STUDIES ON THE APPLICATION OF HYBRID HYDROGEN PRODUCTION SYSTEM-A CASE STUDY OF EAST COAST OF PENINSULAR MALAYSIA

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This thesis is dedicated to

My parents (Hj Zailan bin So'od and Hjh Kamisah binti Mahat), my siblings (Mohd Hamim, Hamizah, Mohd Jahidin, Juraidah and Naliza)

Also

All those gracious and inspiring personalities whose serenity, courage and wisdom lead me to the *Path of Guidance*

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December 2010

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Energy predicament in Malaysia ruptured due to the higher populations, living standards and increase of income per capita which boosted the energy demand continuously. Hence, the final energy consumption, fossil fuels, electricity and pollutants data for 1996-2007 were modeled through 2016 employed the Box-Jenkins time series analysis, ARIMA method to stimulate an effort to solve the problem. Whiles, the population, economic and transportation sector also were modeled through the simple regression method. The prediction models for each parameters show the increasing trends ahead, respectively.

To prove the possibility of adopting the hydrogen energy system in this nation, the system designs of coastal residential area and the fueling station which integrating the hydrogen energy power system were analyzed taking into consideration of technical and economic aspects. Wind speed and solar radiations data obtained from Meteorological Department and Universiti

Malaysis Terengganu Renewable Energy Research Station (UMT RERS) have been used in the simulation process through optimization software, Hybrid Optimization Model for Electric Renewables (HOMER). The selected case areas are east coast areas (Kuala Terengganu, Kota Bharu and Kuantan).

The comparisons of coastal residential analysis show that the grid connected PV-wind-hydrogen energy system for Kota Bharu had the lowest total net present cost and cost of energy, which are $45, 535 and $0.49/kWh accordingly that makes it the most cost effective system. Whiles, in the hydrogen production perspective, the most feasible system goes to stand alone PV-Wind-hydrogen power system for Kuala Terengganu as it performance in generating 93.8 kg/yr hydrogen that costs about $122/kg. In fact, the hydrogen production is feasible by standalone system rather than grid system. In particular, the fueling station fallout the monthly hydrogen production around 80 kg/d. It totals up the hydrogen outcome to achieve 30,215 kg/yr and put the cost of $5.51 per kg of hydrogen. The results of the techno-economic analysis also indicated that the combination of PV, wind turbine and hydrogen system was not economically viable at current costs of wind turbine and hydrogen energy technology components. Hence, it can be concluded that the hydrogen-based system can become a favorable system without aid from the grid system and bring advantage in technical and economic point of view if only the current cost of wind turbine and hydrogen system technology have been reduced to its minimum rate.

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KAJIAN PERAMALAN DAN TEKNO EKONOMI TERHADAP SISTEM BERASASKAN TENAGA HIDROGEN YANG MESRA ALAM DI MALAYSIA

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Krisis tenaga yang tercetus dewasa ini adalah berikutan peningkatan jumlah populasi, taraf hidup dan pendapatan per kapita yang telah meningkatkan keperluan tenaga secara berterusan. Maka, data penggunaan tenaga, bahan-bahan bakar fosil, bekalan elektrik dan bahan pencemar bagi tempoh tahun 1996-2007 telah dimodelkan sehingga tahun 2016 dengan menggunakan analisis siri masa Box-Jenkins iaitu kaedah ARIMA. Model ramalan tersebut bertujuan untuk menyelesaikan krisis tenaga yang semakin meruncing. Data populasi, ekonomi dan sektor pengangkutan juga telah dimodelkan dengan menggunakan kaedah model regresi. Model peramalan bagi setiap parameter menunjukkan peningkatan pada masa depan.

Untuk menentukan kebolehlaksanaan tenaga hidrogen di negara ini, analisis terhadap rekabentuk sistem rumah di kawasan berhampiran pantai dan stesen hidrogen telah dijalankan dengan mengambilkira aspek teknikal dan

ekonomi. Data angin dan radiasi yang diperolehi daripada Jabatan Meteorologi Malaysia dan Stesen Tenaga Keterbaharuan UMT (UMT RERS) telah digunakan dalam proses simulasi tersebut. Perisian yang digunakan ialah perisian HOMER. Manakala kawasan kajian terlibat ialah kawasan pantai timur (Kuala Terengganu, Kota Bharu dan Kuantan).

Perbandingan yang telah dijalankan di antara kesemua sistem rumah berhampiran pantai menunjukkan sistem grid PV-angin-hidrogen bagi Kota Bharu menghasilkan jumlah kos semasa dan kos tenaga sebanyak $45, 535 dan $0.49/kWjam sekaligus menjadikannya sistem yang paling kos efektif. Sementara itu, dari perspektif pengeluaran hidrogen, sistem yang paling munasabah untuk dilaksanakan ialah sistem tunggal PV-angin hidrogen bagi Kuala Terengganu berdasarkan keupayaannya menjana hidrogen sebanyak 93.8kg/tahun pada kadar kos $122/kg. Khususnya, stesen hidrogen mampu menjana hidrogen bulanan sebanyak 80kg/hari dan menjadikannya 30,215kg/tahun dengan kos sebanyak $5.51 untuk 1 kg hidrogen. Hasil keputusan daripada kajian tekno ekonomi yang telah dijalankan mendapati kombinasi PV, turbin angin dan hidrogen sistem tidak begitu memberangsangkan dari segi kos komponen sistem pada masa kini. Maka, dapat disimpulkan bahawa sistem berasaskan hidrogen akan menjadi sistem pilihan tanpa melibatkan sistem grid dan dapat diaplikasikan sekiranya kos komponen tersebut dapat dikurangkan pada kadar minimum.