in UiTM Pulau Pinang Malaysia states the solar Photovoltaic (PV) systems have been gradually growing on demand in Malaysia. This paper has developing the solar PV plant is on the cost effective feed-in tariff (FIT). The objective of the journal is to design and analyse the cost-benefit of a small scale guard house in Universiti Teknologi MARA (UiTM) Pulau Pinang, Malaysia. Based on their journal, A PV system generating electricity is constructed on a guard-house in UiTM Pulau Pinang, Malaysia that operates for 24 hours using a load of 9kWH/day. The supply system is modified to suit a dual-metering system in order to monitor actual electricity usage. Daytime will be defined between 7.00 am until 6.59 pm whilst the local energy supplier, Tenaga Nasional Berhad (TNB) supplied the energy for night time (7.00 pm to 6.59 am). A bank battery is used to provide backup power supply during day time if there is an unexpected weather change during that period. The estimated cost for dual-tariff PV system is predicted using HOMER. The cost of energy of total capital, replacement, operation, maintenance and salvages are to be found.

Al-Shamiry et al {13}in Design and Development of a Photovoltaic Power System for Tropical Greenhouse Cooling states that renewable energy sources like photovoltaic (PV) panels are used today in many applications. This paper also states that Natural ventilation in tropical greenhouse is common method for ventilation, which gives higher inside temperatures compared to the outside temperatures. In addition, this type of ventilation is not enough to reduce high temperature inside the structure in low land areas. Thus the requirement of cooling is increased. This research presents a study on the installation and test of a complete photovoltaic hybrid system for cooling a tropical greenhouse. A hybrid photovoltaic system consisting of two photovoltaic sub-systems were connected to each other. This system includes 48 photovoltaic solar Panels with 18.75 watt each, one inverter, 1 charge controller and a battery bank (including 12 batteries). The PV system is located at University Putra Malaysia (UPM) Research Park. The national electricity grid was used as a backup unit. The load consisted of two misting fans for cooling greenhouse (during test period time) with 400 Watt electric power and five hours (11:00 am to 16:00 pm) daily operation. The results obtained showed that the maximum current drawn from the array was found to be 14.9 ampere at 13:00 pm (with load). The voltage of array was found to be 26.9 volt while the voltage and current of battery bank were found to be 26.2 volt and 23.0 ampere respectively. In conclusion, this study highlights the primary study of PV hybrid energy systems for tropical greenhouse cooling as an application of renewable energy in Selangor, Malaysia. The results showed that PV system would be suitable to supply electricity to cover the loads requirement demands without using energy from the grid.

2.4 WIND RENEWABLE ENERGY

Zuhairuse et al {14} in The Development of Hybrid Integrated Renewable Energy System (Wind and Solar) for Sustainable Living at Perhentian Island, Malaysia was developed the strategies of achieving national energy objectives which among others are diversification of fuel type sources, technology, maximize use of indigenous energy resource and minimizing negative environment. The Renewable Energy Policy Network, REN(2007), reported that the potential wind energy generating capacity has increased by 28% and the solar energy surged to 52%. The energy efficiency and renewable energy under the Eight Malaysia Plan (2001 – 2005) and Ninth Malaysian Plan (2006 – 2010) focused on targeting for renewable energy to be significant contributor and for better utilization of energy resources. An emphasis to further reduce the dependency on petroleum provides for more effort to integrate alternative source of energy. Aware at the potential of the harvesting the wind energy, Malaysian Government under Joint venture partnership with the State Government of Terengganu and National Electric Board in 2007 embarks on the project of integrating power supply at Pulau Perhentian (Perhentian Island). This journal consist the project of installing two wind turbine, solar farm (Solar Panel), Generator and battery. This paper will encompass on the hybrid system implemented at the Perhentian Island, Malaysia.

CHAPTER 3

METHODOLOGY

3.1 INTRODUCTION

The assumption were made that the remote villagers are around 30 families. Firstly, the energy require for the villagers was estimated. Based on the information from Electrical Department, the minimum energy consumption for one person in Malaysia was calculated. By assuming the energy use for one family is same, the total energy requirement for the 30 families in kilowatt hour (kWh) was determined. The researches were done for three of renewable energy resource that is biomass or biogas, solar photovoltaic and wind energy.

3.2 BIOGAS

For the first part, by using the total energy consumption required for the 30 families, the numbers of the animal needed was calculated. By using this equation,

Energy available from biogas digester, $E = \prod H_b V_b = \prod H_m V_b f_m$ (1)

Volume of biogas, $V_b = cm_o$ (2)

Volume of fluid per day in the digester, $V_f = m_o/\rho_m$ (3)

Volume of digester, $V_d = V_f t_r$ (4)

Where;

$\prod$ - combustion efficiency ~ 60%

H_b – heat of combustion of biogas ~ 20 MJ/m³

H_m – heat of combustion of methane ~ 28 MJ/ m³

F_m – fraction of methane in biogas ~ 0.7

V_b – volume of biogass, m³

c – Biogas yield per unit dry mass ~ 0.2 to 0.4 m³/kg mass

m_o - mass of dry input

V_f – volume flow rate of fluid per day, m³/day

ρ_m – density of dry matter in the fluid ~ 50kg/m³

t_r – retention time in the digester, days ~ 20 days

Even though the numbers of the animal needed was determined, this part is inappropriate because the numbers of animal available is less than the number of animal needed.

3.3 SOLAR PHOTOVOLTAIC

After that, the solar photovoltaic was used. For the solar photovoltaic, the size of module was founded to generate the energy for the 30 families. To calculate the size of modules and size of battery needed, the power consumption demand for the villagers in kWh was determined. After that, the power consumption demand must multiply the energy lost in photovoltaic system to get the total energy which must be provided by the modules or panels. The amount of energy lost in system is 1.5 that we called as fudge factor. Then, to calculate the size of array needed, the available sunlight per hour was determined in APPENDIX C. With the data for available sunlight, the size of solar photovoltaic need was calculated. If more photovoltaic modules are installed, the system will perform better and battery life will be longer. After get the numbers of modules, the battery sizing must be found. The battery type recommended for using in solar photovoltaic system is deep cycle battery. Deep cycle battery is specially designed for to be discharged to low energy level and rapid recharged. The battery should be large enough to store sufficient energy to operate the appliances at night and days. For the battery sizing, the capacity of battery bank should be able about five times daily load. It also suggests that the system will be able to provide power continuously for five days without recharging. The result is the recommended amp-hour rating of the battery bank.

3.4 WIND TURBINE

For the wind turbine, the yearly data of the velocity of wind in East Coast Malaysia was determined. With this data, the diameter of rotor and the numbers of battery was calculated.

From the equation;

$P_t = 0.112\ P_o$

$P_o = ½(\rho \pi r^2 V^3)$

Where;

P_t = power total

P_o = power from the wind turbine

ρ = density of air

r = radius of rotor

V = velocity of wind

35% is an efficiency of rotor

Based on this equation, the suitable diameter of rotor was calculated by using data for the minimum wind velocity and maximum wind velocity. After that, the number of the batteries used was determined. The result shown the diameter was too large and it's not economical because the cost is very expensive. Then, the hybrid system was determined either used biogas and wind or biogas and solar photovoltaic.

For this system, the cattle from the village to produce the biogas was used. Cattle dung is the most suitable material for biogas plants because of the methane-producing bacteria already contained in the stomach of ruminants. The specific gas production, however, is lower and the proportion of methane is around 65% because of pre-fermentation in the stomach. From the numbers of cattle, the amount of biogas produce was determined. Even though, the amount of biogas produce by the cattle from the village was calculated, it's not enough to serve all the villagers. So, for the balance, either a solar photovoltaic or wind turbine will be used. By calculating the numbers of modules and the cost for the solar photovoltaic, the diameter of rotor and its costs also was calculated.

3.5 FORTRAN Software

With the formulas for the biogas and solar photovoltaic, the program was developed. The program was developed by used the Fortran Compiler and Editor software. With this program, the analysis will be done when the parameter was inserted.

3.5.1 Equations from Literature

The first step in FORTRAN before working on the Programming Language is to collect and identify all the equations related to the biogas and solar photovoltaic. The equations are then written in coding form of FORTRAN so that the program could read the equations properly and run without errors. List of the equations is presented in Appendix E.

3.5.2 Writing the Programming Language of FORTRAN

In order to obtain the analysis for hybrid system, a set of coding is needed which describes on how the program will be running. It is to be noted that while writing the coding, all the equations stated above must be included so that the program will come out with the analysis.

3.5.3 Data File

In this project, according to the coding written in FORTRAN, the program requires the file name of the data file. So the file name must be keyed in so that the program is able to do the calculations and come out with the analysis.

CHAPTER 4

RESULT AND DISCUSSION

4.1 INTRODUCTION

In this project, the amount of energy for one person was calculated. With the amount of energy for one person, the estimation the total energy required for 30 people in remotes places were done. After that, with that result, the number of animal needed to produce the enough biogas for that community was calculated. Then, the cost of the biogas digester needed in that place was estimated. For the solar photovoltaic and wind turbine, the same step was used. With the amount of energy required, the size of array, battery bank and the cost for solar photovoltaic system were determined. For the wind turbine also, the suitable diameter of rotor that must be used was calculated if want to generated the electricity for that place. The total cost for the wind turbine system also was calculated. If the number of animal available is less than number of animal needed for produce the enough energy, the hybrid system were applied either use a biogas-solar photovoltaic or biogas-wind turbine. Based from the first calculation, the program was developing to choose a suitable design to plant in that habitant. By using the Fortran Compiler and Editor software, the program was run and graph were plotted.

4.2 RESULT

4.2.1 Estimation of Energy Consumption

Table 4.1: Shown the calculation for the energy consumption for one person

Load	**Quantity**		**Daily use (hours)**		**Wattage (Watt)**		**Total energy consumption (Watt hour)**
Lamp (Fluorescent)	6	×	5	×	35	=	1050
Ceiling Fan	2	×	5	×	65	=	650
Kitchen Equipment;(examples- water heater, rice cooker, blender)	1	×	3	×	1200	=	3600
Television	1	×	4	×	100	=	400
Total energy consumption (Watt hour)							5700

In the table 4.1, for one day, the total energy use is 5.7 kWh. It's approximately to 6 kWh/person/day. So, the estimation of the energy consumption for one person is about 6 kWh. Then, for the remotes places, the assumption were made that the villagers are around 30 people. Thus, the total energy consumption for 30 people is 180 kWh for one day.

4.3 FOR BIOGAS ENERGY

Energy available from biogas digester, $E = \prod H_b V_b = \prod H_m V_b f_m$ (1)

Volume of biogas, $V_b = cm_o$ (2)

Volume of fluid per day in the digester, $V_f = m_o/\rho_m$ (3)

Volume of digester, $V_d = V_f\, t_r$ (4)

Where;

$\prod$ - combustion efficiency ~ 60%

H_b – heat of combustion of biogas ~ 20 MJ/m³

H_m – heat of combustion of methane ~ 28 MJ/ m³

F_m – fraction of methane in biogas ~ 0.7

V_b – volume of biogas, m³

c – Biogas yield per unit dry mass ~ 0.2 to 0.4 m³/kg mass

m_o - mass of dry input

V_f – volume flow rate of fluid per day, m³/day

ρ_m – density of dry matter in the fluid ~ 50kg/m³

t_r – retention time in the digester, days ~ 20 days

1 person required 6 kWh of energy

For 30 persons, we need 180 kWh or 648 M Joule (MJ)

To get 648 MJ,

4.3.1 Biogas Calculation from Cow Waste:

Energy, $E = \prod H_b V_b$; $V_b = E/\prod V_b$

$= 648\ \text{MJ}/(0.6)(20\ \text{MJ/m}^3)$

$= 54\ \text{m}^3$

For cow, $c = 0.4\ \text{m}^3/\text{kg}$

$V_b = cm_o$; $m_o = V_{b/c}$

$= 54\ \text{m}^3/(0.4\text{m}^3/\text{kg})$

$= 135\ \text{kg}$

Mass dry input for cow is 2 kg/day

Then, total cows required to generate 648 MJ = 135 kg/2 kg

= 67.5 cows ≈ 68 cows

4.3.2 Biogas Calculation from Buffalo Waste;

Energy, $E = \prod H_b V_b$; $V_b = E/\prod V_b$

$=648\ MJ/(0.6)(20\ MJ/m^3)$

$=54\ m^3$

For cow, $c = 0.35\ m^3/kg$

$V_b = cm_o$; $m_o = V_{b/c}$

$= 54\ m^3/(0.35 m^3/kg)$

$= 154.3\ kg$

Mass dry input for buffalo is 4 kg/day

Then, total buffalos required to generate 648 MJ = 154.3 kg/4 kg

= 38.6 buffalo's ≈ 39 buffalos

4.3.3 Biogas Calculation from Goat and Sheep Waste;

Energy, $E = \prod H_b V_b$; $V_b = E/\prod V_b$

$=648\ MJ/(0.6)(20\ MJ/m^3)$

$=54\ m^3$

For goat or sheep, $c = 0.3\ m^3/kg$

$V_b = cm_o$; $m_o = V_{b/c}$

$= 54\ m^3/(0.3 m^3/kg)$

$= 180\ kg$

Mass dry input for goat or sheep is 0.6 kg/day

Then, total goats and sheep's required to generate 648 MJ = 180 kg/0.6 kg

= 300 goats and sheep's

If the biogas digester for this place was design, there are 68 of cows or 39 buffalos or 300 goats and sheep's was needed to supply enough energy for habitant. However, usually in remote places, the amount of these animals is less than the amount of animals needed. So, the biogas digester for this remote place cannot be built. Then, the other alternative ways is by used a solar photovoltaic or a wind turbine.

4.3.4 Estimation Cost of Biogas Digester;

First, the height and the diameter needed for design the biogas digester in that place was calculated based on the energy consumption for 30 persons. However, the value is very large and not practical to build it. After discuss, a standard size of the biogas digester was chosen. The 30m³ of biogas digester was because it more suitable for that area. Based on the standard 30m³ of biogas digester, the value height of the digester is about 3.2m and the value of radius for digester is 3.0m.

For the estimation cost of 30m³ of biogas digester;

Material needed;

- Brick
- Pipe (inlet pipe, outlet pipe, gas control pipe, feed pipe)
- Hose pipe
- Mould of digester chamber lid
- Handle for digester chamber
- Thread tape
- Glue
- Gas fitting

For brick, to build 1m³ need 60 pieces of brick

For 30m³ = 30*60 = 1600 pieces

1 pieces bricks = USD 1.00

1600 pieces bricks = USD 1600.00

For pipe, = USD 300.00

For mould and handle digester chamber = USD 300.00

For other (thread tape, glue, gas fitting etc) = USD 300.00

Total costs = USD (1500 + 100 + 200 + 250) = USD 2500.00

4.4 SOLAR PHOTOVOLTAIC AND WIND TURBINE

4.4.1 Solar Photovoltaic System

For E = 180kWh;

Energy load required in watt hours

= Number of watts consume by the hours per day*1.5 (5)

Fudge factor for solar photovoltaic system is 1.5

180kWh*1.5 = 270kWh

From the Table 4.2(refer appendix), the maximum availability sunlight hour per day is 7.4 hours/day

PV array size = energy needed/availability of sunlight per day (6)

= 270kWh/7.4hours

= 36.49kW

Size of battery = (energy needed*5)/12V (7)

Assume the system will be able to provide power continuously for five days without recharging.

Size of battery = (270kWh*5)/12V = 112.5k Ah

Estimation cost of array = size of array*$5 per watt (8

= 36.49kW*$5 = $182 450

Estimation cost for battery bank = size of battery bank*$1000 per kAh (9)

` = 112.5k Ah*$1 = $112 500

Total cost for array and battery = $182 450 + 112 500 = $294 950 (10)

20% is the cost to cover the system (wire, fuses, switch and etc)

Total cost for array and battery*0.2 (11)

$294 950*0.2 = $58 990

Thus; total estimated cost of PV system = $294 950+ $58 990= $353 940 (12)

In Rm = $353 940*Rm 3.10 = Rm1 097 214.00

If the energy required for 30 persons was generated in that remote place from the solar photovoltaic, 36.49kW for the solar photovoltaic array size and 112.5k Ah for the size of battery was calculated. The total cost for this system is Rm 1 097 214.00. Before get those values, some assumption were made. Sometimes, it is difficult to anticipate every electric load in the household. Usually, television and other electric appliances sometimes draw small amounts of power even when they are turn off. For this reason, the daily load was multiply by a fudge factor. For this problem, fudge factor is 1.5. Before determined the size of battery, some assumption also were made. The battery used is 12V because it is the standard of battery. The daily load must have multiplied by 5 because the system was assumed will be able to provide power continuously for five day without recharging. By used these assumptions, the value for the solar photovoltaic system were calculated.

4.4.2 Wind Turbine System

After that, an extraction the energy from the wind was used. The suitable diameter for rotor for wind turbine based on the energy needed was calculated.

Energy required = 180 kWh = 648 MJ = 648 MW

Efficiency of a rotor, E= 0.2*0.8*0.7 = 0.112 = 11.2%

$P_t = 0.112\ P_o$ (13)

$P_o = 648000000J/0.112 = 5785.7\ MJ$

From equation $P_o = \frac{1}{2}\rho\pi r^2 v^3$ (14)

Where ρ – density of air

r – Radius of rotor

v – Velocity of wind

Table 4.3: Show the average monthly wind speed m/s recorded for 2005 in East Coast Malaysia (Zuhairuse et al)

	Year 2005		
Month	Min	Max	Ave
Jan	5.6	14	7.9
Feb	6.1	8.2	6.85
Mar	6.1	13.3	7.56
Apr	5.5	10.7	6.78
May	4.9	11.5	6.91
Jun	N.A	N.A	N.A
Jul	4.8	11.5	6.63
Aug	5	15.6	7.16
Sep	4.4	12.7	6.88
Oct	3.9	14.3	7.12
Nov	4.7	15.4	7.57
Dec	4.6	15.3	7.88

From table 4.3, we get the maximum wind velocity is 7.9 m/s and minimum wind velocity is 6.63 m/s.

For maximum velocity;

$5785.7 \text{ M} = \frac{1}{2}\rho\pi r^2 v^3 = \frac{1}{2}(1.23)\pi r^2 (7.9)^3$

$r^2 = 6073.6 \text{ m}^2$

$r = 77.9 \text{ m} \approx 80 \text{ m}$

For minimum velocity;

$5785.7 \text{ M} = \frac{1}{2}\rho\pi r^2 v^3 = \frac{1}{2}(1.23)\ \pi r^2\ (6.63)^3$

$r^2 = 10275.2 \text{ m}^2$

$r = 101.34\text{m} \approx 102 \text{ m}$

To get the diameter of the rotor of wind turbine, the total efficiency was estimated. By taking a conservative estimation for the rotor efficiency of 20%, generator efficiency around 80% and transmission efficiency around 70%, total efficiency of of wind turbine was 11.2%. After that, by using the data for the East Coast Malaysia, 204m for the diameter of the turbine was calculated. For this value, the minimum wind speed average was used. Actually the cost for the wind turbine is too big to build in that area. So hybrid system was the suitable ways to generate the energy for that place.

4.5 HYBRID SYSTEM

In the remote village, the villagers usually have farming, fishing with the animal and more for their activity. Based on their activity, some assumptions were made for the amount of cattle in there. For this problem, the cattle from the place were cows, buffalos, goat and sheep. The quantity of the cattle was shown in Table 4.4.

Table 4.4: The amount of cattle in the remote place

Cattle	Quantity
Cow	6
Buffalo	8
Goats	15
Sheep	15

Energy available from biogas digester, $E = \prod H_b V_b = \prod H_m V_b f_m$ (1)

Volume of biogas, $V_b = c m_o$ (2)

Volume of fluid per day in the digester, $V_f = m_o / \rho_m$ (3)

Volume of digester, $V_d = V_f t_r$ (4)

Where;

$\prod$ - combustion efficiency ~ 60%

H_b – heat of combustion of biogas ~ 20 MJ/m³

H_m – heat of combustion of methane ~ 28 MJ/ m³

F_m – fraction of methane in biogas ~ 0.7

V_b – volume of biogass, m³

c – biogas yield per unit dry mass ~ 0.2 to 0.4 m³/kg mass

m_o - mass of dry input

V_f – volume flow rate of fluid per day, m³/day

ρ_m – density of dry matter in the fluid ~ 50kg/m³

t_r – retention time in the digester, days ~ 20 days

For 6 cows;

$m_o = 6*2kg = 12kg$

$Vf = m_o/\rho m = 12kg/(50kg/m^3) = 0.24\ m^3$

$Vd = Vf\ tr = 0.24\ m^3(20\ days) = 4.8\ m^3$

$Vb = cm_o = 0.4*12kg = 4.8\ m^3$

$E = \prod HmfmVb = 0.6*(28MJ/m^3)*(0.7)*(4.8m^3)$

$= 56.45\ MJ = 15.68\ kWh/day$

For 8 buffalos;

$m_o = 8*4kg = 32kg$

$Vf = m_o/\rho m = 32kg/(50kg/m^3) = 0.64\ m^3$

$Vd = Vf\ tr = 0.64\ m^3(20\ days) = 12.8\ m^3$

$Vb = cm_o = 0.35*32kg = 11.2\ m^3$

$E = \prod HmfmVb = 0.6*(28MJ/m^3)*(0.7)*(11.2m^3)$

$= 131.7\ MJ = 36.6\ kWh/day$

For 30 goats and sheeps

$m_o = 30*0.6kg = 18kg$

$Vf = m_o/\rho m = 18kg/(50kg/m^3) = 0.36\ m^3$

$Vd = Vf\ tr = 0.36\ m^3(20\ days) =7.2\ m^3$

$Vb = cm_o = 0.3*18kg = 5.4\ m^3$

$E = \prod H m f m V b = 0.6*(28MJ/m^3)*(0.7)*(5.4m^3)$

$= 63.5$ MJ $= 17.64$ kWh/day

Total energy from cattle dung is = (15.58 + 36.6 + 17.64)kWh/day

= 96.92 ≈ 70 kWh/ day = 252 MJ

The total energy can produce from the cattle in that village in about 252 MJ. The energy needed for that place is 648 MJ. There is 396 MJ more needed. For generated the other 396 MJ of energy, the solar photovoltaic system or wind turbine were used. To find the best solution, the investigation was done for these two types of renewable energy.

4.5.1 Estimation cost

For these cattle, they need to build 3 of 30 m^3 biogas digester.

For 1 of 30 m^3 biogas digester = USD 2500.00

Thus, for 3 of 30 m^3 biogas digester = 3*USD 2500.00 = USD 7500.00

Balance energy needed = 180 kWh – 70 kWh = 110 kWh

If go with the solar photovoltaic system;

For E = 110kWh;

Energy load required in watt hours

= Number of watts consume by the hours per day*1.5

Where is 1.5 the fudge factor for solar photovoltaic system.

110kWh*1.5 = 165kWh

From the table 4.2 (refer appendix), the maximum availability sunlight hour per day is 7.4 hours/day

PV array size = energy needed/availability of sunlight per day

= 165kWh/7.4hours

= 22.3kW

Size of battery = (energy needed*5)/12V

Assume the system will be able to provide power continuously for five days without recharging.

Size of battery = (165kWh*5)/12V = 68.75Ah

Estimation cost of array = size of array*$5 per watt

= 22.3kW*$5 = $111 500

Estimation cost for battery bank = size of battery bank*$1000 per kAmp

= 68.75k Ah*$1 = $68 750

Total cost for array and battery = $111 500 + 68 750 = $180 250

20% is the cost to cover the system (wire, fuses, switch and etc)

$180 250*0.2 = $36 050

Thus; total estimated cost of PV system = $180 250+ $36 050= $216 300

In Rm = $216 300*Rm 3.10 = Rm670 530.00

If go with the wind turbine;

Energy required = 110 kWh = 396 MJ = 396 MW

Efficiency of a rotor = 0.2*0.8*0.7 = 0.112 = 11.2%

$P_t = 0.112\ P_o$

P_o = 396000000J/0.112 = 3294.6 MJ

From table 4.3, we get the maximum wind velocity is 7.9 m/s and minimum wind velocity is 6.63 m/s.

For maximum velocity;

$3294.6\ M = \frac{1}{2}\rho\pi r^2 v^3 = \frac{1}{2}(1.23)\pi r^2(7.9)^3$

$r^2 = 3458.6\ m^2$

$r = 58.8\ m \approx 59\ m$

For minimum velocity;

$3294.6\ M = \frac{1}{2}\rho\pi r^2 v^3 = \frac{1}{2}(1.23)\ \pi r^2\ (6.63)^3$

$r^2 = 5850.1\ m^2$

$r = 76.5m \approx 77\ m$

For the solar photovoltaic system, 22.3kW for the photovoltaic array size and 68.75k Ah for the battery size was calculated. The total cost for photovoltaic system also was calculated that is Rm 670 530.00.

For the wind turbine, to generate 396 MJ of energy, the diameter of rotor is 118m when the wind speed is highest speed. When the minimum wind speed was used, the diameter is 154m. Usually, to design a wind turbine, the minimum wind speed will use to get the diameter of the rotor. In that case, if the wind turbine wanted to be built, the diameter of rotor will be 154m.

After done for some research and investigated for the situation in the remotes place, the suitable way was by used the biogas-solar photovoltaic for that place. This is because the cost of the system is cheap than the other ways that is biogas-wind turbine. The availability of Malaysia in solar energy also is the factor. As we know, Malaysia has received a large amount of the radiation from solar. With the power from the solar, it can be can to make their life in remote habitant better. Besides, there were many ways that to extract the energy from this source. Compared to the wind, there were some difficulties. For the example, to plant the wind turbine, the large area was provided. In other hand, this wind turbine usually makes a noise. It will make the life there uncomfortable.

4.6 Discussion Graph

The program was run by using the Fortran Compiler and editing software after done a calculation. In the program, the parameter was change and the result is display. By using these results, the graph has been draw.

If only the cow was used, the two figures were shown. The Figured 4.1 shown the total cost of hybrid power in USD when the number of cows is constant that is 30. The minimum cost of the hybrid power is USD 2500 when the number of person is 10 for both energy requirement 3 kWh and 6 kWh. The maximum cost from the graph is

USD 101875 for the energy requirement is 3 kWh and USD 237426.2 for energy requirement is 6 kWh. The total cost in increase when the number of person increases.

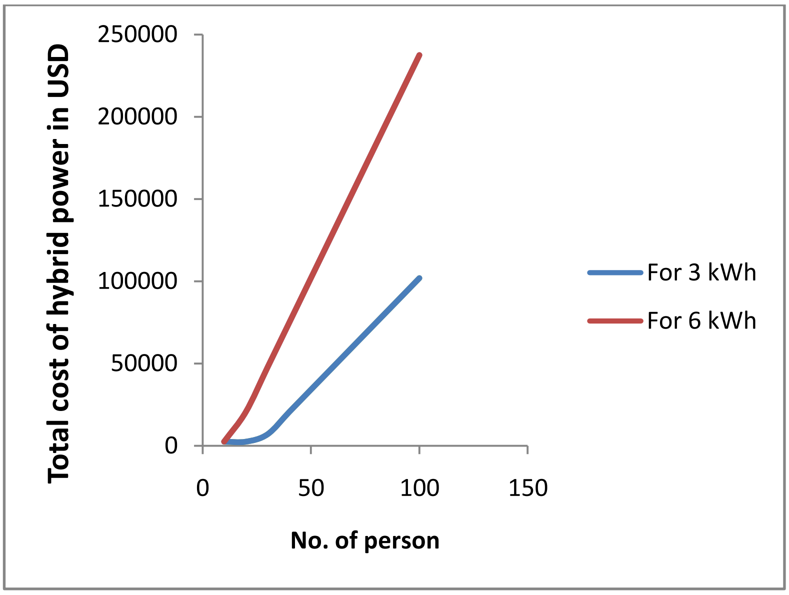

Figure 4.1: Graph Total cost Vs No. of Person for 3 kWh and 6 kWh

The Figured 4.2 shown the total cost of hybrid power in USD when the number of person is constant that is 30. The cost of the hybrid power is USD 28606.7 when the number of cow is 10 for the energy requirement 3 kWh and USD 69272 for energy requirement is 6 kWh. The cost from the graph is same for both energy requirements when the number of cow is 100 that are USD 7500. From the graph, when the number of cow is above the 70, the total cost of hybrid power decrease. The total cost is reducing because when the number of cow is above 70, it can generate the power only from biogas digester.

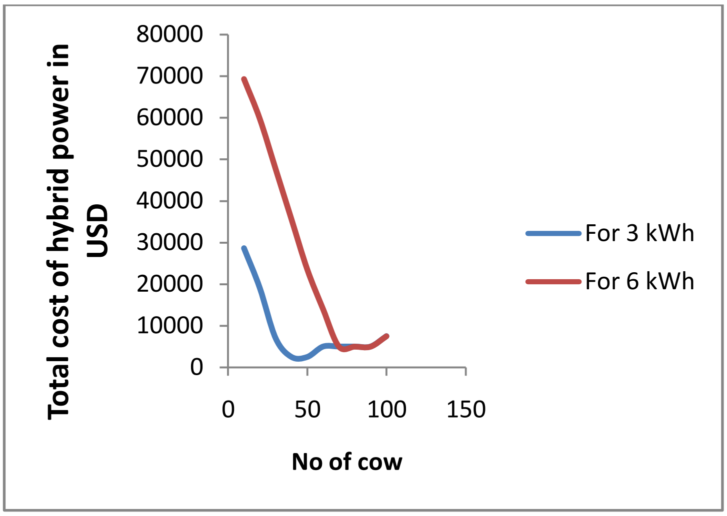

Figure 4.2: Graph Total cost Vs No. of Cow for 3 kWh and 6 kWh

When only the buffalos were used, the graph was shown in Figures 4.3 and Figure 4.4. For the graph, the number of buffalo is constant that is 30. For the energy requirement is 3 kWh and 6 kWh, the total cost is same when the number of person is in range 10 to 20. For the number of person is above 20, the total cost is increase. It is because the solar PV has been used when the number of person is above 20. From the graph, for the energy requirement is 3 kWh, the total cost is increasing when the number of person is more than 40. For the energy requirement is 6 kWh, the total cost is increasing when the number of person more than 20. So, from the both graph the total cost of hybrid power is increasing when the number of person increase.

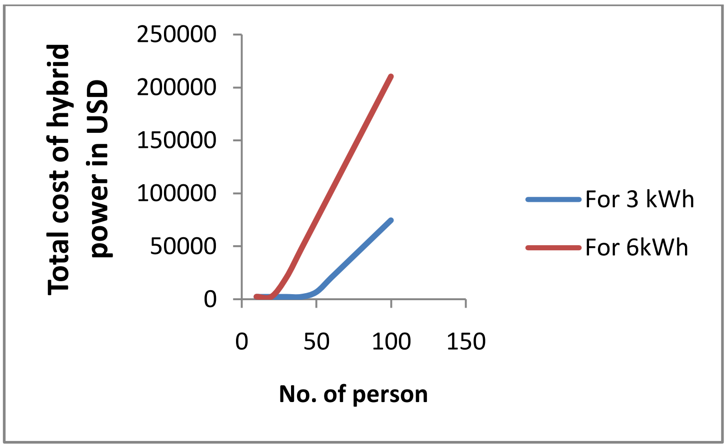

Figure 4.3: Graph Total cost Vs No. of Person for 3 kWh and 6 kWh

When the number of person is constant that is 30, we get the graph below. From the graph, the total cost is highly first. Then, when the number of buffalo is increase, the total cost is decreasing. The total cost is decreasing because when the number of buffalo increases, it can generate the power only from biogas digester. For the energy requirement is 3 kWh, the power from biogas digester is used when the number of buffalo more than 20. For the energy requirement is 6 kWh, the power from the biogas digester is used when the number of buffalo more than 40.

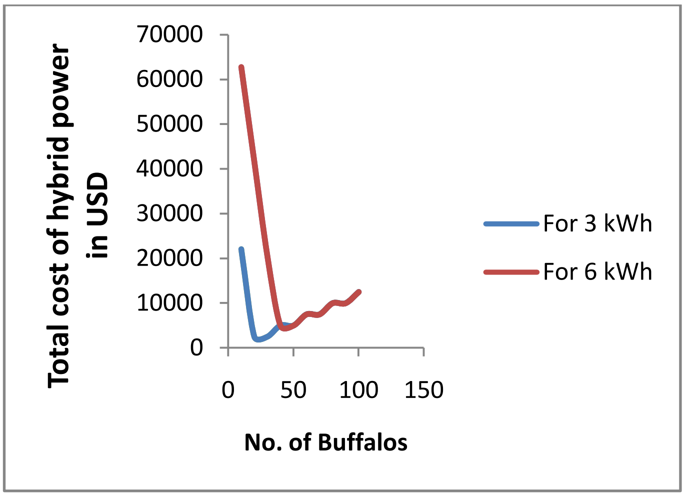

Figure 4.4: Graph Total cost Vs No. of Buffalo for 3 kWh and 6 kWh

If the goat and sheep was used, the two graphs were shown in Figure 4.5 and Figure 4.6. Figure 4.5 shown the graph of total cost and number of person when the number of goat and sheep is constant that is 30. From the figure, the cost when the number of person is 10 is USD 5415.5 for energy requirement is 3 kWh and USD 18970.6 for energy requirement is 6 kWh. The maximum total cost from the graph is USD 127411.5 for energy requirement is 3 kWh and USD 262962.5 for energy requirement is 6 kWh. From the graph, when the number of person is increase, the total cost of hybrid power is also increasing.

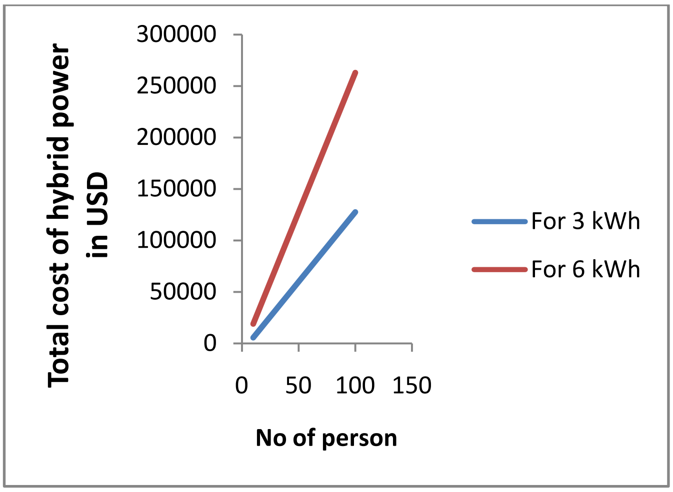

Figure 4.5: Graph Total cost Vs No. of Person for 3 kWh and 6 kWh

The figure 4.6 is shown the graph of total cost and number of goat and sheep when the number of person is constant that is 30. The total cost for energy requirement 3 kWh is USD 37952.1 when the number of animal is 10 and USD 16033.4 when the number of animal is 100. For the 6 kWh, the total cost is USD 78617.4 when the number of animal is 10 and USD 56698.7 when the number of animal is 100. From the graph, the total cost of hybrid power is reducing when the number of goat and sheep increase.

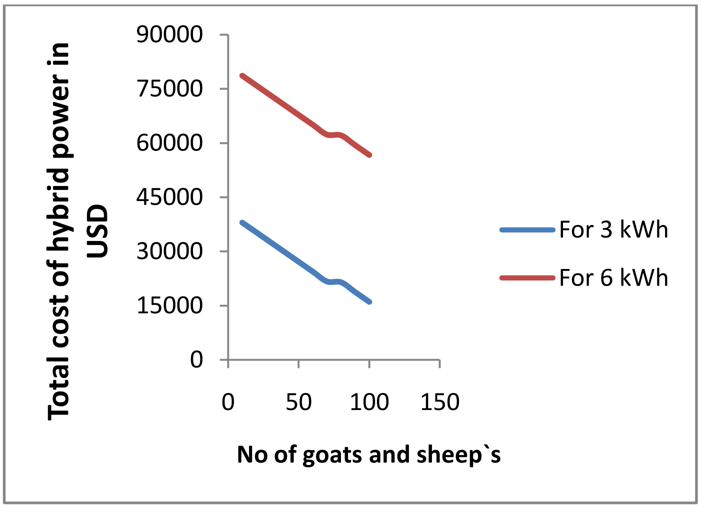

Figure 4.6: Graph Total cost Vs No. of Goat and Sheep for 3 kWh and 6 kWh

By used a Fortran Compiler and Editor software, in a constant number of cow and 3 kWh for energy requirement, the graph was shown in Figure 4.7. From the Figure 4.7, if the people is below than 30 person, the cost was remains same because it just only used a biogas digester to generate the energy. But, when the number of people was more than 30, the cost was increase because the solar photovoltaic system was applied with the biogas digester. So that, by increasing the number of people, the total cost will be increase.

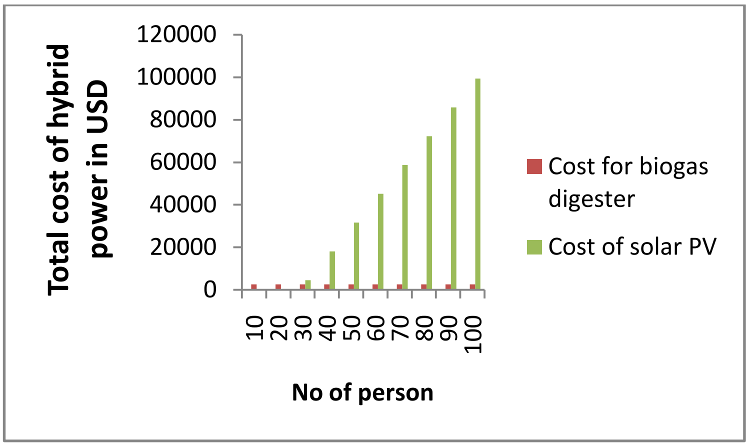

Figure 4.7: Graph Total cost Vs No. of Person for 3 kWh

For the 6 kWh energy requirements, the graph was display in Figure 4.8. If the number of people is less than 20 persons, only the biogas digester were used for generate the energy in that place. When the number of people is more than 20 persons, the hybrid system were used. So, the total cost will increase with the number of people increase.

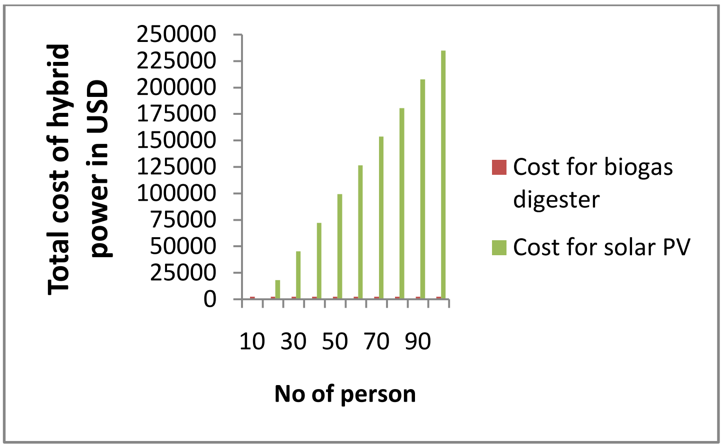

Figure 4.8: Graph Total cost Vs No. of Person for 6 kWh

When the number of person is constant that is 30 and energy requirement is 3 kWh, the graph was shown in Figure 4.9. From the graph, for the first 10 cows, the total cost is higher because it only used the solar photovoltaic system. If the number of cow is more than 30, only the biogas digester was used. So that, the total cost was decreasing because the solar photovoltaic system was not used. In a range 20 to 30 number of cow, the hybrid system was applied.

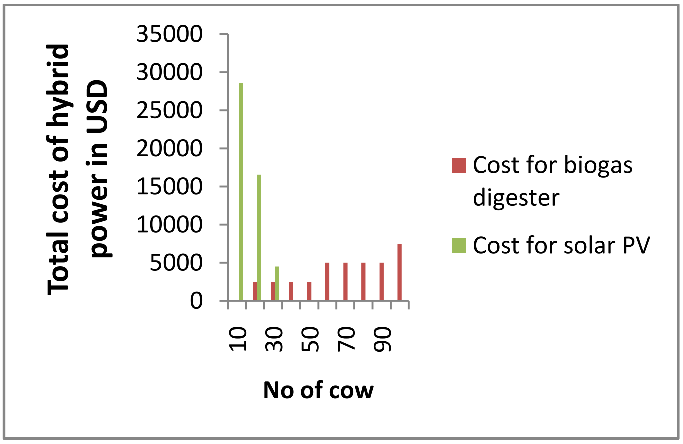

Figure 4.9: Graph Total cost Vs No. of Cow for 3 kWh

For the 6 kWh energy requirements, when the number of people is same that is 30 persons, the graph below was in Figure 4.10. When the number of cow is less than 60, the hybrid system was used. The cost for the biogas digester was same but the cost for solar photovoltaic is different. Less the number of cow, higher the cost of solar photovoltaic required. When the number of cow more than 60, only biogas digester was be used to produce the energy for that place. Then, total cost was reduced.

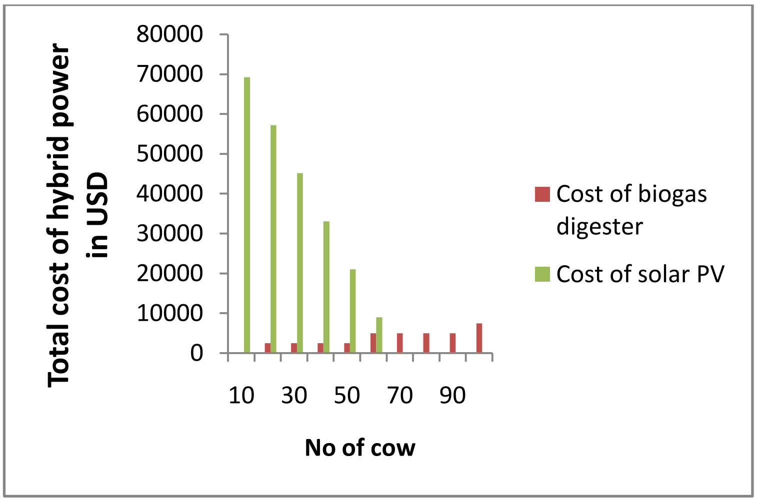

Figure 4.10: Graph Total cost Vs No. of Cow for 6 kWh

When the number of buffalos was 30 and energy requirement is 3 kWh, the graph was shown in Figures 4.11 and 4.12. From the Figure 4.11, when the number of people was less than 40, the energy was generated only by biogas digester. The cost was same for the number of person less than 40. The hybrid system was used when the number of person is more than 40. The cost was increased because it used a solar photovoltaic system.

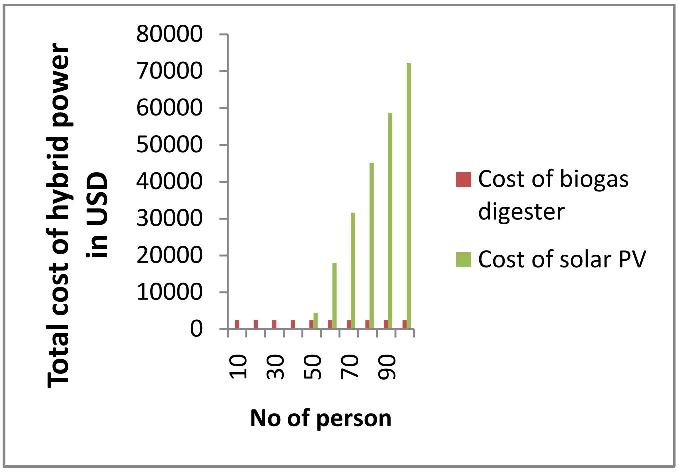

Figure 4.11: Graph Total cost Vs No. of Person for 3 kWh

When energy requirement is 6 kWh and the number of buffalo is 30, the graph was shown Figure 4.12. From the graph, the biogas digester was used and the cost is same for the all number of person. When the number of person is more than 20, the hybrid system were used and increase the total cost. So, the cost of solar photovoltaic was increase when the number of person was increase.

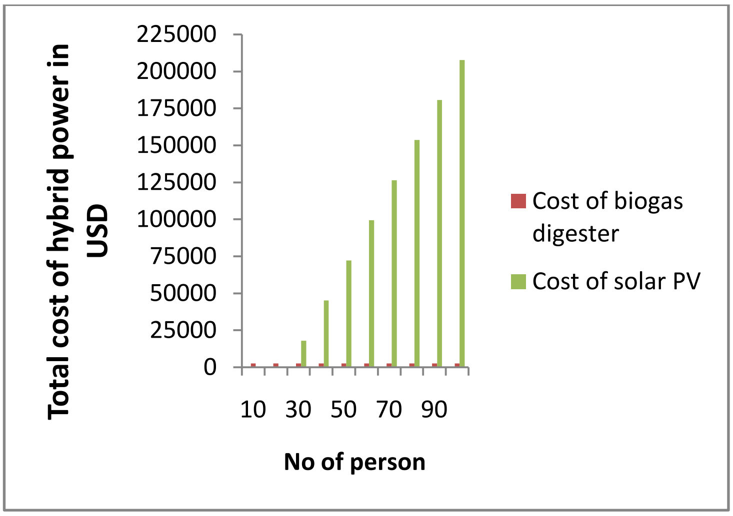

Figure 4.12: Graph Total cost Vs No. of Person for 6 kWh

In other condition, when the number of person was constant that is 30 and energy requirement was 3 kWh, the graph was shown in Figures 4.13 and 4.14 for energy requirement is 3 kWh and 4 kWh. From the Figure 4.13, the hybrid system was used when the number of buffalo was less than 10. So, the cost was higher when the solar photovoltaic was used. When the number of buffalo is more than 10, only biogas digester were be used to produce the energy. By increasing the number of buffalos, the cost of biogas digester also increases.

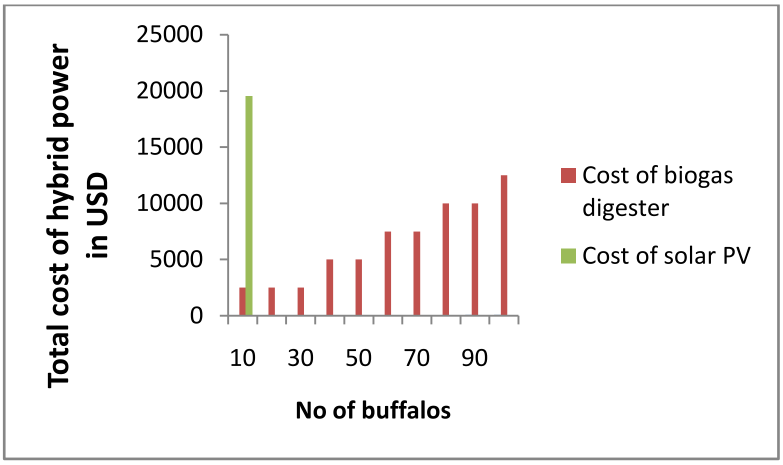

Figure 4.13: Graph Total cost Vs No. of Buffalo for 3 kWh

For 6 kWh of energy requirement and 30 number of person, the graph was shown in Figure 4.14. From the Figure 4.14, when the number of buffalo below than 30, hybrid system were used and the cost was higher. When the number of animal is more than 30, only biogas digester were used and reduced the total cost.

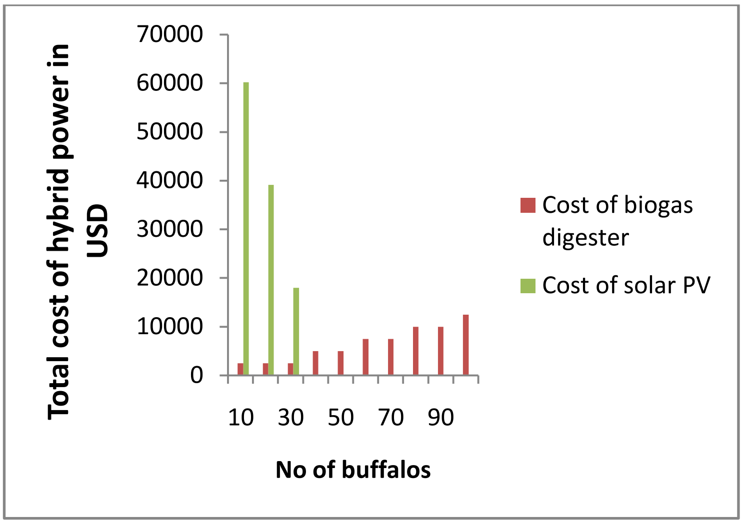

Figure 4.14: Graph Total cost Vs No. of Buffalo for 6 kWh

When the goat and sheep's was used, the graph was shown in Figures 4.15, 4.16, 4.17 and 4.18. The pattern of the graph for the both energy requirement 3 kWh and 6 kWh was same when the number of goat and sheep's were 30. From the graph, the energy was only generated by the solar photovoltaic. By increasing the number of person, the cost also increased.

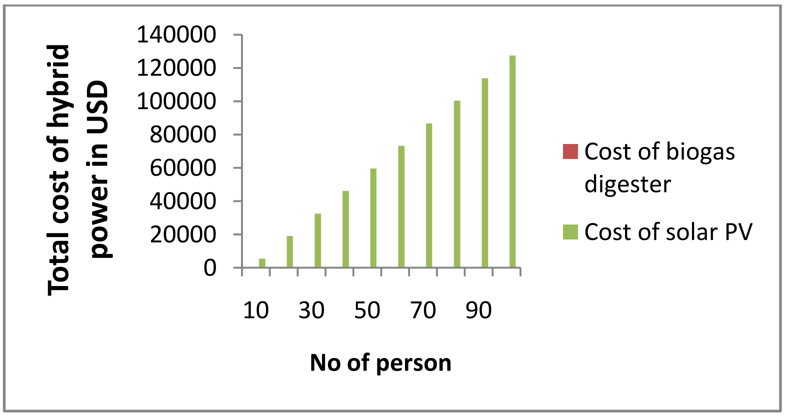

Figure 4.15: Graph Total cost Vs No. of Person for 3 kWh

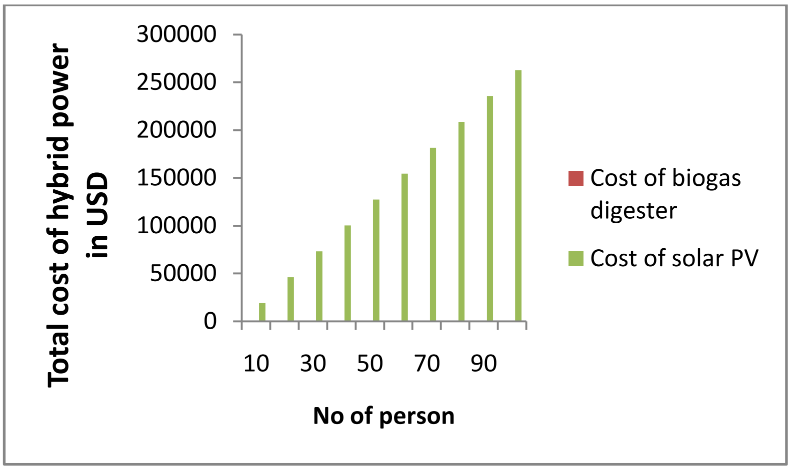

Figure 4.16: Graph Total cost Vs No. of Person for 6 kWh

When the 30 number of person were used, the pattern of the graph is same for the 3 kWh and 6 kWh. From the Figures 4.17 and 4.18, the cost was higher when the number of goat and buffalo was decreased. For the number of goat and sheep was less than 80, only solar photovoltaic system were used. When the number of goat and sheep more than 80, hybrid will be used.

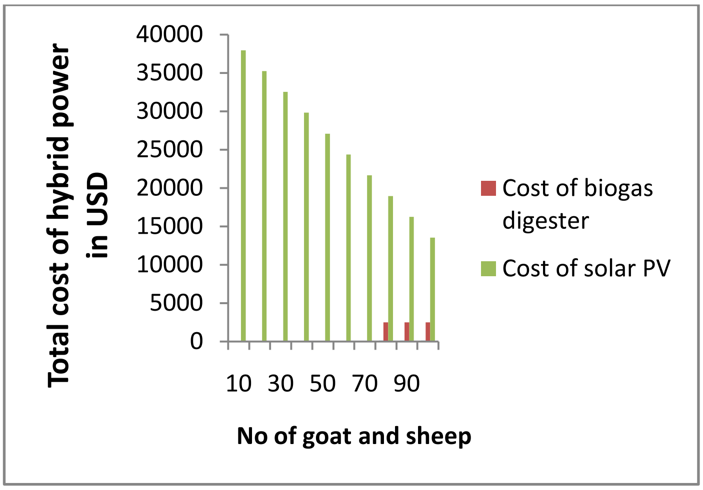

Figure 4.17: Graph Total cost Vs No. of Goat and Sheep for 3 kWh

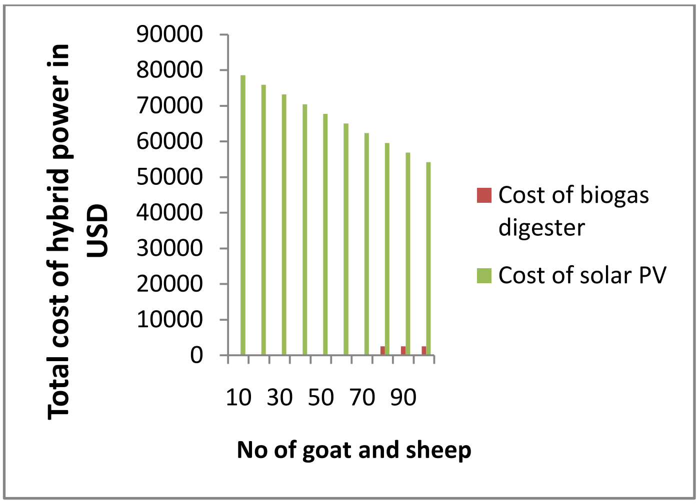

Figure 4.18: Graph Total cost Vs No. of Goat and Sheep 6 kWh

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

In this paper, a case study of hybrid system was investigated. By take one of remote places in Malaysia, the parameter was assumed for that place. Then, the availability of the renewable resource in that place was investigated. After some research, there are three kind of renewable energy source that can use in that place. That is biomass energy, solar energy and wind energy. With three kind of energy, the alternative ways to produce the energy for that place were founded. After that, some calculation was done for find the suitable size of biogas digester. In that case, the size of solar arrays and battery bank for the solar photovoltaic system also was calculated and for wind turbine system; the suitable diameter of rotor and size of the battery by using the energy consumption for that remote places was calculated. With the some calculation that has done, the hybrid system was built for that place. If the biogas was used alone, the energy produce is less than the energy need for that place. So, the others ways either the solar photovoltaic system or wind turbine but the cost of the system is higher. So that, the hybrid system was used to make sure it can produce the energy needed for that place. The hybrid system is either biogas-solar photovoltaic or biogas-wind turbine. The biogas-solar photovoltaic system is better than the biogas-wind turbine system. It is because the biogas- solar photovoltaic system is more economics than the biogas-wind turbine system.

5.2 RECOMMENDATION

- Use a solar air heating system for improved the project.
- Use the entire biomass source in that place like woods and more.
- Determine the availability of hydro energy in that place.

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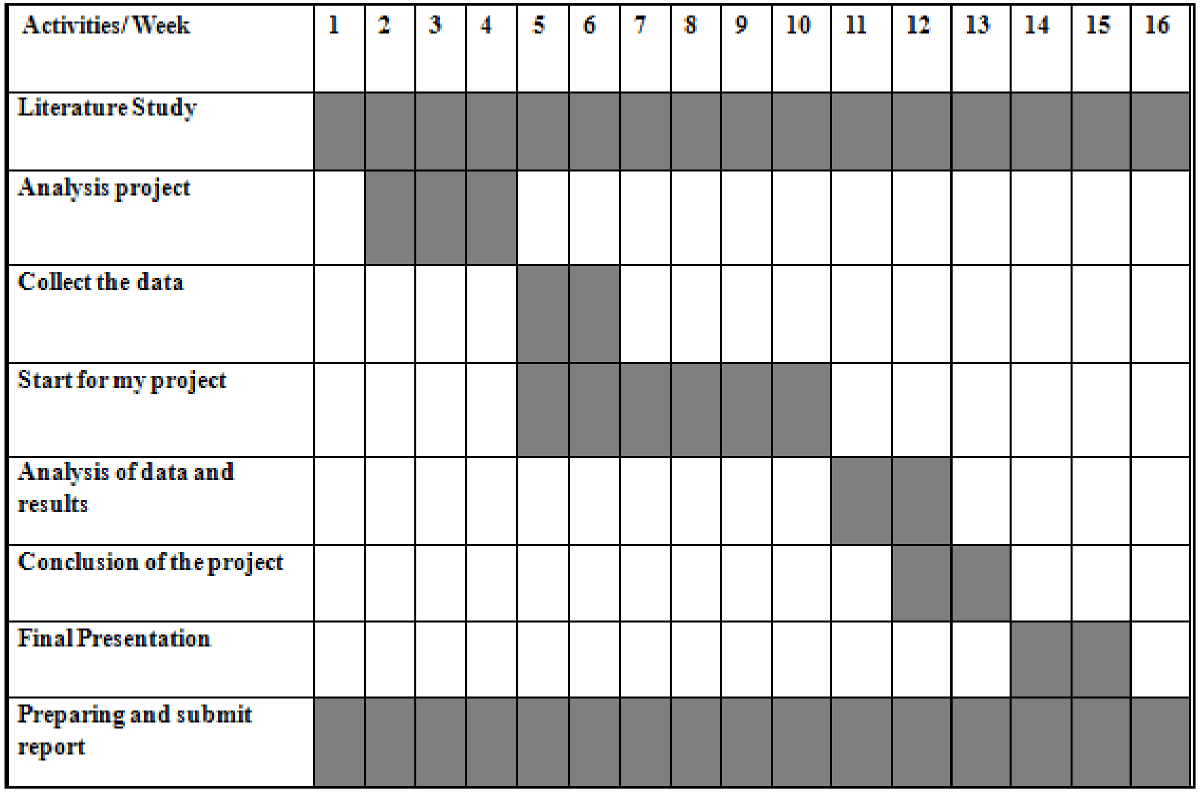
APPENDIX A

GANTT CHART FOR FYP 1

Activities/ Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Discuss with supervisor about the project-agree to change the project title	■															
Title of project briefing by supervisor	■	■														
Verify the project title, objectives and scopes			■	■												
Literature Study	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Write down the background, abstract, objective and scope					■	■	■	■	■	■						
Collect the data about the renewable energy					■	■	■	■	■	■						
Decide the design and calculate the design parameter									■	■	■					
Start writing report in full format											■	■	■			
Submit proposal and draft of report														■		
Presentation of Proposal															■	■

APPENDIX B

GANTT CHART FOR FYP 2



APPENDIX C

Table 4.2: Malaysia Weather Averages

	Ave.Minimum Temp. in Malaysia (°C)	Ave. Maximum Temp. Malaysia (°C)	Malaysia Average Temp. (°C)	Ave. Sea Temp (°C)	Average Precipitation/ Rainfall (mm)	Wet Days (>0.1 mm)	Ave. Sunlight Hours/ Day	Relative Humidity (%)	Ave. Wind Speed in Malaysia (Beaufort)	Ave. Number of Days with Frost	
Weather in Malaysia in January	22	32	27	-	171	16	6.2	60	-	0	*Average Temperature in Malaysia in January*
Weather in Malaysia in February	22	33	27.5	-	169	15	7.4	60	-	0	*Average Temperature in Malaysia in February*
Weather in Malaysia in March	23	33	28	-	237	17	6.5	58.0	-	0	*Average Temperature in Malaysia in March*
Weather in Malaysia in	23	33	28	-	279	21	6.3	63	-	0	*Average Temperature in*

April											*Malaysia in April*
Weather in Malaysia in May	23	33	28	-	216	17	6.3	66	-	0	*Average Temperature in Malaysia in May*
Weather in Malaysia in June	23	33	28	-	126	13	6.6	63	-	0	*Average Temperature in Malaysia in June*
Weather in Malaysia in July	22	32	27	-	102	11	6.5	63	-	0	*Average Temperature in Malaysia in July*
Weather in Malaysia in August	23	32	27.5	-	157	14	6.3	62	-	0	*Average Temperature in Malaysia in August*
Weather in Malaysia in September	22	32	27	-	188	17	5.6	64	-	0	*Average Temperature in Malaysia in September*

Weather in Malaysia in October	23	32	28	-	275	21	5.3	65	-	0	*Average Temperature in Malaysia in October*
Weather in Malaysia in November	23	32	28	-	259	22	4.9	66	-	0	*Average Temperature in Malaysia in November*
Weather in Malaysia in December	22	32	27	-	230	18	5.4	61	-	0	*Average Temperature in Malaysia in December*

*Source: http://www.climatetemp.info/malaysia/

APPENDIX D

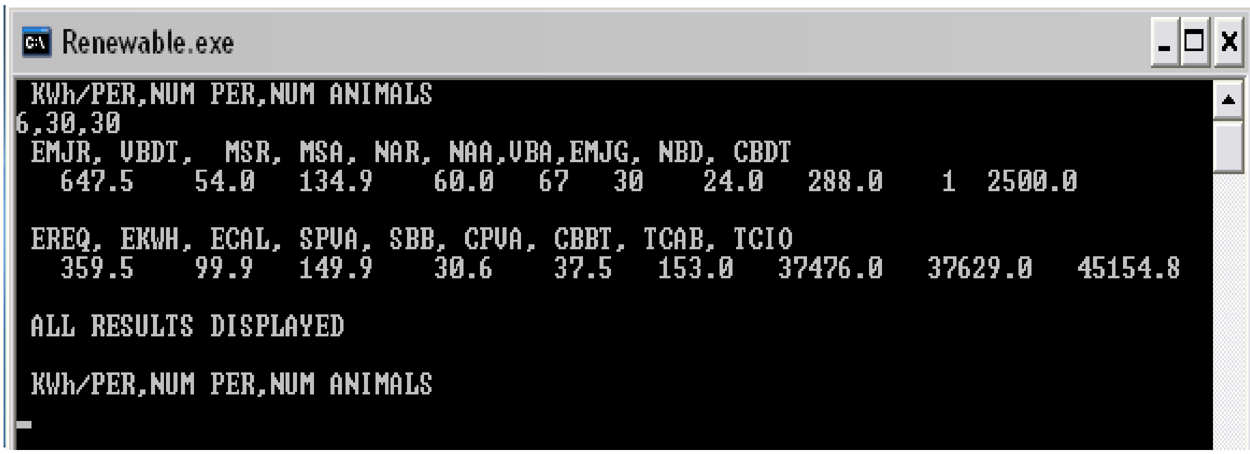
Coding for the FORTRAN software

```
c       Estimation of energy required/generated from dung, solar and wind ON DAILY
BASIS
C
******************************************************************************
*******
c       CONVERSION FACTOR 0.278 kWh = 1.0 MJ
c       TOTAL NO OF PERSONS, NP
c       ENERGY REQUIREMENT PER PERSON, ERP = 6 kWh  (ASSUMED)
c       MASS OF SOLIDS IN DUNG PER ANIMAL, MSPA = 4.5 kg
c       VOLUME FRACTION OF BIOGAS YIELD, VFBY = 0.34
c       VOLUME FRACTION OF METHANE IN BIOGAS, VFM = 0.6
c       HEAT OF COMBUSTION OF BIOGAS, HCB = 20 MJ/m3
c       VOLUME OF BIOGAS DIGESTER REQUIRED, VBDT
c       MASS OF SOLIDS REQUIRED, MSR
c       MASS OF SOLIDS AVAILABLE, MSA
c       NO OF ANIMALS AVAILABLE, NAA
c       COST OF BIOGAS DIGESTER OF 30 m3 CAPACITY, CBD1 = 2500  US
DOLLATS (ASSUMED)
C * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *  * * * * *
c       ENERGY REQUIRED FROM SOLAR/WIND HYBRID SYSTEM, EREQ
c       ENERGY IN kWh, EKWH
c       FUDGE FACTOR, FF = 1.5 (ASSUMED)
c       NO OF SUNLIGHT HOURS/DAY, NSLH = 4.9
c       SIZE OF PV ARRAY, SPVA
c       SIZE OF BATTERY BANK, SBB
c       NO OF DAYS WITHOUT RECHARGING, NDWR = 3
c       VOLTAGE OF BATTERY, VB = 12 V
c       COST OF PV ARRAY, CPVA
c       COST OF PV ARRAY PER WATT, CPVAPW  = 5 US DOLLARS
c       COST OF BATTERY BANK PER KILO AMPERE HOUR, CBB1 = 1000 US
DOLLARS
c       TOTAL COST OF ARRAY + BATTERY, TCAB
c       COST OF ACCESSORIES, CA = 20% OF TCAB
c       COST OF PV SYSTEM, CPVS
C * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
C
      PROGRAM RENEW
      REAL MSR,MSA,MSPA,NSLH,NDWR
      REAL NP
         DATA MSPA,VFBY,VFM,HCB,CBD1/2.0,0.40,0.6,20,2500/
```

```
c          DATA MSPA,VFBY,VFM,HCB,CBD1/4.0,0.35,0.6,20,2500/
c          DATA MSPA,VFBY,VFM,HCB,CBD1/0.6,0.30,0.6,20,2500/
           DATA FF,NSLH,NDWR,VB,CPW,CBB1/1.5,4.9,3,12,5,1000./
       DO 100 IN=1,10
       WRITE(*,*)'KWh/PER,NUM PER,NUM ANIMALS'
       READ(*,*)ERP,NP,NAA
       WRITE(*,*)'EMJR, VBDT,  MSR, MSA, NAR, NAA,VBA,EMJG, NBD, CBDT'
       EMJR=NP*ERP/0.278
       VBDT=EMJR/(VFM*HCB)
       MSR=VBDT/VFBY
       MSA=NAA*MSPA
       NAR=(MSR/MSPA+0.54)
       VBA=MSA*VFBY
       EMJG=VBA*VFM*HCB
       NBD=(VBA/30.+0.54)
       CBDT=NBD*CBD1
       WRITE(*,500)EMJR,VBDT,MSR,MSA,NAR,NAA,VBA,EMJG,NBD,CBDT
       WRITE(*,*)
 500   FORMAT(4(1X,F7.1),2(1X,I4),2(1X,F7.1),1X,I4,1X,F7.1)
       IF(MSA.GE.MSR) GO TO 20
c                              Calculations of solar PV energy costs
       WRITE(*,*)'EREQ, EKWH, ECAL, SPVA, SBB, CPVA, CBBT, TCAB, TCIO'
C        EREQ=(VBDT-NBD*30.)*VFM*HCB
       EREQ=(EMJR-EMJG)
       EKWH=EREQ*0.278
       ECAL=EKWH*FF
       SPVA=ECAL/NSLH
       SBB=ECAL*NDWR/VB
       CPVA=SPVA*CPW
       CBBT=CBB1*SBB
       TCAB=CBBT+CPVA
       TCIO=TCAB*1.2
       WRITE(*,600)EREQ,EKWH,ECAL,SPVA,SBB,CPVA,CBBT,TCAB,TCIO
  20   CONTINUE
      WRITE(*,*)
  600  FORMAT(6(1X,F7.1),3(2X,F8.1))
       CLOSE(2)
       WRITE(*,*)'ALL RESULTS DISPLAYED'
       WRITE(*,*)
  100  CONTINUE
       STOP
       END
```

APPENDIX E

Sample of the Program



```
Renewable.exe
 KWh/PER,NUM PER,NUM ANIMALS
6,30,30
 EMJR, VBDT,  MSR, MSA, NAR, NAA,VBA,EMJG, NBD, CBDT
   647.5    54.0   134.9    60.0   67   30    24.0   288.0    1  2500.0

 EREQ, EKWH, ECAL, SPVA, SBB, CPVA, CBBT, TCAB, TCIO
   359.5    99.9   149.9    30.6    37.5   153.0   37476.0   37629.0   45154.8

 ALL RESULTS DISPLAYED

 KWh/PER,NUM PER,NUM ANIMALS
```