THE POTENTIAL OF WIND AND SOLAR ENERGY FOR DEVELOPMENT OF HYBRID ENERGY SYSTEM

NURUL AFIQAH BINTI ZAINAL

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ABSTRACT

This project is motivated by an interest in promoting the use of renewable energy to perform hybrid energy system as one of the alternative to replace the used of gas and coal as the main demand in producing electricity. With depleting local gas reserves and the need to adhere to stricter environmental regulations whilst still having to meet the requirement for growing electricity demand, the consideration of new options in the future generation fuel mix are inevitable. The main purpose of this project is to study on hybrid energy system and the potential of the system to run in UMP, Pekan based on the weather data collected. Two types of energy have been chosen to perform this project which are solar and wind energy. Weather meter and solar equipment are installed to obtain the data within a week and study on the possibilities of both energies if it is installed in this area. The graph shows the data collected within a week and also the highest temperature and wind speed that are captured. Besides that, calculation on types of solar equipment need to be used and wind turbine parameters also been done. Thus, both solar and wind energy able to capture 4W each which gives out total 8W of power produce a day. This is shown that both energies are potential to perform hybrid energy system in UMP Pekan.

ABSTRAK

Projek Tahun Akhir ini dilaksanakan seiring dengan kepentingan dalam menggalakkan penggunaan tenaga boleh diperbaharui bagi melaksanakan sistem tenaga hibrid sebagai salah satu alternatif untuk menggantikan penggunaan gas dan arang batu dalam menghasilkan tenaga elektrik. Cadangan bagi membuat campuran bahan api untuk generasi pada masa depan adalah tidak dapat dielakkan memandangkan rizab gas tempatan yang semakin berkurangan dan keperluan untuk mematuhi alam sekitar yang lebih ketat disamping tuntutan dalam memenuhi keperluan permintaan tenaga elektrik yang semakin meningkat. Tujuan utama projek ini dijalankan adalah untuk mengkaji mengenai sistem tenaga hibrid dan potensi sistem ini untuk dijalankan di UMP, Pekan berdasarkan data yang diperoleh. Dua jenis tenaga telah dipilih untuk menjalankan kajian ini iaitu tenaga solar dan juga angin. Alat kaji cuaca dan set solar dipasang untuk mendapatkan data selama seminggu dan mengkaji keberangkalian potensi jika sistem ini dipasang di kawasan ini. Graf menunjukkan data yang telah diperolehi selama seminggu dan juga suhu dan kelajuan angin yang tertinggi. Selain itu, pengiraan mengenai peralatan bagi solar set yang ingin digunakan dan juga parameter untuk kincir angin juga telah dilakukan. Hasil kajian mendapati bahawa tenaga solar dan angin masing-masing telah menghasilkan sebanyak 4W tenaga dan jumlahnya adalah sebanyak 8W tenaga dihasilkan dalam sehari. Ini menunjukkan bahawa, kedua-dua tenaga mempunyai potensi untuk dijadikan sebagai sistem tenaga hibrid di UMP, Pekan.

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LIST OF ABRREVIATIONS

AC	Alternating Current
DC	Direct Current
EIA	Energy Information Administration
ETP	Economic Transformation Programme
FiT	Feed-In Tariff
GDP	Gross Domestic Product
GHG	Green House Gases
PPP	Purchasing Power Parity
PW	Petawatts
RE	Renewable Energy
SCORE	Special Committee on Renewable Energy
SREP	Small Renewable Energy Program
UMP	University Malaysia Pahang

CHAPTER 1

INTRODUCTION

1.1 PROJECT BACKGROUND

In Malaysia, the demand for electricity in Malaysia is growing in tandem with its Gross Domestic Product (GDP) growth. It received a welcomed boost from the rollout of projects under the rolling 5-year Malaysia Plans and the on-going Economic Transformation Programme (ETP). The forecasted growth for electricity has shown an increase of 3.7% in 2012 compared to 3.1% in 2011. This growth has been driven by strong demand from the commercial and domestic sectors. For the period till 2020, the average projected demand for electricity is expected to grow at 3.1%. Based on this forecast, the country is going to need even more energy as it strives to grow towards a high-income economy. An estimated 10.8 GW of new generation capacity will be needed by 2020 given that 7.7 GW of existing capacity are due for retirement.

By 2020, the total installed capacity will see an increase of 16% over the total installed capacity in 2012. Of this new capacity, gas and coal will continue to feature strongly in the Peninsular energy mix for power sector, with coal probably taking up a bigger share on the basis of rising gas prices. The Government had approved The National Renewable Energy (RE) Policy and Action Plan on 2nd April 2010. One of the main elements of this policy was the introduction of the Renewable Energy Act which entails the implementation of the Feed-In Tariff (FiT) system. The FiT is a premium in which the RE

power is sold according to each RE sources. The introduction of the RE Act also provide a mandatory requirement for the utility to accept and buy RE power. Both the RE Act and the FiT System was enforced on 1st December 2011. On 1st September 2011, the Sustainable Energy Development Authority of Malaysia (SEDA Malaysia) was officially established to undertake the role of a one stop centre to promote sustainable energy and to help facilitate the RE industry (Chin, 2012).

Hybrid energy has become an alternative source of energy nowadays. Higher energy demand and decrease in supply of fossil fuels and coals for energy enhance the research on the hybrid energy since it plays the important role in our live. Basically, hybrid energy usually consists of two or more renewable energy sources used together to increase system efficiency as well as greater balance in energy balance. Several types of renewable energy are solar, wind, biomass, geothermal and hydropower.

For this project, it will emphasize more on solar and wind energy as the combination for hybrid energy system. The reason on choosing this combination is because solar energy is one of the best renewable energy sources as it also suitable to use in Malaysia due to the high solar radiation received per year. Figure 1.1 shows the annual average daily solar irradiation in Malaysia where Malaysia receives about 4.96 kWh/m^2 of solar radiation in a year. The maximum solar radiation receive is 5.56 kWh/m^2 mostly in Northern region of Peninsular Malaysia and Southern region of East Malaysia. The Southern and Northeast region of Peninsular Malaysia as well as most parts in Sabah receives the lowest solar radiation (Azhari et al., 2007).

The Earth receives 174 petawatts (PW) of incoming solar radiation (insulation) at the upper atmosphere. Approximately 30% is reflected back to space while the rest is absorbed by clouds, oceans and land masses. The spectrum of solar light at the Earth's surface is mostly spread across the visible and near-infrared ranges with a small part in the near-ultraviolet. Earth's land surface, oceans and atmosphere absorb solar radiation, and this raises their temperature. Warm air containing evaporated water from the oceans rises, causing atmospheric circulation or convection. When the air reaches a high altitude, where

the temperature is low, water vapor condenses into clouds, which rain onto the Earth's surface, completing the water cycle.

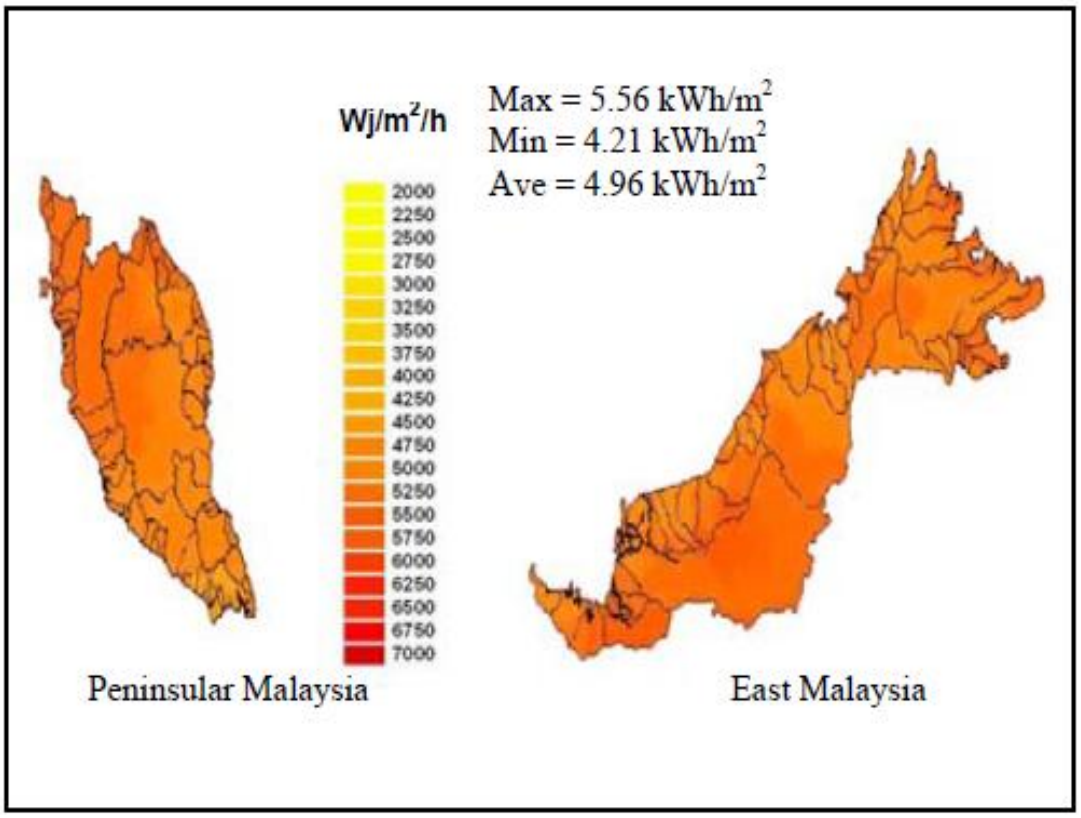

Figure 1.1: Annual average daily solar irradiation of Malaysia

Source: Azhari et al., 2007

The latent heat of water condensation amplifies convection, producing atmospheric phenomena such as wind, cyclones and anti-cyclones. Sunlight absorbed by the oceans and land masses keeps the surface at an average temperature of 14 °C. By photosynthesis green plants convert solar energy into chemical energy, which produces food, wood and the biomass from which fossil fuels are derived (Noor et al., 2011).

Next, wind energy growth in Asia is on the rise. Both India and China are leading the switch to wind energy with more installed capacity and manufacturing facilities. India rank fourth with 4.4 GW production and China in eighth with 1.26 GW. The Asian region is set to be the most dynamic geographical zone with a growth rate of 48 % (Darus et al.,

2004). Malaysia experiences two main weather seasons; southwest monsoon (May/June to September) and northeast monsoon (November to March). Wind speeds during the southwest monsoon are often below 7 ms^{-1}, but during the northeast monsoon, wind speeds could reach up to 15 ms^{-1} particularly in the east coast of Peninsular Malaysia. Moreover, during April to September, the effects from typhoons striking neighboring countries (such as Philippines) may cause strong winds (even exceeding 10 ms^{-1}) to Sabah and Sarawak (Christopher, 2010). Malaysia experiences stronger winds in the early and late parts of the year. On the whole, Malaysia's mean annual wind speed is 1.8 ms^{-1}. However, towns in the east coast of Peninsular Malaysia such as Mersing, Kota Baharu, and Kuala Terengganu experience stronger winds. For these places, their mean monthly wind speed could exceed 3 ms^{-1}. East Malaysian towns, Kota Kinabalu and Labuan (with the exception of Kuching) also see stronger wind speeds than the national average (Christopher, 2010)

This project is about integrated energy controller for hybrid energy system which focuses on how to control the energy produce by sources. Data collection for wind and solar energy will be done at Faculty of Manufacturing Engineering, University Malaysia Pahang (UMP) to observe the performance of the energy before fabricated the hybrid energy system.

1.2 PROBLEM STATEMENT

With depleting local gas reserves and the need to adhere to stricter environmental regulations whilst still having to meet the requirement for growing electricity demand, the consideration of new options in the future generation fuel mix are inevitable (Chin, 2012). Furthermore, the higher energy demand nowadays and lower supply also sources of fossil fuels and coals enhance many research toward renewable energy. With greater worldwide awareness on carbon mitigation measures to combat green house gases (GHG) emissions, there are now more concerted efforts to promote and encourage the use of renewable for power generation (Chin, 2012)

1.3 PROJECT OBJECTIVES

The main purpose of this project is to study on hybrid energy system and the potential of the system to run in UMP, Pekan based on the weather data collected. Besides that, this project is done to investigate wind and solar energy potential as renewable energy sources at UMP, Pekan, Pahang. This project is done by involving two processes which are analyze the data obtained from solar and wind energy and next, integrate the data of both energies.

1.4 PROJECT SCOPE

Before start the project, project scope is proposed. The project scopes are:

1) Literature review
   - In this chapter, it will emphasize on the types of renewable energy present in this world. As for Malaysia, the suitable renewable energy that can be used especially at UMP Pekan, Pahang are solar and wind energy. These two energies is selected since the location of UMP itself that located near the sea which enables it to received much source of solar and wind energy.
2) Design and Fabrication
   - Data of solar and wind energy will be collected by using the kit of weather meters to collect the data for wind energy and solar kit for solar energy. As the data collected, the data will be integrated and will be used as hybrid energy system.

Flow chart and gantt chart for this project will be shown in Appendix A and B.

CHAPTER 2

LITRATURE REVIEW

2.1 INTRODUCTION

Malaysia is one of the most developing ASEAN countries, with a GDP of US$14,700 per capita (PPP basis), and steady GDP growth of 5.5 in 2008. Malaysia is in the midst of an era of vigorous industrial growth brought about by strong domestic demand together with its significant science and technology development. The demand of energy is growing very rapidly in order to cope with the economical and industrial growth (Islam et al., 2009). According to the estimation of international Energy Agency, 53% global energy consumption will be increased by 2030, with 70% of the growth in demand coming from developing countries (Oh et al., 2010). Malaysia is one of the most developing countries among ASEAN countries next to Singapore, with GDP of US$15,400 per capita (PPP basis), and steady GDP growth of 4.6% in 2009 (IMF, 2010). Malaysian economy grew at 5% in 2005 and overall energy demand is expected to increase at an average rate of 6% per annum (Saidur et al., 2009).

Besides economical and industrial growth, the population of Malaysian people also growth. Malaysia Demographics Profile indicates that the population growth rate has been increased to 1.542% for year 2012 compared to 2011 as the population increase to 29 million compared to 27.5 million in 2011 (indexmundi.com, 2012). Figure 2.1 shows

Malaysia used lots of electricity in industrial which is 49% rather than residential with 19% and commercial with 32%. The balance of 1% is used for others usage.

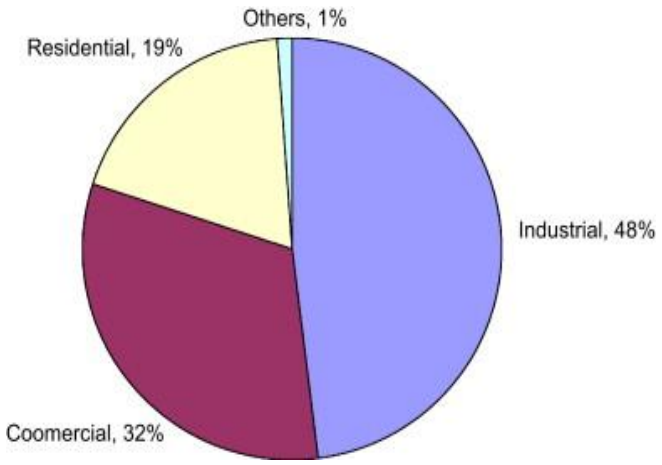

Figure 2.1: Usage of electricity in Malaysia

Source: Saidur (2009)

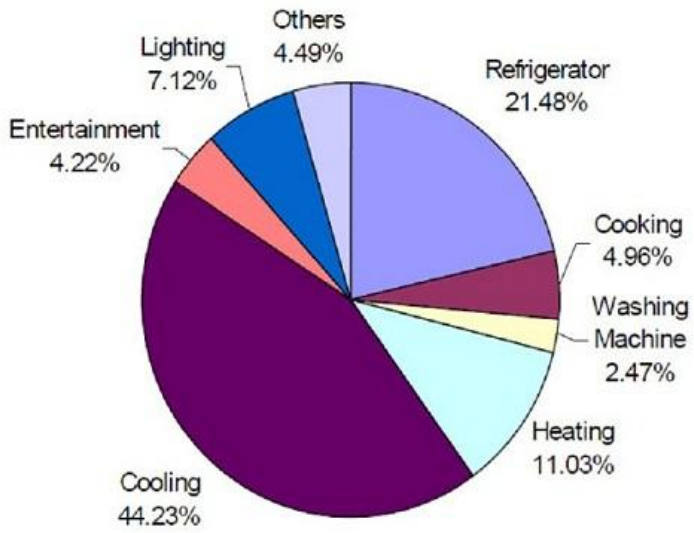

Figure 2.2: Usage of electricity in residential in Malaysia

Source: Christopher (2010)

In parallel with Malaysia's rapid economic development, final energy consumption grew at rate of 5.6% from 2000 to 2005 and reached 38.9 Mtoe in 2005. The final energy consumption is expected to reach 98.7 Mtoe in 2030, nearly three times the 2002 level. The industrial sector will have the highest growth rate of 4.3 percent. Industrial sector accounted for some 48% of total energy use in 2007 which represents the highest percentage. The natural gas reserve is estimated and expected to last for around 70 years, while depletion of oil is expected to be in 16 years at current rate of usage (Islam et al., 2009).

In Malaysia, is seen as one of the sensible solutions of the reducing number in natural resources is green technology applications which are being adopted by many countries around the world to address the issues of energy and environment simultaneously. In Malaysia, there seems to be renewed impetus in promoting the growth of an indigenous "green economy." Instead of facing the threat of climate change and pollution, Government also has to find new sources of growth and move up the value chain (Islam et al., 2009) for prevent any problems occur in years times. For the past 60 years, numbers of energy-related policies has formulated by Malaysian government to ensure sustainability and security of energy supply. But over the last three decades, pragmatic energy policies have facilitated a more environment-friendly energy development path (Islam et al., 2009).

The national Energy Policy, the more significant policy was actually introduced in 1979 with three primary objectives; supply, utilization and environmental. The fuel diversification policy in Malaysia was further revised in 1999 with the announcement of the Five-Fuel Diversification Strategy is reviewed from time to time to ensure that the country is not over dependent on main energy source. In the Eighth Malaysian Plan, Renewable energy (RE) was made the fifth fuel in the energy supply mix with the target to contribute 5% of the country's electricity demand by year 2005. The Small Renewable Energy Program (SREP) was launched in May 2001 under the initiative of the Special Committee on Renewable Energy (SCORE) aimed to support the government's strategy in intensifying the development utilization of RE as the fifth fuel resource in power generation in order to meet the goal in Eighth Malaysian Plan (Islam et al., 2009).

2.2 RENEWABLE ENERGY

Renewable energy is energy which comes from natural resources such as sunlight, wind, rain, tides, waves and geothermal heat, which are renewable (naturally replenished). Rapid depletion of fossil fuel reserves as well as climate change has driven the world towards renewable energy sources which are abundant, untapped, and environmentally friendly (Islam et al., 2009). About 16% of global final energy consumption comes from renewable, with 10% coming from traditional biomass, which is mainly used for heating, and 3.4% from hydroelectricity. New renewable energy which are small hydro, modern biomass, wind, solar, geothermal, and biofuels, are accounted for another 3% and are growing very rapidly. The share of renewable in electricity generation is around 19%, with 16% of global electricity coming from hydroelectricity and 3% from new renewable sources. Renewable energy is becoming more acceptable to be used around the world, but it is still not act as the dominant energy resource. The primary 6 types of renewable energy are biomass, hydro power, geothermal, biofuels, solar and wind, which are available on the earth. Each of these renewable energy sources provides an alternative to traditional energy generation and can be reproduced as in reducing human footprints on the environment also reducing in depletion of natural resources (renewablesguide.co.uk, 2011).

Figure 2.3 shows how biomass can be used as electricity. As for biomass energy, it is produced from organic materials such as plants and animals, but the energy that is produced in this cycle is originally provided by the sun. For example, plants absorb the sun's energy through a process called photosynthesis. Then, the energy is then passed on through the organism that eats the plant and creating the biomass energy. Wood, crops, manure and some rubbish are the most common forms used to generate biomass energy. These substances will give off energy as heat when it is burned. For example, if you have a wood fuelled heating, you are generating renewable biomass energy. Besides that, biomass energy also can be create by converting these substances into methane gases, ethanol and biodiesel fuels which can be translated more easily into current methods of energy use (renewablesguide.co.uk, 2011).

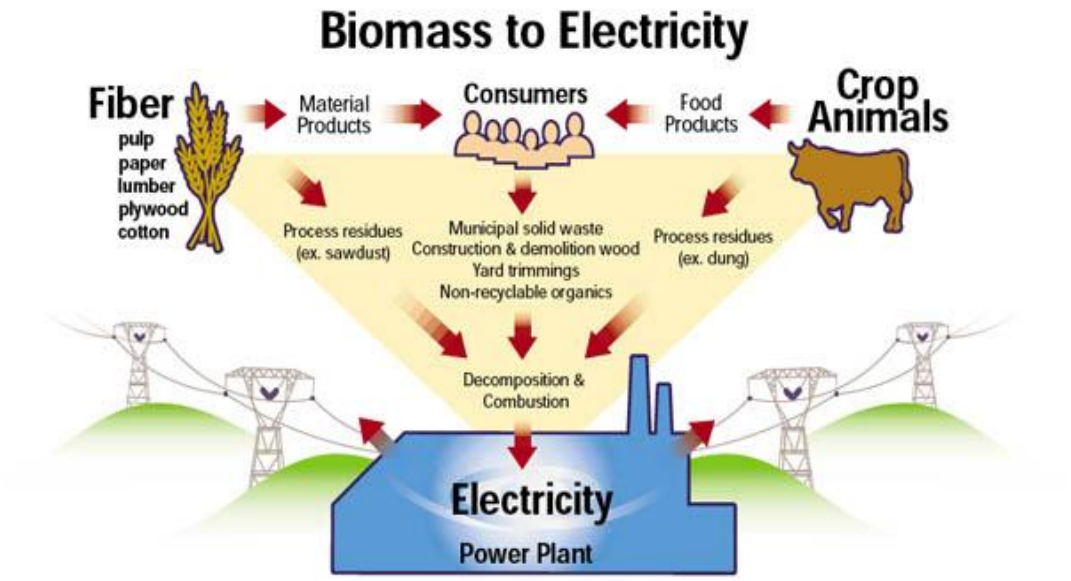

Figure 2.3: Biomass to electricity cycle.

Source: energy.ca.gov

Next, hydro energy is derived from the movement of water. Based on Figure 2.4, hydro power is generated through the movement of water through turbines, such as water running through turbines in a Dam. As the water is continuously cycled back through the plant or into nature, hydro power is considered a renewable energy source (renewablesguide.co.uk, 2011). According to the Energy Information Administration (EIA), the power of water is abundant which approximately 73 percent of all renewable energy sources. In details, hydro power is generated using the mechanical energy of flowing water by forcing it through piping called a penstock, which then turns a generator in order to produce electricity. Water power also consists of wave and tidal energy, which are both in the infant stage of research, as scientists try to discover how to harness the energy produced from movement of the ocean (greenenergychoice.com, 2012).

Geothermal named comes from two Greek letters “thermal” that means ‘heat’ and “geo" have means with ‘earth’ (Kakkar et al., 2012). This energy is derived from the heat that is given off by the Earth as been shown in Figure 2.5. For example, the Earth generates steam energy or hot water and the energy can be used to generate energy. It is

considered to be a renewable source of energy as the water in the Earth is replenished by regular rainfall and the heat used is regularly produced by the planet (renewablesguide.co.uk, 2011).

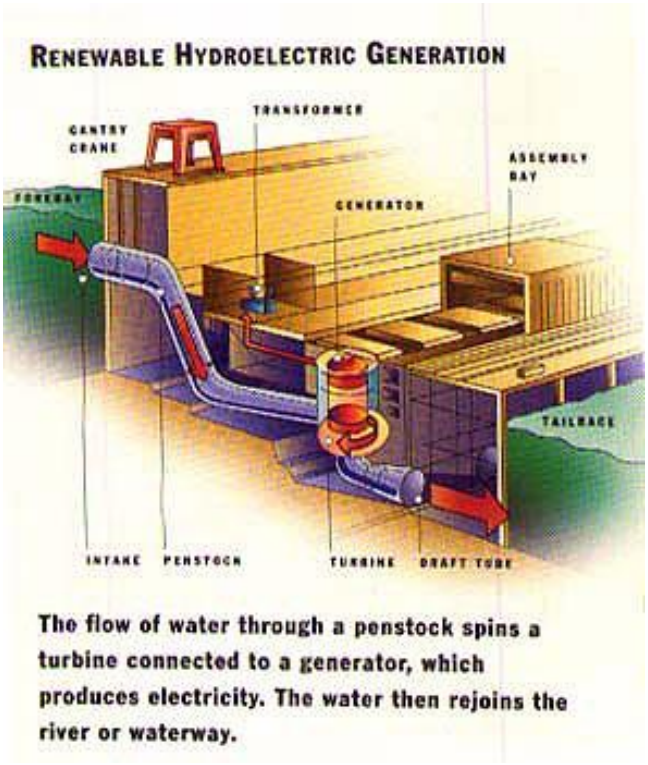

Figure 2.4: Basic concept of hydro energy.

Source: niagarafrontier.com

Besides that, biofuels are a form of renewable energy that derived from burning plant or animal substances, which usually known as combustion. Biofuels has been challenging as it is not easily transferred into a liquid form which is the primary method used to fuel most cars and homes. Two of the most common strategies that are used to produce biofuels are growing crops to produce ethanol and also growing plants that produce biofuel oils. They are challenging to produce and maintain on a large scale while these methods are effective sources of renewable energy (renewablesguide.co.uk, 2011). Figure 2.6 indicates the life cycle of biofuels which the end user is to power up the vehicles.

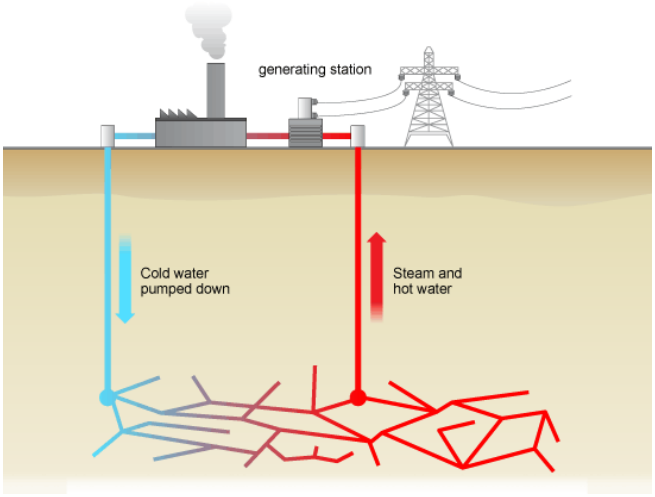

Figure 2.5: Geothermal energy process flow.

Source: bbc.co.uk

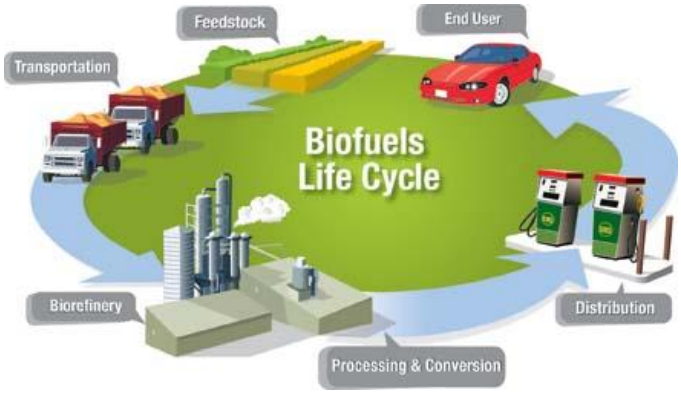

Figure 2.6: Biofuels life cycle.

Source: climatelab.org

As for solar energy, solar power is a type of power that has been around for thousands of years. Instead of warming the world and give energy to living things, solar as a renewable source of free, green energy, technology has found a way of harnessing the sun's energy via solar panels which are used either to generate electricity (solar photovoltaics) or to produce heat to warm water (solar thermal). Figure 2.7 shows the solar system that used in generating electricity to be supply to AC loads and other appliances.

Solar technology does not generate greenhouse cases and is environmentally friendly (renewablesguide.co.uk, 2011). Photovoltaic cells are the solar cells that are made from silicon that able to absorb the sun's radiation. The photovoltaic process involves the movement and displacement of electrons to absorb the sun's radiation and create electricity. Besides that, there are also solar systems that use large-scale mirrors to heat water, or produce high temperatures and generate steam, which is used to turn a generator and produce electricity (greenenergychoice.com, 2012).

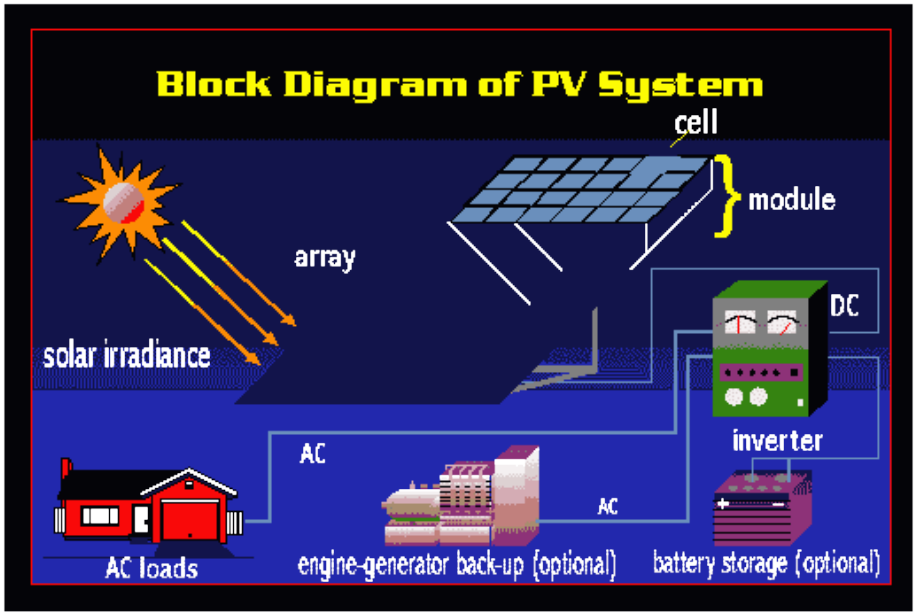

Figure 2.7: Block diagram of Photovoltaic (PV) system.

Source: cogeneration.net

An abundant source of renewable energy, wind power is used for generating electricity. Wind power is a very simple process. In order to generate electricity, wind turbine converts the kinetic energy (motion) of wind into mechanical energy such as shown in Figure 2.8. The energy is fed through a generator, converted a second time into electrical energy, and then fed into the grid to be transmitted to a power station. Wind power is abundant in California and Texas, with the two largest wind farms in the world residing in West Texas which creating more energy and save money (Weisenbach, 2010). Wind is unique because it carries incentives for farmers to give parcels of land for building wind

turbines, and has the most potential as far as widespread adoption due to the large areas of land with consistent wind available to harness (greenenergychoice.com, 2012). Wind is a source of clean, green renewable energy. A favorable climate condition in Europe means wind energy is a highly recommended method for electricity generation (renewablesguide.co.uk, 2011).

In Malaysia, a researched has been done and result that the mean daily wind speed is 2 ms^{-1} which is not too high. Figure 2.9 shows the idealized daily wind speed distribution in Malaysia. In the mean time, some area in Malaysia experiences high wind speed that could reach up to 15 ms^{-1} especially during southwest and northeast monsoon. Besides that, Malaysia also experience the effects of typhoon striking from neighboring country such as Philippines which cause high wind speed especially at Sabah and Sarawak. Hence, Malaysia also faced strong wind in certain area.

Figure 2.8: Wind energy.

Source: Christopher (2010)

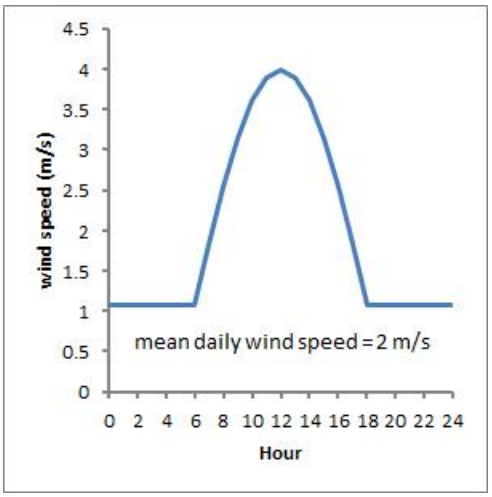

Figure 2.9: Idealized daily wind speed distribution in Malaysia

Source: Christopher (2010)

2.3 HYBRID ENERGY SYSTEMS

‘‘Hybrid energy systems are combinations of two or more energy conversion devices such as electricity generators or storage devices, or two or more fuels for the same device, that when integrated, overcome limitations that may be inherent in either.’’ (Manwell, 2004).

This definition includes a wide range of possibilities and the essential feature of the multiplicity of energy conversion (Manwell, 2004). Hybrid systems can be known as the limitations in terms of fuel flexibility, efficiency, reliability, emissions and (or) economics (Burch, 2001). In order to supply an energy requirement, the term hybrid energy system used to refers to those applications in which multiple energy conversion devices are used together. These systems are often used in isolated applications and normally it will include at least one renewable energy source in the system. Hybrid energy systems are used an alternative to more conventional systems, which typically are based on a single fossil fuel source. Furthermore, hybrid energy systems may also be used as part of distributed generation application in conventional electricity grid (Manwell, 2004).

There are many possible applications for hybrid power systems nowadays. The most common examples are remote AC network, distributed generation applications in a