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ECONOMIC ANALYSIS OF A GRID CONNECTED SOLAR HYDROGEN PV SYSTEM

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ABSTRACT

The grid connected solar hydrogen energy system has been developed in order to investigate the performance under the local climate conditions. The grid connected solar hydrogen energy system (GCSHES) have the capability of overcoming the problems that occur on the grid connected power system (GCPS) when there is a black-out of grid electricity. Moreover, stand alone power system (SAPS) requires batteries, and larger hydrogen tank capacity is required for higher energy generation. An experimental GCSHES has been setup and tested. The GCSHES consists of subsystems photovoltaic (PV) array with 40 PV module with its capacity of 5000 Wp, inverter capacity (6000W), electrolyzer, hydrogen tank and fuel cell (500 W). The monthly efficiency and performance of PV array is 12.7% and 26%, while the efficiency and performance of inverter is 95.1% and 98%, respectively. The techno-economical analysis indicated that the pay back period of this system is 18 years.

1. INTRODUCTION

1.1 Solar Hydrogen Energy System

The technology concept of connected solar hydrogen energy systems (SHES) consists of two stages. The first stage is the direct conversion of energy sources from solar energy to DC electric energy to alternating current (AC) and delivers to the grid. The second stage is the indirect conversion of energy sources through certain stages of energy storage in the form of chemical energy (hydrogen energy technology: production, storage and utilization), and then the chemical energy can be converted again becoming the electric energy. The solar energy is converted to the electric energy by using the photovoltaic (PV), when the excess electric supply occurs and this excess supply will be delivered to the grid or change to the chemical energy (hydrogen). The grid electric will be used whether there is adequate or inadequate solar energy. When there is no sun light and grid electric, for example the grid electric black-out at night, hydrogen is reconverted to the electric energy by fuel cell. The produced hydrogen can be used too for other purposes, such as for stove, internal combustion engine and laboratory research study. The schematic of grid connected solar hydrogen energy systems is shown in Fig. 1. Meanwhile table 1 shows the characteristics of PV that have been used in this study.

The characteristic of PV is expressed by its relationship with current and voltage (I-V), power and voltage (P-V) of photovoltaic on the certain solar light and temperature. The equation of characterizing parameter model for PV was commonly used for research study in PV [see 1, 2, 3 and 4].

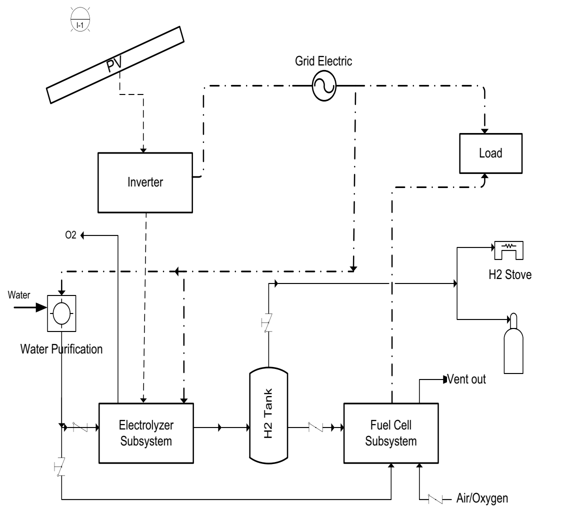

Fig.1 Schematic of grid connected solar hydrogen energy system

Table 1. Specification of PV Module

Type	Multicrystalline
Total Capacity (40 panel)	5 kWp
Maximum Power(P_{MP})	120 Watts
Voltan Max. Voltage (V_{MP})	16.9 Volts
Maximum Current(I_{MP})	7.10 Amps
Open Circuit Voltage(V_{OC})	21.5 Volts
Short Circuit Current (I_{SC})	7.45 Amps

The output energy of PV is the total of power during certain period. Hourly power is the operation time for every hour, while daily power is the operation time for one day. The PV efficiency is calculated by the ratio of PV output energy and solar energy per PV area and can be state in the equation as follows:

$$\eta_{PV,d} = \frac{E_{PV,d}}{E_{SR,d}} = \frac{\sum_{t=0}^{t} P_{PV}(t)}{\sum_{t=0}^{t} A_{PV} G_T(t)} = \frac{\int_0^t P_{PV}(t).dt}{A_{PV}\int_0^t G_T(t).dt} \qquad (1)$$

1.2 Inverter

Inverted used in the grid connected solar hydrogen energy system consists of maximum power point tracker (MPPT) and alternating current electric wave synchronization unit. MPPT employed for the optimization of photovoltaic module power output. The alternating current electric wave synchronizer was utilized to synchronize the wave frequency of output AC current from inverter and electric grid current. The inverter efficiency is the ratio of AC inverter output power and DC input power and depends on the input power. The energy efficiency and performance work of PV can be seen in Fig. 2.

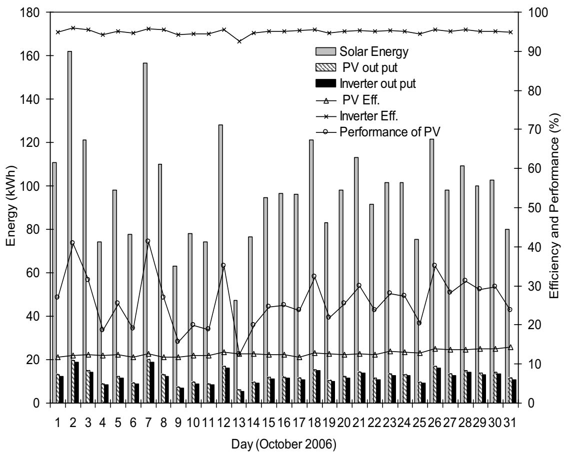

Fig. 2. Solar energy, PV, inverter, PV efficiency, inverter and PV performance in October 2006.

2. ECONOMICAL ANALYSIS

The grid connected solar hydrogen energy system was analyzed using the life cycle cost (LCC) method by referring to the present worth value. This energy system generates the electric and chemical (hydrogen) energy. Hydrogen can be either reconverted into electric as a storage if the grid electric disconnects) or used for any other purposes. The analysis of profit or saving system is based on the present electric rate (RM 0.285/kWh) and hydrogen rate (RM36/Nm^3). The economical analysis of this grid connected solar hydrogen energy system predicts the payment period (PP), which is time required for the annual payment flow with cumulative saving system to become positive [2]. The operation of this system can be simulated into two parts as follows:

a. The system operates in concentrating the electric generation only, while hydrogen produced is stored to be used when grid electric disconnected. This system does not employ hydrogen for any other purposes.
b. The system if considered as grid connected photovoltaic energy system (electrolyzer subsystem, fuel cell and tank) is not taken into account in the economical analysis.

The cost of present worth (C_{PW}) in this system is the total cost of photovoltaic system, inverter, electrolyzer system, hydrogen tank, fuel cell system and installation costs. The economical analysis was carried out by referring to the market discount of 7%, interest rate of 6%, electric rate of RM 0.285/kWh, hydrogen rate of RM 36/Nm^3, and life cycle of 30 years. It is obtained that the payback period for B and C simulation is 18 and 21 years, respectively. The payback period for A simulation was not achieved during life cycle. Therefore, it can be concluded that the grid connected solar hydrogen energy system is better to be used for hydrogen production for the other purposes or can be sold.

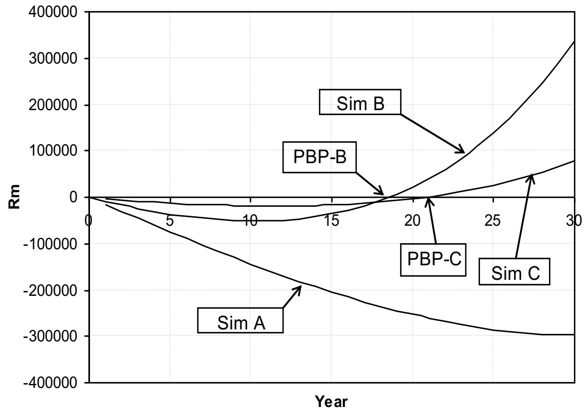

Fig. 3 Cumulative system saving of A, B and C simulation

3. CONCLUSION

The GCSGES system is the clean and friendly-environment energy system and it is knows as the appropriate future energy system to be implemented on the transmission system from the use of conventional fuel to the renewable energy. This system can reduce the air pollutant so that the warming global and climate changes can be slowed down and diminished. The performance and mathematical equations of the subsystems is required for the design of GCSHE system and renewable energy system. The techno economical analysis was performed by referring to some economical factors, which is market discount of 7%, interest rate of 6%, electric rate of RM 0.285/kWh and hydrogen rate of 36Nm^3, life cycle of 30 years. The operation time of electrolyzer by 2.6 hour per working day obtained the payback payment period of 18 years.

4. REFERENCES

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