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Economical, environmental and technical analysis of building integrated photovoltaic systems in Malaysia

Lim Yun Seng[a,*], G. Lalchand[b], Gladys Mak Sow Lin[b,1]

[a]*Department of Physical Science, Electrical and Electronic Engineering, Tunku Abdul Rahman University, 53300 Setapak, Kuala Lumpur, Malaysia*
[b]*Malaysia Energy Centre, Building Integrated Photovoltaic Project, Malaysia*

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Abstract

Malaysia has identified photovoltaic systems as one of the most promising renewable sources. A great deal of efforts has been undertaken to promote the wide applications of PV systems. With the recent launch of a PV market induction programme known as SURIA 1000 in conjunction with other relevant activities undertaken under the national project of Malaysia Building Integrated Photovoltaic (MBIPV), the market of PV systems begins to be stimulated in the country. As a result, a wide range of technical, environmental and economic issues with regard to the connection of PV systems to local distribution networks becomes apparent. Numerous studies were therefore carried out in collaboration with Malaysian Energy Centre to address a number of those important issues. The findings of the studies are presented in the paper and can be served as supplementary information to parties who are directly and indirectly involved in the PV sector in Malaysia.

Keywords: Financial viability of PV systems; Reduction in greenhouse gas emissions; Technical issues caused by PV systems

1. Introduction

Greenhouse gas emissions from combustion of fossil fuels for electricity generation have grown extensively over the past two decades. Such a rapid growth of emissions has caused the world to suffer, increasingly, the adverse effects of climate changes. In the past few years, Malaysia has experienced a number of such effects. For example, the floods in Johore on Peninsular Malaysia from December 2006 to January 2007 were the worst in 100 years. These floods caused 90,000 people to leave their homes and killed 17 people. This natural event resulted in the country to suffer financial losses of about RM 6 billion (= US$1.38 billion; BBC News, 2007).

The demand for electricity will continue to grow worldwide over the next two decades. In Malaysia, the energy demand is predicted to increase from 11,050 MW in 2001 to 20,087 MW in 2010 (Ninth Malaysia Plan, 2006). Therefore, the emission of greenhouse gases is predicted to increase from 43 million tones in 2005 to 110 million tones in 2020 (Mahlia, 2002). In addition, the global price of crude oil increased enormously from USD 23.17/barrel in January 2000 to USD 86.02/barrel in November 2007 (Energy Information Administration, 2007). The average increased rate of the oil price is about 34%/year. As a result, Malaysia will increasingly face a wide range of social and economic issues caused by climate changes as well as the increased prices of fossil fuels. The government has therefore put in a great deal of efforts to explore and increase the utilization of renewable energy sources in order to reduce the use of fossil fuels and so the emission of greenhouse gases (Abdul and Lee, 2005).

In 2000, the government reviewed its energy policy and implemented the Five Fuel Diversification Policy, making renewable energy as the fifth source of energy in the country. It was estimated that if the use of renewable source can be increased to 5% of the total electricity generation, then the country could save RM 5 billion

*Corresponding author. Tel.: +6034109802 or +60123459598; fax: +60 03 41079803.
E-mail addresses: yslim@mail.utar.edu.my (L.Y. Seng), lalchand@ptm.org.my (G. Lalchand), gladys@ptm.org.my (G.M. Sow Lin).
[1]Tel.: +60389434300 or +60133910540.

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(US$1.32 billion) over a period of 5 years (Abdul and Lee, 2005). Since then, a wide range of programmes have been undertaken to promote and increase the installation of renewable power plants. One of the programmes is the implementation of Small Renewable Energy Power (SREP) Programme in May 2001 (Ministry of Energy, Water and Communications, 2007). Under this programme, the owners of any SREP plants can apply for a license to sell their renewable electricity to the main utility company, Tenaga National Berhad (TNB), for a period of 21 years. Up to date, 59 applicants have been approved under the SREP with total energy generation capacity of 352 MW. Many of the approved renewable power plants use biomass, wood waste and rice husk as a source of energy.

Malaysia is a tropical country where solar energy is available throughout the year with solar radiation in the range of 1419 to 1622 kWh/m^2/year (Solar Radiation, 2008). Under such a climatic condition, photovoltaic systems become another favourable renewable energy source. However, at present, the prices of PV modules and related components are extremely high. The current market value of PV system is about RM 28.00/Wp (US$ 8.40). The reason for such a high price is that, at present, Malaysia does not have any local PV manufacturer. All the PV modules and inverters are imported from foreign countries, such as Germany and Japan, hence causing the cost of PV systems to be very high. As a result, photovoltaic systems are not an attractive option to the public. Therefore, PV business becomes unsustainable and is often regarded by PV suppliers and service providers as their side income stream.

In order to reduce the cost of PV system, Malaysia Energy Centre has carried out a project named Malaysia Building Integrated Photovoltaic (MBIPV). This project is funded by the government, United Nations Development Programme (UNDP/GEF) and various private sectors. The main idea of the MBIPV project is to incorporate PV grid-connected systems aesthetically into the building architecture and envelope. Activities undertaken in this project are aimed at creating the necessary conditions that will, in turn, lead to sustainable and widespread application of BIPV starting from 2006 onwards. The MBIPV project is expected to induce the growth of BIPV installations by 330% from the current status of 470 to about 2000 kW, with a unit cost reduction of about 20% by the year 2010.

Since the commencement of the MBIPV project, a wide range of activities have been undertaken. For example, a PV market induction programme, known as SURIA 1000, was started from September 2006, although it was officially launched on 22nd June 2007. Under this programme, electricity customers can bid for price rebates on PV systems under the MBIPV project (Southeast Asia Renewable Energy Newsletter, 2007). The first round of bidding yielded 14 successful bids from 39 applicants. The successful applicants received the discount of, on average, 53% of their PV systems. This programme will operate every year until 2010. In addition, a US-based PV manufacturing company, namely First Solar, is currently setting up a manufacturing branch in Kulim Hi Tech Park located in Kedah. It is expected to complete the construction of the first phase of its factory by the end of 2007. Its first production is expected to begin by the end of 2008. First Solar will continue to expand its manufacturing plant in the future.

With such increased activities associated with the PV sector, it becomes essential to address issues with regard to the connection of PV systems to local distribution networks. Therefore, collaboration was established between Tunku Abdul Rahman University and Malaysia Energy Centre to carry out studies on several critical issues. Among all these issues, the economic viability, environmental benefits and technical impacts of installing PV systems are discussed in this paper. The paper can serve as supplementary information to any parties who are directly and indirectly involved in the PV sectors. Economic viability of installing PV systems is evaluated under several considered regulatory and commercial frameworks as discussed in Section 2. Reduction in the emissions of greenhouse gases as a result of PV penetration is determined as presented in Section 3. Simulation studies are carried out to investigate the effects of PV systems on distribution network voltage level, energy losses and maximum demand charge as discussed in Section 4. Conclusions are given in Section 5.

2. Economic viability of installing PV systems

2.1. Net present value (NPV)

The NPV is a standard method for financial appraisal of long-term projects. The higher the NPV, the greater the financial benefits will be (Bernal-Agustin and Dufo-Lopez, 2006). It is used to evaluate the economical viability of installing a 1 kWp PV system. The following shows the derivation of the equation for calculating NPV.

The initial cost of the grid-connected PV system is expressed as follows:

$$S = C_{\text{gen}} + C_{\text{inv}} + C_{\text{inst}} - C_{\text{sub}}$$

where S is the cost of the PV system, C_{gen} the cost of the solar cells, C_{inv} the cost of the inverter, C_{inst} the cost of installation and C_{sub} the amount of financial subsidy under SURIA 1000.

The net cash flow Q_j for year j is the profit made in a particular year j as a result of the investment and can be calculated by using the following equation. It is the difference between the savings achieved in electricity bill and expenses incurred as a result of the investment:

$$Q_j = p_{\text{pv}} E_{\text{gen}} - (C_{\text{O\&M}} + C_{\text{Ins}}) \quad (2)$$

where Q_j is the profit made in year j, p_{pv} the PV electricity tariff, E_{gen} the annual amount of PV generation, $C_{\text{O\&M}}$ the