CHAPTER 2.0 LITERATURE REVIEW

2.1 World's Energy Consumption

Natural resources such as the wind and sun are effectively utilize to produce energy. Since these types of resources are theoretically infinite, it offers attraction to be utilized and developed extensively. In 2008, about 19% of primary energy for the world's consumption is sourced from renewable resources. Large hydropower constitutes the highest percentage followed by biomass. Modern technologies like wind, solar, geothermal and other technologies produce very less of the world's demand [7]. Figure 2.1 and 2.2 highlights the present renewable energy scenario.

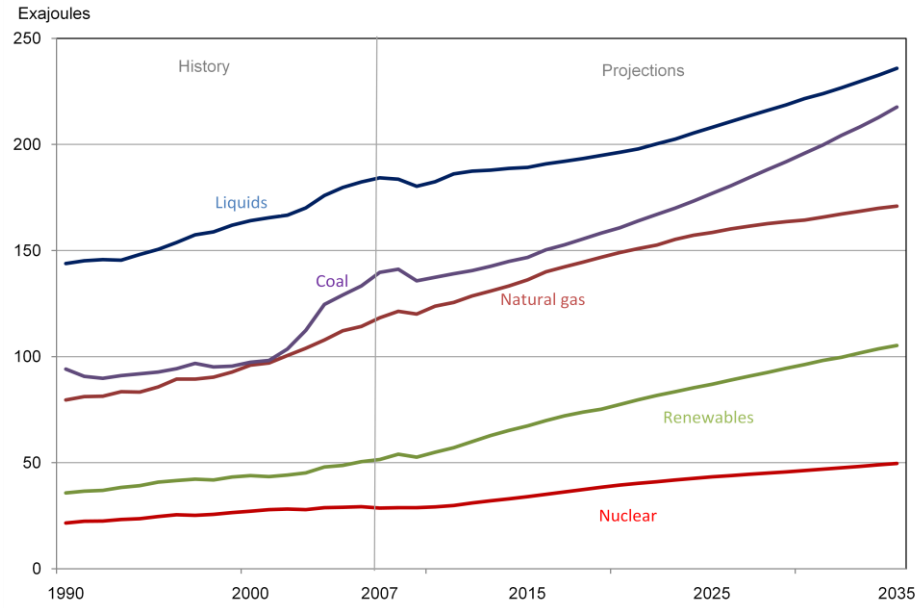

Figure 2.1: Global Energy Usage for the Year 1990-2035 (Exajoules)
(Source: US Energy Information/International Energy Outlook 2010)

From figure 2.1, it can be seen that liquid fuels and other petroleum are the slowest-growing energy in the world with annual increasing rate of 0.9 % whereas renewable sources are the fastest-growing energy in the world with the annual increasing rate of 2.6 % from 2007-2035.

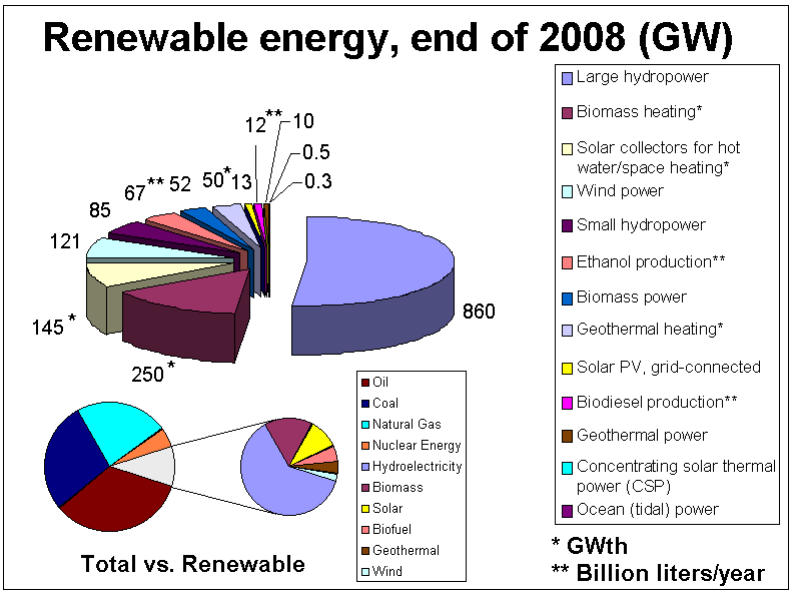

Figure 2.2: World Renewable Energy in 2008

(Source: Wikipedia)

2.1.1 Malaysia Energy Sector: An Overview

Renewable energy in Malaysia has a very big potential to be developed in the future to replace the non-renewable fuels that will come to the end some day. The country has a big potential due to the abundance of renewable energy sources that not be exploited actively such as biogas, biomass, mini-hydro and solar. At present, development of renewable energy still in the small scale and the very low amount had been contributed to the total electricity generation mix. The government of Malaysia is still in the process of stabling the part of renewable energy as the fifth fuel in energy mix. Due to the reason, the government had approved a new renewable energy and action plan in April 2010 to boost up its usage. As the end of 2009, only less than 1 % of renewable energy contributed to the national electricity generation.

In 2007, the total electricity generated in Malaysia was 108,539 GWh and mainly contributed by gas with 57 %, followed by 24.1 % of coal, 8.4 % of hydropower,

6.4 % of oil products, and 4.2 % of biomass and other fuels. From the total electricity produced, 62, 518 GWh was generated by IPPs [22]. The Malaysia's electricity production and consumption from 2005-2009 was shown in table 2.1.

Table 2.1: Malaysia's Electricity Production and Consumption (in Megawatts)
(Source: Energy Commission Annual Report 2009)

	Production Capacity			
Year	**TNB Production Capacity**	**IPP Production Capacity**	**Total Production Capacity**	**Maximum Demand**
2005	6346	11277	17623	**12493**
2006	6346	11977	18323	**12990**
2007	6346	13377	19723	**13620**
2008	6346	13377	19723	**14007**
2009	7040	14777	21817	**14245**

From the table, it can be seen that total production of electricity is rising constantly from year to year. It is also can be seen that IPP (Independent Power Producer) was contributed more than 5 % of total production capacity in Malaysia.

2.1.2 Current Energy Patterns

2.1.2.1 Power Generation

According to Energy Commission the electricity produce to the national network of Malaysia is 19,023 MW, with the request of 13,340 megawatts in July 2007 [19]. Generation of gaseous fuel mixture is 62.6%, 20.9% from coal, 9.5% of hydroelectric, and only 7% comes from other types of fuel [20]. The primary commercial energy supply in Malaysia is shown in table 2.2 below according to their sources.

Table 2.2 Primary Commercial Energy Supply by Source in Malaysia

(Source: Malaysian 9th Development Plan, 2006-2010)

Source	Petajoules			% of Total			Average Annual Growth Rate (%)	
	2000	2005	2010	2000	2005	2010	8MP	9MP
Crude oil and petroleum products	988.1	1181.2	1400.0	49.3	46.8	44.7	3.6	3.5
Natural gas	845.6	1043.9	1300.0	42.2	41.3	41.6	4.3	4.5
Coal and Coke	104.1	230.0	350.0	5.2	9.1	11.2	17.2	8.8
Hydro	65.3	71.0	77.7	3.3	2.8	2.5	1.7	1.8
Total	**2003.1**	**2526.1**	**3127.7**	**100.0**	**100.0**	**100.0**	**4.7**	**4.4**

The most important sources supplies were crude oil and petroleum products and then followed by the natural gas. It can be stated that the total supply of energy is increased gradually from 2000 to 2010. In 2010, the percentage of crude oil and petroleum products descending to 44.7 % but the percentage of natural gas is ascending to 41.6 %. Although crude oil and petroleum had contributed the largest percentage of total amount supply, an increase in the usage of coal and coke had reduced the annual growth rate of oil supply. The contribution of the other sources whereas had remained the same.

The cost effective, quality, reliability, and security supply need to be considered to produce optimal energy mix from domestic sources. The international market price of crude oil is projected to remain high so that alternative approaches need to be make to reduce the dependency on petroleum products.

2.1.2.2 Generator Generating Capacity (MW)

Malaysia has about 16 gigawatts (GW) of generation capacity, of which 87% is thermal and 13% from hydro. In 2005, Malaysia generated around 79 billion kilowatt hours of electricity. Fuels of the total electricity in Malaysia are presented in Table 2.3.

Table 2.3 Fuel Mix (%) in Total Electricity Generation in Malaysia
(Source: 9th Malaysia Plan, 2006-2010)

Year	Oil	Coal	Gas	Hydro	Other	Total (GWh)
2000	4.2	8.8	77	10	0	**69,280**
2005	2.2	21.8	70.2	5.5	0.3	**94,299**
2010	0.2	36.5	55.9	5.6	1.8	**137,909**

Between 2000 and 2005, fuel resources for the electricity generation were varies with the rising of coal usage, consistent with the strategy to ensure security and reliability to the electricity supply and also to least the huge dependency to the gas. Also, between 2000 and 2005, an amount of 6,420 MW new capacities was installed. The efforts was decreased a lot to the dependency of natural gas usage in the capacity mix and increased from 8.8 % in 2000 to 21.8 % in 2005 whereas natural gas declined from 77 % to 70.2 %.

Through this period, electricity transmission system were further growth with completion of new projects of transmission system which linked to the national grid and also providing a new connection to the industrial and commercial areas. The rural electrification projects gave benefited to the Sabah and Sarawak citizens in particular. 66,000 of houses are expected will be accesses to electricity by 2012. Peak demand of electricity is at the rate of 7.8 % annually and reached 20, 087 MW (peninsular alone) in 2010. Initiatives are being taken to grow up the skills and efficiency of the utility companies and IPPs. Fuels mix for power generation is largely coal and natural gas with coal plays the most important role. New coal based independent power producers utilize an electrostatic filter of coal fuel can tackle the environment. In addition, as a part of effort to ensure the optimal use of household waste for energy production, energy pilot project was implemented in the Malaysia.

When Malaysia formulated its first energy policy, concern over efficient utilization of energy and the need for energy development to take account of environmental issues were fundamental. This fear was caused by the oil crisis of 1973 and 1978, and the solution is necessary to provide adequate and reliable supplies of energy. The Energy Policy of 1979, National Depletion Policy 1980 and the four fuel diversification policy in 1981 had introduced to develop the energy supplied. The objective of energy policy operates through three main objectives, the objectives of supply, use and environmental issues. The objectives of these policies are necessary for the preparation of development plans in Malaysia in five years development plans. Since then, the focus in the energy sector has moved to the sustainable development of non-renewable energy sources and energy diversification. The Four Fuel Diversification policy identifies four sources of energy as a preferred energy mix which are oil, natural gas, coal and hydropower. In 2001, government introduced Five Fuel policies, adding renewable fuels and a combination of durability and efficiency.

2.1.3 Status of Available RE Resources in Malaysia

2.1.3.1 Biomass Energy

Biomass is all the earth's living matter; consist of materials produced through photosynthesis or organic by-products from the waste stream. Therefore, it is a form of stored solar energy. It contains a lot of organic waste, mainly from agriculture, food processing, forestry, municipal solid waste and wastewater. In the process of photosynthesis, plants produce energy and oxygen from light, water and carbon dioxide from their environment. The energy can then be released through the combustion of solid fuels, or the conversion into liquid fuels such as methanol and ethanol or biogas,

that mainly consist of methane and carbon dioxide. This form of usable energy produced from biomass, is called bio-energy. Source of energy from biomass is attractive because it produces no emissions of CO_2, because it is converted into usable energy of CO_2 emissions that is included in the origin of photosynthesis.

Biomass power plants are available in over 50 countries around the world and are likely to be an important energy supplier for many countries around the world. They accounted for about one third of the total consumption of primary energy in the developing countries. Even in developed countries, biomass is an important contribution. The country that derived most of the total consumption of primary energy that comes from renewable and waste fuels are Finland (20%), Austria (7%) and Germany (5%) [8].

2.1.3.2 Solar Energy

Solar thermal and photovoltaic (PV) are the two categories of energy that are generated directly from the sun. In solar thermal, it can be form of the active solar heating, where solar energy is collected with flat or tubular sensors and used for water heating or pool heating. Alternatively, it can be a passive solar system which utilizes the airflow to circulate stored energy in the construction to reduce energy needed to heat the living space.

To directly produce electricity from the sun, there are basically two ways of generating electricity which are from solar thermal and photovoltaic [9]. Installation of solar collectors concentrates sunlight by collectors. Concentrated sunlight heats the water until temperature is high enough to turn a steam turbine and hence generate

electricity. Photovoltaic solar cells have a special surface that emits electrons when exposed to light. The moving electrons produce a direct current, which can be routed through inverters to generate AC output.

2.1.3.3 Wind Energy

Wind power is a translation of wind energy into useful form, such as electricity, using wind turbines. Most of the wind power in the form of electricity generated by converting the rotation of the rotor of turbine blades into electrical currents by means of an electrical generator. Wind energy is used in large scale wind farms for national electrical networks, and lowers in some plants to produce electricity for rural homes or places of the remote network. Technology of the wind is the fastest growing technologies in the world, rising to 32% on the annually average [8].

At the end of 2009, the total installed capacity was 157,899 MW, which was acquired in Asia by 24.6%. China topped the list with a total installed capacity of 25,104 MW, up to now. India is the second with 10 926 MW, followed by 2,056 MW in Japan and Taiwan were added in the fourth generation of 436 MW [10].

2.1.3.4 Hydropower

Hydropower is the first modern technology and development of renewable energy technologies. This is a significant contribution to the world's supply of electricity and provides one sixth of the worlds annual electrical output and over 90% of electricity from renewable [7].

Hydropower eliminates the emission of flammable gases from fossil fuels, and also contaminants such as carbon monoxide, particulate matter, mercury, nitrogen oxide and sulfur dioxide in coal. Hydroelectricity also avoids the danger of removing coal and the health effects from burning coal. Compared to nuclear, water or hydro produces no nuclear material or the dangers of uranium neither mining, nor nuclear leaks. Unlike uranium, hydroelectricity is also categorized as a renewable energy. Compared to wind farms, hydroelectric power stations had the extra load factor. If the project has a storage reservoir, it can dispatch to produce electricity, if necessary. Hydroelectric can be easily synchronized with fluctuations in demand for energy.

Unlike fossil fuels of gas turbines, hydroelectric development needs an extensive time for on-site studies, hydrological studies and environmental impact assessment of power. Hydrological information for 50 years or more often need to find out the most visible conditions to determine and apply a large dam Inequality with power plants operated by fuel, such as fossil fuels and nuclear power, number of sites that are capable of cost-effectively development of hydropower production is restricted.

2.2 Future Developments

2.2.1 Energy Growth

The Malaysia's economy after the last recession (1997 - 2000) entered in the ASEAN region, with the optimistic view about the Malaysian economy in the average maturity, means that the prospects for electricity demand to increase significantly. In the coming years, demand will grow by an average of 6.8% per year. In addition, Malaysia is expected to have 21 052 MW of peak demand in 2010 for the peninsula alone. [18].

By the end of 2011, it was assumed that the mixture of fuel oil in Malaysia were 58% of oil and gas, 33% of coal and the rest is hydro and other renewable energy sources [18]. It was not without environmental costs, because it focuses on the future of coal and gas demand for power. Coal and natural gas (10 GW in total) emit about 31 million additional tonnes of CO_2 (coal) and nearly 8 million tons of CO_2 (gas) per year. Growth in electricity demand is more or less uniformly conducted in residential, commercial and industrial.

Upon request, they showed almost all the sectors exhibited growth in energy consumption with industrial demand resulting from development and construction industry. According to recent studies, the demand for energy will increase to 4013 PJ in 2030 from 2000 PJ in 2009 at the averaged rate of 3.6% per year [23]. Supply growth has been driven by three main factors:

1. Commissioning of new facilities, which leads to an increase in installed capacity
2. The increase in imports of coal for power plants
3. LNG (Liquid Natural Gas) Terminal regasification in Malacca to operate by August 2012, Lahad Datu by 2015 and Tanjung Pengerang Johor by 2016

2.2.2 Malaysia's Energy Policies

Energy is an important contribution to the rapid growth of the economy in Malaysia. Currently, about 80% of the total population in Malaysia lives in Peninsular Malaysia, the center of economic activities in the country. As Malaysia moved towards a developed country, energy consumption will increase accordingly. In meeting growing demand for energy, a concerted effort has been introduced to increase security and

stability of energy supplies. The consumption of energy produces an unpleasant effect on the environment and climate. Therefore, the sustainable use of energy is being given consciousness in Malaysia.

Malaysia energy policy came in the '70s, when oil prices are high and the discovery of new oil wells in the Malay Peninsula. Petroleum Development Act (PDA) was founded in 1974 as a result of National Petroleum Policy in 1975. However, comprehensive national energy policy came in 1979. The national energy policy has three main objectives to guide future development of energy policy. They are:

1. Power supply: provision of adequate energy supply by reducing dependence on oil and the development and use of alternative energy sources.
2. Energy Utilization: In order to promote and improve energy efficiency and waste production and energy consumption patterns.
3. Protecting the environment: reducing environmental damage in the delivery and enforcement purposes.

In terms of reliability and security of supply, four fuel diversification policy was introduced in 1981, focuses on four main sources of fuel that is coal, hydro, oil, and gas which was also designed to decrease the dependency on oil in energy consumption, particularly in power sector. This policy is then expanded in 2005 to comprise renewable energy as the fifth fuel to complement energy supplement from conventional energy.

The Government of Malaysia is strengthening the role of renewable energy as the fifth fuel in the energy mixture. However, the share of renewable in overall energy balance is very low. In December 2009, renewable energy accounts for less than 1% (55.5 MW) of electricity to the national grid company. Malaysian government has approved the Renewable Energy and Action Plan in April 2010 and the implementation will started in 10th Malaysia Plan onwards. One of the main points of the action plan for renewable energy supply is the Feed-in-Tariff mechanism. Feed-in tariff will be implemented in 2011 to strengthen renewable energy in the country.

2.3 Renewable Energy Programs and Implementation

2.3.1 Small Renewable Energy Power (SREP)

To support the implementation of RE projects, SREP project was executed by the government on 11th May 2001 to promote greater use of renewable energy in electricity generation. SREP project can be more than 10 MW in size, but the maximum capacity that allowed for power export to distribution system should be up to 10 MW only. The SREP was allowed with all types of RE, including biomass, biogas, municipal waste, solar, hydroelectric and wind power. Just as in 2010, 43 projects of 286.15 MW capacity target had been approved by the Government of Malaysia under various types of renewable energy sources (Figure 2.3 and Figure 2.4), most of them were from biomass and small hydroelectric plants. However, only ten are currently in operation with total capacity of 56.7MW.

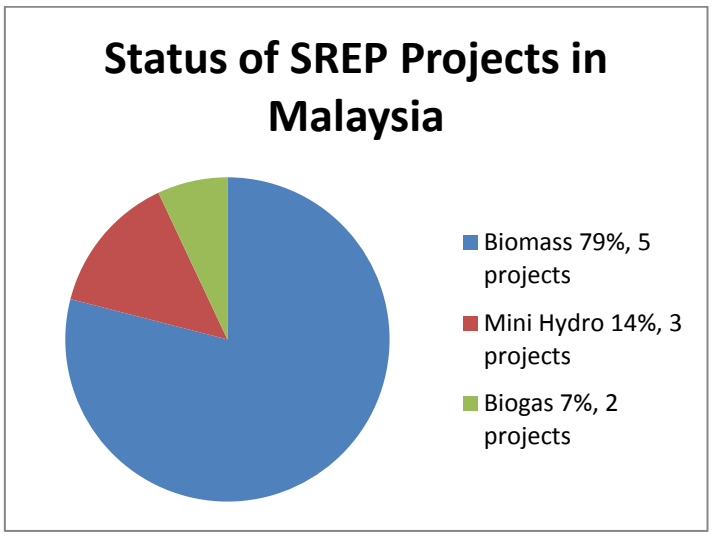

Figure 2.3: Status of SREP Projects in Malaysia

(Source: Energy Commission Malaysia Report, as of February 2010)

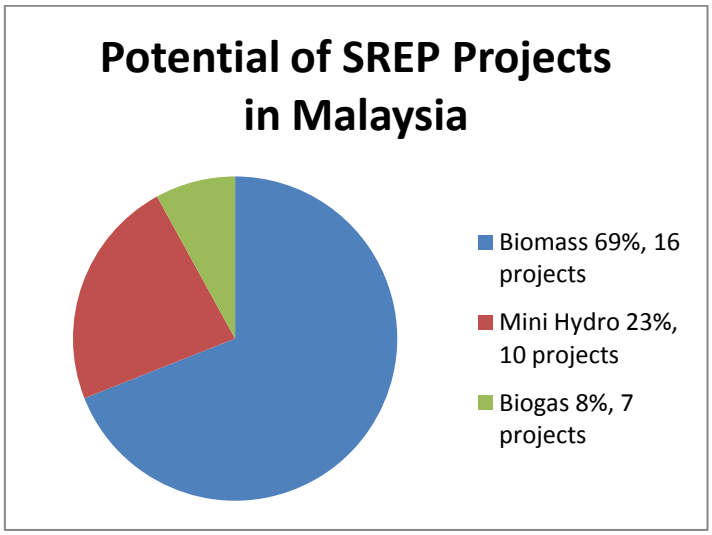

Figure 2.4: Potential of SREP Projects in Malaysia

(Source: Energy Commission Malaysia Report, as of February 2010)

The SREP has agreed from the previous Renewable Energy Power Purchase Agreement (REPPA) to sell to the national energy utility (TNB) for all projects related to the RE ranged from 14-17 cents / kWh (US4.6 cents/kWh). However, it seems that the current price of 17 cents/kWh (US5.6 cents/kWh) is not enough high performance for some investors and promoters of the given size of SREP project leave. Therefore, the government increased electricity tariff for biomass and biogas to 19 cents/kWh

(US6.2 cents/kWh) in September 2006 and later, at a price of 21 cents/kWh (US6.9 cents/kWh) had been amended effectively on August 2007. However, the price of RE sources, such as hydropower and solar power is still 17 cents/kWh. Since that, it is expected to further intensify the development of SREP projects.

2.3.1.1 Progress SREP Project

Many RE projects that approved in 2007-2008 have made significant progress. These projects have a total of 32 MW (30 MW from biomass and biogas power of 2 MW) of electricity at the end of 2010. It is notes that these projects, during the period of SREP, are experienced progress on the key elements of the program; increase the price sold to the utility by electricity producers and the standardization REPPA to reduce the bargaining power of RE which less than 2 MW. Changes to these two factors which showed in 2006 research founded that the obstacles to the implementation of approved projects in the SREP.

2.3.2 Biomass Power Generation & Demonstration Project (BioGen)

Biomass Power Generation and Demonstration (Biogen) was launched in October 2002 with a destination in order to promote and demonstrate biomass and biogas projects for the national network of energy production and limit the growth of greenhouse gas (GHG) emissions from fossil fuels of palm oil waste in excess utilization. Biogen facilitates the development of networks connected to the biomass plant of small power, information and awareness of the palm oil sector, and provides technical assistance to formulate financial, banking credits, tax breaks and other forms of support. Some major projects include the Biogen first 14 MW (10 MW export) power

plant in Tawau, Sabah which uses palm oil residues (empty fruits bunches, fiber and shell), have successfully reduced about 40,000 to 50,000 tons of CO^2 in 2005 and recently, 46.2 MW and 500 kW are grid connected to the network in April 2009 and has produced a total of 700 MW off-grid network of the private palm oil millers.

2.3.2.1 Progress BioGen Project

So far there are only two major projects of the full scale model and the commission is started in early 2009, namely:

1. 13 MW (export 10 MW) project under MHSE's Asia Sdn Bhd produce by IPP and running on biomass using EFB as fuel
2. 500 kW of FELDA Serting power plant that are using biogas from palm oil mill effluents (POME)

2.3.3 Malaysia Building Integrated Photovoltaic Project (MBIPV)

The Malaysia Building Integrated Photovoltaic (MBIPV) project fulfills the requirement of GC-BIPV (Grid Connected-Building Integrated Photovoltaic) installation within Malaysia. This installation is under the UNDP/GEF (United Nation Development Program/Global Environment Facility) supported MBIPV Technology project. The project is within the 9th Malaysia Plan period of 2006 till 2010.

The scheme focused on the growth of suitable, integrated, and practical strategies and policies that will generate better environment for extensive adoption of

Building Integrated Photovoltaic (BIPV) ahead of the 9th Malaysia Plan period to utilize solar Photovoltaic energy in Malaysia.

The project focuses on the growth of national BIPV project Malaysia in 10th Malaysia Plan (2011-2015), supported with appropriate and adapted mechanism for local conditions in market growth to accelerate, improve and extend the growth of photovoltaic industry in the countries.

2.3.4 SURIA 1000

Suria 1000 is the National Programme for the adoption of solar energy which was promoted in the opening ceremony of the International Conference on Renewable Energy in Asia on November 27, 2006.

One of the most important parts of the project supported by UNDP (United Nation Development Program) and Malaysia Building Integrated Photovoltaic (MBIPV) is to support the Suria 1000 target the installation of the solar cells in homes and offices.