Total Solar Energy System – ToSES®

M. Shawal[1] , S. Taib[1] , I. Daut[2] , C. M. Hadzer[1] , M. Syafrudin[1]

[1] *Department of Electrical and Electronic Engineering,*
University Science of Malaysia, 14300 Nibong Tebal, Penang, Malaysia
Tel: +604-7788674 x 6073, Fax: +6 04 -265566, Email: m_shawal@yahoo.com

[2] *Department of Electrical and Electronic Engineering,*
Kolej Universiti Kejuruteraan Utara Malaysia, Kampus Kubang Gajah, 02600 Arau, Perlis, Malaysia
Tel: +604 -9798146, Fax: +6 04 - 9798304, Email: ismail.daut@kukum.edu.my

Abstract - *Traditionally, rural loads are supplied from stand-alone diesel power station or via grid extension. Such sources are sometimes not cost effective due to the high fuel and maintenance cost of diesel stations, as well as, long distances from the grid to the loads. Due to this reason, renewable energy (RE) is selected for electricity supplier. Photovoltaic (PV) is one of the suitable RE to replace the conventional suppliers. This paper describes the procedures used to evaluate the power supply technologies model and deployment strategy. Using the real time monitoring of photovoltaic power supply, the expert system can evaluate the performance of the selected photovoltaic technology. The monitoring system will collect power, voltage, current and temperature of the photovoltaic and download the data to the expert system to be analyzed. Many factors are being considered including cost effective, environment impact, payback period, resources availability and efficiency. The final product of this research will give a complete model of photovoltaic system for the selected area which is called ToSES®.*

Keywords: **Expert System, RE, Photovoltaic, Power Monitoring**

1. INTRODUCTION

The development of RE in Malaysia and the development countries is still in the early stage. The government have launched RE programs in early 2001 to generate 5 % of the country's electricity from RE by 2005[1]. Malaysia National Policy (1979) aims to have an efficient, secure and environmentally sustainable supply of energy in the future as well as to have an efficient and clean utilization of energy. Renewable energy resources and technologies are viable for rural and semi rural electrification in Malaysia. Especially in isolated island and very remote areas, renewable energy could well be a least-cost option. The technology of solar photovoltaic is available for various locations with a limited numbers in Malaysia. It is therefore reassuring to note that the idea of providing electricity to an area is tempered first with study of resources availability, socio-economic situation, electricity demand, environmental impact, market-based and ability, pay-back period and willingness of the end users to pay for the electricity. All of these criteria have to be considered for realizing the RE electric power supply development.

Considerable attention is being given to the accelerated deployment of RE in an attempt to reduce the environmental impact associated with traditional energy supply system and meet obligations emanating from the Kyoto Summit and Montreal Protocol. To further the expansion RE beyond this threshold required the adoption of a new deployment strategy, which uses RE at the local level in the form of building integrated system to minimize the quantity of energy imported from the electrical network. This approach is seen as the most effective to maximize the use of RE to meet ever-increasing building energy demands while minimizing the negative impacts associated with existing network integration. The successful integration of RE system within buildings requires careful consideration at all design stages to ensure that the selected technologies are well suited to the application.

To evaluate the potential of creating a 100% RE supply from local resources, a program has been developed. This program has been design to be as flexible and generic as possible, so that it can easily applied to areas of varying size and local energy resources.

II. SYSTEM DEVELOPMENT

To provide a user–friendly and maintain flexibility, this program was coded in Borland C++ builder. The tool uses a structured navigating path to enable user to specify energy demand and energy supply option for possible utilization. Fig.1 shows the architecture of the ES software development integration with solar panel and meteorological instruments. The program consist of testing to the characterize the electrical performance of solar panel that utilize various cell technologies, modeling to predict the annual energy production of the characterized panels, and long term performance monitoring of the panels under real world conditions. In order to accurately predict the electrical output of the systems, the panel's electrical response to various parameters must be known. For example, the model advocated by King [4] requires the following parameters:

- Influence of solar angle of incidence
- Influence of solar spectrum
- Temperature coefficient for the open circuit voltage and maximum power voltage
- Temperature coefficient for the short circuit current and the maximum power current
- Module operating temperature as a function of ambient temperature, wind velocity and solar radiation.

All the parameter will be recorded in database depend on the technology selected by user. These parameters we can get from solar panel datasheet. For the temperature, voltage and current produce by solar panel will be measure directly from the solar module. Some required parameters such as location name, demand and summary meteorological information about the location must be inserted by the user as a reference for the expert system. Fig. 2 describes the tool's modular components, whereby the user enters the program through the central program manager and continues through a series of dialog modules typically followed in the clockwise order depicted. The complete system can be seen at block diagram in Fig. 3. A microcontroller used to control the solar panel and meteorological instruments and to collect the data before send to Expert System (pc). Fig. 4 shows the initial specification window. The ES has been established to assist practitioners to identify the demand, supply technologies, and to ensure the effective operation of these technologies when deployed together. It also considered the economic factor for the whole system including pay-back period when using solar compared to conventional supply.

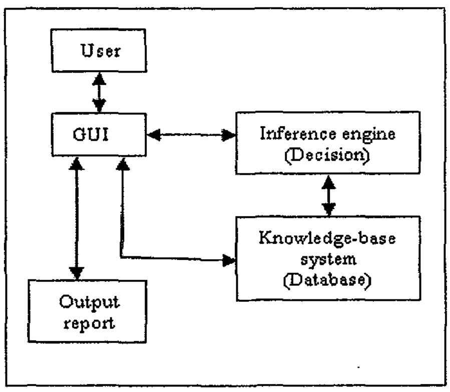

Fig. 1. Architecture of expert system ES

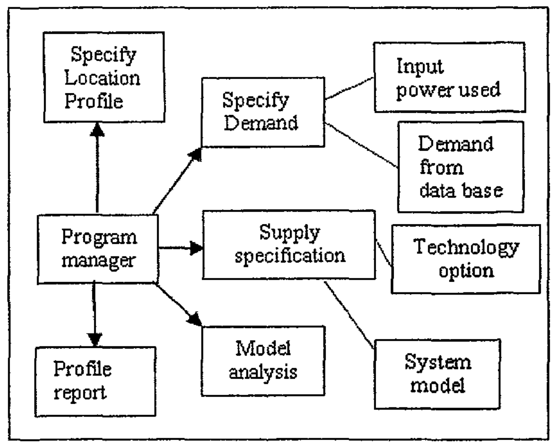

Fig. 2. Components of software development

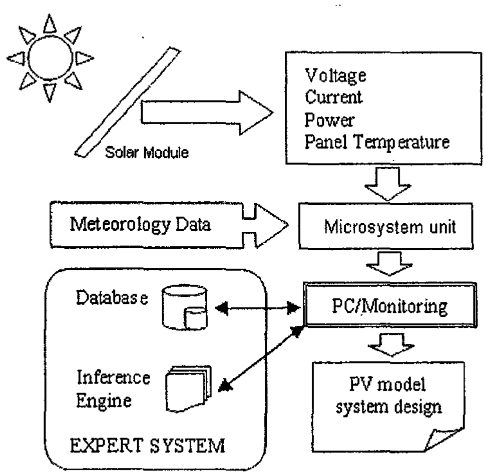

Fig.2. Block diagram of the system

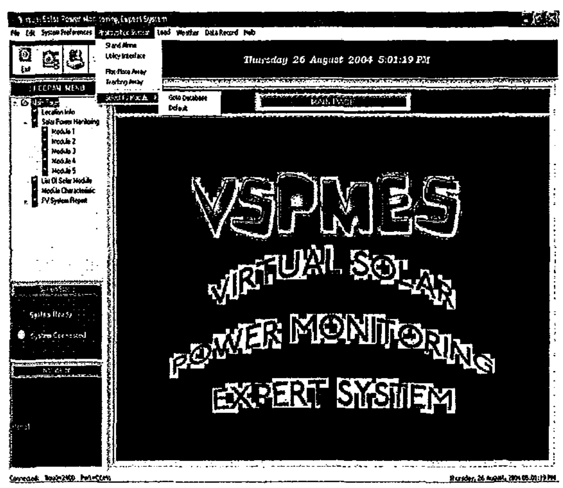

Fig.4. Initial specification windows

III. SYSTEM OPERATION

The first task for the user is to specify the site location name and total house in the selected area. Currently this ES has capability to evaluate the system in housing area only. Weather information also must be filling because the ES will evaluate the availability sources and performances of the photovoltaic system. As for next reference, this information will be saving in database. User can open the recorded data to be analyzed. The second stage in the definition process is to calculate the total electricity demand and power used for the location. The ES will analyze all the saved data and find the best solution for photovoltaic power supply system. As can be seen in Fig. 5, the location information window will come out when the user select the location info at tree view box. All required information must be inserting here.

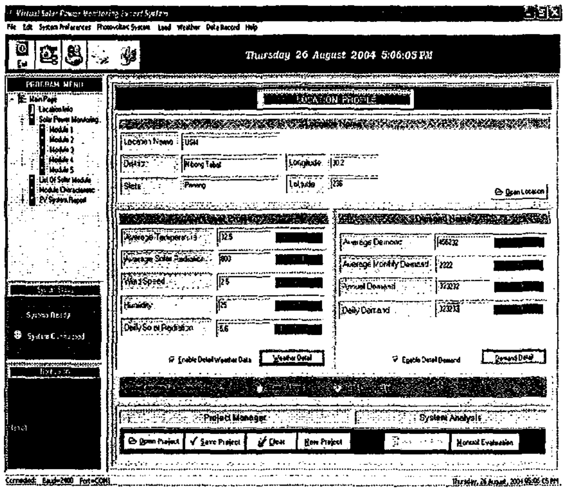

Fig. 5. Location information windows

As to evaluate the performance of the photovoltaic system, the ES will download the data from solar panel and temperature sensor. Its can be seen in Fig. 6 where all the data showed in the photovoltaic monitoring windows. Using a serial port to communicate with a microcontroller, the ES show the value and graph of temperature, voltage, current and power generated by the panel and all the will save to database before analyzing. After the user has entered the required data of the energy consumption, the next step is selecting the system characteristic tab to specify the system configuration and application type that the user prefers to use. The next step is to choose PV panel technology or just click analyze button for the expert system recommend the most suitable model and technology of PV. If user want to select PV panel type manually, click the PV characteristic button to see the detail parameters of PV panel such as cell type, maximum power point open circuit voltage and system description. Fig. 7 shows the specification form of a solar panel technology. It also contains the price and supplier address that available in market. Most of available PV panel in market are already stored in data based to make it easier for user to choose. This form can be added or edited by user to add new technology if not available in database. Following an appraisal, user is presented with a reporting window. The total energy demands are displayed together with the total energy supplied from the RE system. The complete system model including battery, panel type and charge controller are list in the report window. Its also will show the performances and total cost of the complete photovoltaic power supply system.

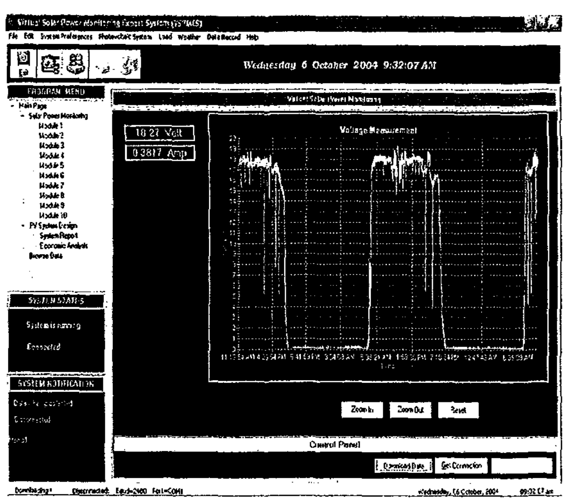

Fig. 6. Photovoltaic monitoring window.

IV. PHOTOVOLTAIC SYSTEM SIZING

This tool will help end user estimate the size and cost of a PV system. For a PV system powering loads that will be used everyday, the size of PV array is determined by the daily energy requirement or demand. For PV system design to power simple loads such as electric light, water pump or other appliances and loads in a house, the method is easy. But for more complex loads like households and bigger site such as in industrial area, it is sometimes difficult to anticipate every electric load. The sizing of PV also depends on available sunlight to generate the optimum power supply. In peninsular Malaysia, the average solar insulation is 4.5 kWh per meter square per day. All the data are required in this tool, power demand and resources availability. This program will automatically perform the mathematical calculations required for system sizing, greatly reducing the time required to size PV systems. The final model will give the complete design of PV system with the right number of PV modules, number of batteries and charge controllers for a PVsystem

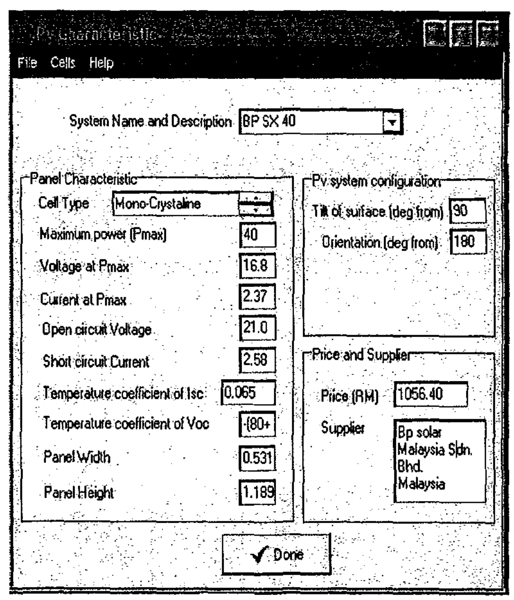

Fig. 7. Specification of a photovoltaic

V. RESULT AND DISCUSSION

The software is easily to use and user friendly. It is useful for design and economic analysis of photovoltaic system. The easiest way to become acquainted with the ES is try an example problem using the default parameters supplied with the program. Fig. 8 and 9 show the samples data collected from a solar panel according to the panel orientation west and east of voltage output. This data will be store in data base to be analyzed and finding the best solution for photovoltaic power supply system. Before develop this program, many household area and location has been studied to get some knowledge about currently electricity utilize and demand. The type of electrical instrument that commonly used in house and building are recorded. It is difficult to measure accurately total power used because for many house different type of instrument and its power running used. Currently this tool only can analyze for household area. The next step for upgrading this tool is doing some research in wider area such as city and industrial site. Some other factor should be considered to make sure this tool can generate result more accurate. The factor such as available land, local geography, positioning of buildings, existing plant, cost analysis including tax, operating and maintenance cost, detail annual availability resources , off-peak demand and energy balance when PV supply for that location.

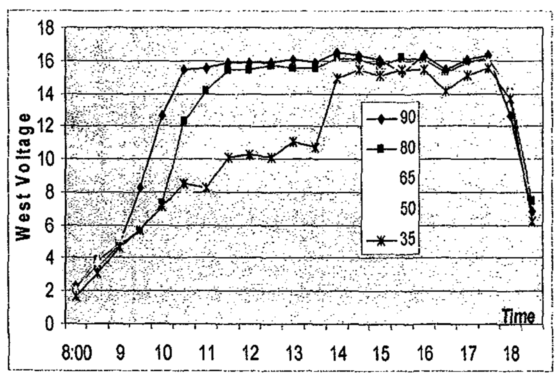

Fig. 8. Sample data of voltage output for west orientation panel

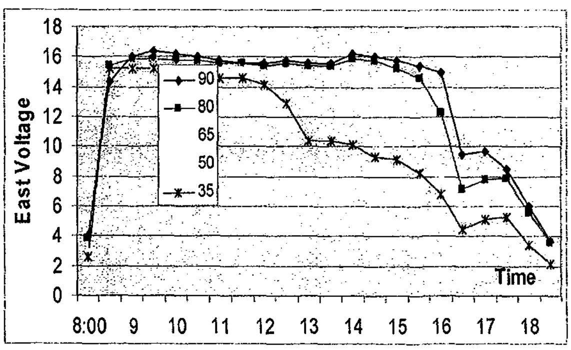

Fig. 9. Sample data of voltage output for east orientation panel

VI. CONCLUSION

To evaluate the potential of creating 100 % photovoltaic electricity supply from local resources, the evaluation tool has been developed. Building photovoltaic power supply replace conventional electricity supply have many advantages for long period of time either for large scale of photovoltaic power supply or for a single building or house. This software allows energy managers, planners and designers to appraise the potential for RE deployment at an early stage in the design process of solar power supply. Site specific technologies can be identified and their installation capacity established. Besides that, this evaluation tool also will increase public awareness about the benefit of photovoltaic power generation. It is also enables users to have a more comprehensive diagnostic of the PV system under different operating conditions. Furthermore, the system is very easily connected and implement. The effectiveness of the tools is confirmed through by several design examples. Building photovoltaic power supply replace conventional electricity supply have many advantages for long period of time either for large scale of photovoltaic power supply or for a single building or house. The propose system designed by this tools will make the user realize how much valuable if they prefer to use renewable energy instead of using conventional energy supply. So the user can measure the values of the actual systems.

Acknowledgement

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