Hydrogen Production from Combined Wind/PV Energy Hybrid System in Malaysia

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Abstract: - Hydrogen is widely considered be the fuel of the near future. Combined wind/PV energy hybrid systems can be used to sources energy to hydrogen production. This paper describes design, simulation and feasibility study of a hybrid energy system for a household in Malaysia. One year recorded wind speed and solar radiation are used for the design of a hybrid energy system. In 2004 was average annual wind speed in Kuala Terengganu is 3 m/s and annual average solar energy resource available is 5.2 kWh/m^2/day. National Renewable Energy Laboratory's HOMER software was used to select an optimum hybrid energy system. In the optimization process, HOMER simulates every system configuration in the search space and displays the feasible ones in a table, sorted by total net present cost (NPC). The optimization study indicates that sensitivity analysis of the HOMER is shown in the overall winner which shows that the most least cost and optimize hybrid system is combination of the 2 kW PV, 1 units wind turbine with capacity 1 kW, 1 kW electrolyzer and 60 kg hydrogen storage tank.

Keywords: Optimization design, Hydrogen production, HOMER, Wind/PV Energy Hybrid System, Malaysia

1 Introduction

Depleting of fossil and gas reserves, combined with the growing concerns of global warming, has necessitated an urgent search for alternative energy sources to cater to the present day demands. Alternative energy resources such as wind and solar energy is becoming increasingly attractive and is being used widely, for substitution of fossil produced energy, and eventually to minimize atmospheric degradation. Hydrogen production is of great significance on seeking a better way to use natural gas resources.

Hydrogen energy is a permanent and environmentally friendly source of energy. It can be presented to consumer in a convenient form at the desired location and time. It is the most economical synthetic fuel to produce, the cleanest fuel, and it can be converted to other forms of energy more efficiently than other fuels. Experimental facilities [2] for investigating the viability of hydrogen production using wind/PV hybrid have been established in College University Science and Technology campus in Terengganu located at east coast of West Malaysia.

Stand-alone hydrogen energy system with different renewable energy sources, namely solar hydraulic and wind energy were analyzed by Santarelli et al. [3], in view of their design and operation. The analysis showed that the preferred solution is case specific, depending on meteorological resources and load profile. The storage of renewable energy (mostly solar energy) in the form of elecrolycally produced hydrogen in stationary stand-alone power system has been investigated in many demonstration system is relevant to non grid-connected communities and remote areas [4]

Design of a hybrid energy system is site specific and it depends upon the resources available and the load demand. This paper describes design, simulation and feasibility study of a hybrid hydrogen energy system for a 1 kW system. One year recoded wind speed, solar radiation and estimation of the hydrogen load are used for the design of a hybrid energy system. National Renewable Energy Laboratory's HOMER software was used to select an optimum hybrid hydrogen energy system. A detailed design, description and expected performance of the system are presented in this paper.

2 Energy Resources

A monthly for over one year wind data and solar radiation used in this design is obtained from the data collected at 18m height above ground level in a College University Science and Technology Malaysia (KUSTEM) (5° 23'-N 103° 06' E) by using NRG Symphonie data acquisition system is shown in figure 1,2,3 and 4 following:

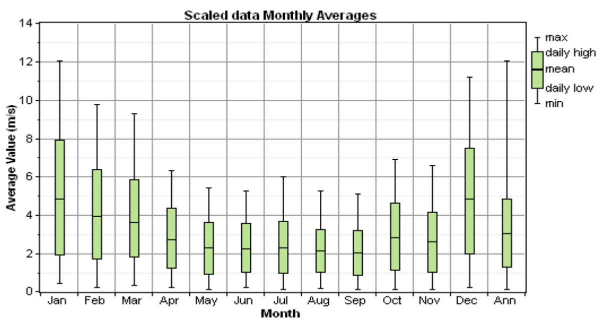

Fig. 1 Monthly average wind speed in Kuala Terengganu 2004 [1]

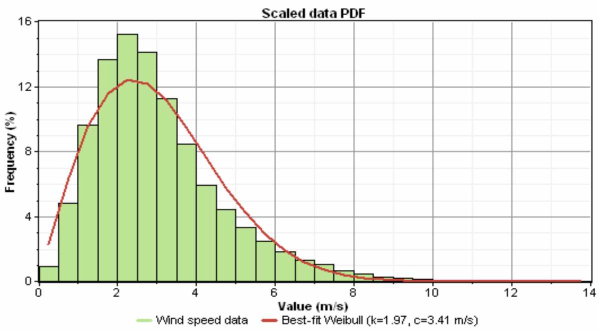

Fig. 2 Wind speed probability in Kuala Terengganu 2004

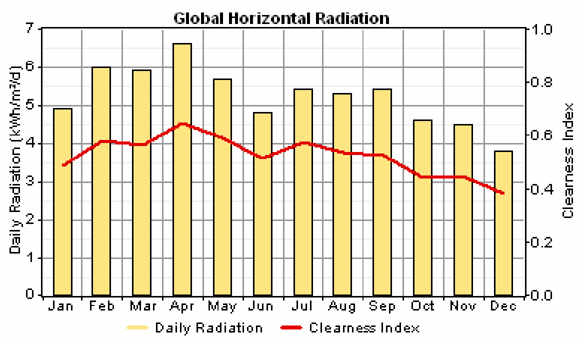

Fig. 3 Daily radiations in Kuala Terengganu 2004

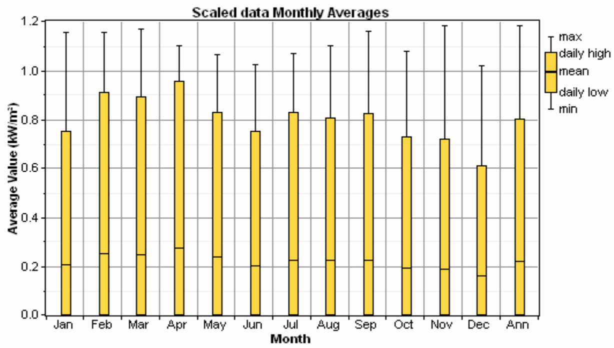

Fig. 4 Monthly average solar radiations in Kuala Terengganu 2004 [1]

September is the least windy month of the year while January and December are the windiest. Hourly wind speed data in end of year 2004 is shown in figure 2. Expected maximum wind speed is about 12 m/s. A best-fit 2 parameter Weibull distribution curve is also shown in figure 3. It indicates that probability of wind speed of 3-4 m/s is highest. Another renewable energy resource in this study is solar energy. Monthly and daily averages of global solar radiations (insolation in kW/m^2) in KUSTEM are shown in figure 3 and 4. In April 2004 was the sunniest month of the year. Annual average solar energy resource available in KUSTEM is 5.2 kWh/m^2/day. In April solar energy resources is 6.6 kWh/m^2/day while in December it is only 3.8 kWh/m^2/day.

3 Configuration and Optimization of Hybrid Energy System

Figure 5 shows a list of all optimization inputs used. One unit wind turbines Bergey XL1 with capacity 1 kW and 1 kW of none tracking PV array were considered as suitable for the hybrid energy system. A total of 12 batteries were considered as an option to store the energy from the PV and wind turbine. The battery is used to supply the energy to 1 kW electrolyzer with the hydrogen produce is stored in the size of 60 kg hydrogen storage tank, prior to serve to hydrogen load with the consumption of 0.006 kg/hour.

The selection of components of hybrid energy system is done using National Renewable Energy Laboratory, Hybrid Optimization Model for Electric Renewable (HOMER). HOMER is general purpose hybrid system design software. It was developed to address the need for a hybrid system design tool accurate enough to reliably predict system performance. HOMER considers all possible combinations of the equipment shown in figure 5.

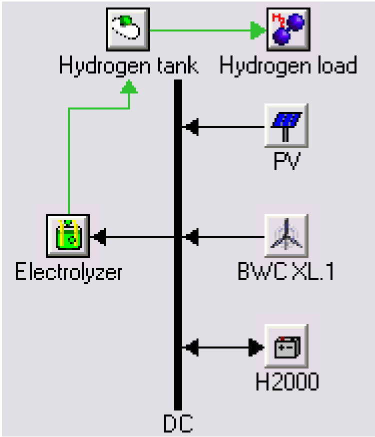

Fig.5 Schematic diagram of the type of systems that HOMER can simulate

HOMER is an optimization model, which performs many hundreds or thousands of approximate simulations in order to design the optimal hybrid system. It is simple and efficient enough to conveniently evaluate a large number of design options in its search for the optimum [7].

HOMER estimates the life-cycle cost of the system, which is the total cost of installing and operating the system over its lifetime. The life-cycle cost is a convenient metric for comparing the economics of various system configurations [5].

HOMER performs comparative economic analyses on a generation power systems. Inputs to HOMER will perform an hourly simulation of every possible combination of components entered and rank the system according to user-specified criteria, such as capital cost, cost of energy (COE) or total net present cost (NPC).

Total capital cost of such system is US$30,000 shown in Table 2 or Table 3, the total hydrogen is approximately 53 kg/year.

Hydrogen can be stored in several ways. Small amounts of hydrogen are most commonly stored as a compressed gas or as a metal hydride. Compressed gas storage is currently the most cost effective for small-scale system tank, so it is used for this study [6]. Sensitivity analysis of the HOMER is shown in the overall winner which shows that the most least cost and optimize hybrid system is combination of the 2 kW PV, 1 units wind turbine with capacity 1 kW, 1 kW electrolyzer and 60 kg hydrogen storage tank. This can be shown in table 3 which shows a complete list of HOMER solutions from the best worst.

Table 2 Cost involved in the most optimizes wind/PV hybrid

Component	**Initial Capital (USD)**	**Annual Replace (USD)**	**Annual O & M (USD)**
2 kW PV Array	10000	96	0
1 kW Bergey wind turbine XL1	4000	27	120
1 kW electrolyzer	7000	500	210
60 kg hydrogen storage tank	9000	0	360
Total	**30000**	**623**	**690**

Table 3 Categorized optimization results of HOMER selected solutions

PV (kW)	XL1	H2000	Elec. (kW)	H2 Tank (kg)	Initial Capital	Operating Cost ($/yr)	Total NPC	COH ($/kg)
2	1		1	60	$ 30,000	702	$ 35,503	75.136
3			1	60	$ 31,000	581	$ 35,561	75.749
2	1	12	1	60	$ 32,400	703	$ 37,916	80.242
3		12	1	60	$ 33,400	583	$ 37,973	80.888

4 Conclusions

A primary simulation design of a hybrid energy system for a hydrogen production in Malaysia, load based on the weather data taken at KUSTEM (East Coast of Malaysia) for period over one year is carried out. This optimization study indicates that energy requirements for the application of the hydrogen load annual average 0.144 kg/day can be accomplished by a combination of the 2 kW PV array, 1kW wind turbine, 1 kW electrolyzer and 60 kg hydrogen storage tank size.

The hybrid system is in significant mode during the day time particularly in the dry season. However, the results of this study can be considered as initial step to look further into the energy sector particularly with regard of renewable energy studies in Malaysia. A more study should be carried out especially for a long term data in order to get a better system performance.

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