Potential of Residential Grid-Connected Photovoltaic System as the Future Energy Source in Malaysia

S. S. Abd Wahid
Faculty of Electrical Engineering,
Universiti Teknologi MARA (UiTM),
Pasir Gudang Campus, Johor, Malaysia
yanuar@utm.my

Z. Nawawi, M. I. Jambak, M. A. B. Sidik
Department of Electrical Engineering,
Faculty of Engineering, Universitas
Sriwijaya (UNSRI), 30662 Inderalaya
Ogan Ilir, South Sumatera, Indonesia

Y. Z. Arief, M. W. Mustafa, Z. Adzis
Institute of High Voltage & High Current
(IVAT), Faculty of Electrical Engineering,
Universiti Teknologi Malaysia (UTM),
81310 Johor Bahru, Johor, Malaysia

Abstract*—Malaysia has started the implementation of solar energy harvesting in 1998. Located at equatorial region, Malaysia has a large potential for solar energy. This paper examines the current energy consumption and demand in Malaysia. The potential of solar energy harvesting in Malaysia is described together with the suitable photovoltaic construction. It also explains the plans conducted by Malaysia involving solar energy that covers investments and also projects involved such as Malaysia Building Integrated Photovoltaic (MBIPV). Finally, this paper analyses the potential of having a grid-connected PV system in a residential area. The positive and negative findings in terms of cost and suitability of the system are explained.

***Keywords*—Renewable energy; solar photovoltaic; solar energy; HOMER; energy demand; grid-connected photovoltaic, cost of energy; net present cost**

I. BACKGROUND

Nowadays, experts in energy sector worldwide have been focusing on the various ways available in reducing the environmental effect throughout the process of producing energy [1]. The conventional way of generating electricity with fossil fuel as the main source such as oil has become a big concern since the greenhouse emission that includes carbon dioxide mainly has contributed a lot on the air pollution [2].

Besides the negative effect on the environment, the decreasing amount of fossil fuel reserves has urges the government and private sectors to reduce the dependency on them. In low-income countries, energy security has become a critical issue as the vulnerabilities of supply and demand overlaps [3].

In Malaysia, as a country located in the equatorial region with high level of heat, solar energy become one of the most potential sources of energy to be implemented. The advantages of being clean with no pollutant emissions and the free availability of the abundant source of solar energy have made it an ideal alternative to generate electricity for the country [1]. The aim of this research work is to examine the current energy consumption and demand in Malaysia. The potential of solar energy harvesting in Malaysia will also be described together with the suitable photovoltaic construction. It also explains the plans conducted by Malaysia involving solar energy that covers investments and also projects involved such as Malaysia Building Integrated Photovoltaic (MBIPV). Finally, potential of having a grid-connected PV system in a residential area will be analyzed. The positive and negative findings in terms of cost and suitability of the system are explained.

II. CURRENT ENERGY SCENARIO IN MALAYSIA

A. Energy Consumption and Demand

The population in Malaysian has reached 27 million in 2010 [4]. In the year 2020, about 75% will settle down in urban area [5]. An annual average consumption of 3300 kWh for every household has been reported in [6] with 21% of the electricity generated is used by residential area in the first half of 2010. Fig. 1 shows the same pattern of primary energy consumption and electricity consumption in Malaysia [7].

In the past six years, the growth domestic product (GDP) grew at the rate of 5.7% [8]. In 2012, the government has predicted economic growth of 5 to 6% [9].The GDP is related directly with energy consumption and demand [8].

In Malaysia, gas and coal has been used most widely as the source of electricity generation. In addition, energy production is totally dependent on fossil fuel sources such as oil and also coal and gas as shown in Fig. 2 [10].

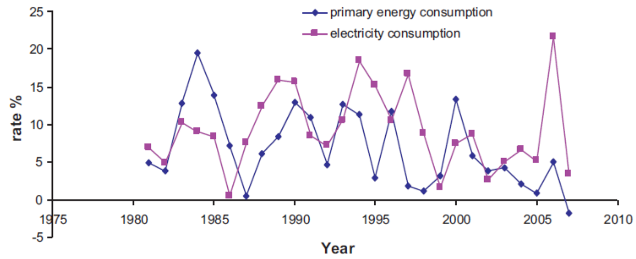

Fig. 1. Rate of primary energy and electricity consumption in Malaysia by year [7].

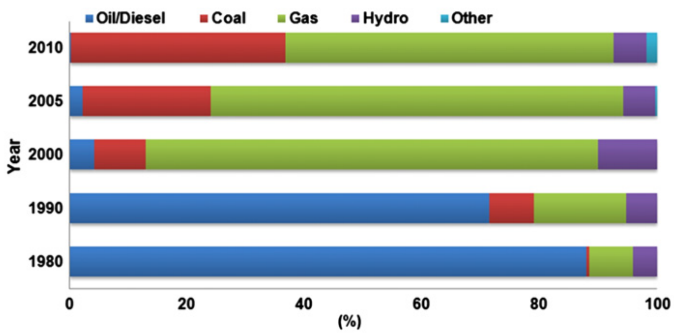

Fig. 2. Source of electricity in Malaysia [10].

B. Policy and Plan on Renewable Energy and PV system

In 2001, renewable energy has been highlighted in the 8th Malaysia Plan (2001~2005). Small Renewable Energy Program (SREP) was introduced to encourage the usage of renewable energy that includes solar, mini-hydroelectric, biomass and wind. Through this program, small power plants that use the renewable energy sources can sell their electricity to the utility via the distribution network. Besides, Fifth Fuel Policy 2000 (5FP2000) is also included in the plan with the purpose of focusing more on energy efficiency and sustainability that is much related to renewable energy.

Currently, in the 10th Malaysian Plan (2011-2015), the National RE Policy & Action Plan has been introduced and the Malaysia Building Integrated Photovoltaic (MBIPV) project is selected as a significant tool towards the RE development in Malaysia. The Prime Minister has stated that the government is planning in introducing a renewable energy law [11] that includes the feed-in tariff (FiT) for the benefit of the solar energy growth.

III. PV INSTALLATION IN MALAYSIA

A. Climate Potential

Malaysia lies entirely on the equatorial region. On average, Malaysia receives around 6 hours of sunlight per day [12]. Throughout the year, the temperature ranges between 220C and 330C (72–910F) and the average daily temperature is 26.50C. The annual average daily solar irradiations for Malaysia are from 4.21 kWh/m2 to 5.56 kWh/m2. The highest solar radiation was estimated at 6.8 kWh/m2 in August and November while the lowest was 0.61 kWh/m2 in December [13]. The monthly solar radiation in Malaysia is approximately around 400–600 MJ/m2 [1]. The average daily global solar irradiation is approximately 4.5 kWh/m2.

B. PV Construction

Solar PV connections can be obtained either in on-grid or off-grid connection [3]. An on-grid connection refers to one with interconnection between the building and the national grid that will enable electricity transfer towards the grid network of the utility. It is usually related to the feed-in tariff (FiT) introduced by the government. Meanwhile, an off-grid connection is not connected to the national grid. This type of connection is often connected to a storage bank which includes battery that will store the electricity. It is much suitable to be implemented in rural area.

In Malaysia PV market, four types of solar panels are normally used, namely mono-crystalline silicon, poly-crystalline silicon, copper-indium-diselenide (CIS) and thin film silicon (using amorphous silicon) [14].

IV. GRID-CONNECTED PV SYSTEM CALCULATION

The proposed grid-connected PV cell in a small residential area involves a total of 10 units of houses located at Johor Bahru, Johor, Malaysia.

A. Size of the PV array

The size of the PV array required is calculated by using equation (1) as stated in [28].

$$PV\ Area = \frac{\mathbf{EL}}{\mathbf{Gav\ x\ \eta PV\ x\ TCF\ x\ \eta out}} \qquad (1)$$

Where

EL is the average daily load demand;

Gav is average solar input per day;

TCF is temperature correction factor;

PV is PV efficiency;

out is battery efficiency ・B × inverter efficiency ・inv

In average, a typical house has a daily load demand of 8.427 kWh [15]. Therefore, for 10 units of houses, the average daily load demand is 84.27 kWh. From the HOMER software, the average solar input per day for Johor Bahru is 4.921 KWh/m2/day. Meanwhile the value of temperature correction factor (TCF) is 0.578 [16].

B. Size of Inverter

The inverter rating must be higher than the total watts of appliances. The inverter plays a big role in the system as it converts the DC input into AC at the output.

In this research work, the rating of the inverter chosen must be 25% to 30% bigger than total watts of appliances. The inverter must be able to sustain the total amount of watts that will be used at a time for a standalone system. Therefore, the inverter is selected considering the rating to be 25% higher than total watts of appliances which take the value of 4375 W. Thus, a 500 W inverter has been chosen.

V. HOMER SIMULATION

The PV system is constructed using HOMER software and the schematic diagram of the system can be seen in Fig. 3. As can be seen from the figure, the system consists of equipment such as PV module, converter, primary load representing the total load for the 10 units of houses and grid. Inverter plays the role of converting the DC supply produced by PV module from the sun into AC supply that will be consumed by the load. The AC supply will also be transferred to the grid network since the PV system for the residential area project is grid-connected.

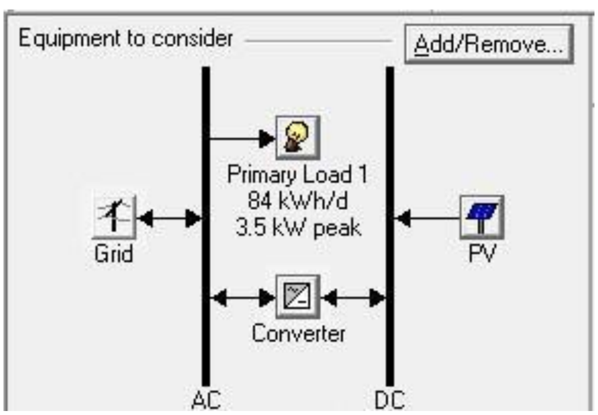

Fig. 3. Schematic diagram for grid-connected PV system of the research work

VI. SUMMARY

Solar energy has high potential in Malaysia. Since 2000, solar PV installations have grown significantly in this country. The Malaysia Building Integrated Photovoltaic (MBIPV) project was one of the important tools to increase solar PV penetration in residential sector. Solar could become one of the major renewable sources for electricity generation in Malaysia since the financial resources for research and development programs and various government policies have shown a positive growth recently. The implementation of FiT undoubtedly will boost the solar PV industry in Malaysia. However, the total return from solar investment is not considered good enough. The implementation of PV system has to cope with the low level of understanding of government policies in Malaysia as well as the important awareness among users. A green energy of solar is only possible when there are complete awareness, sufficient investment, stable market and solid commitment of all stakeholders.

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