DEVELOPMENT OF INTEGRATED RENEWABLE ENERGY SYSTEM FOR SUSTAINABLE ENERGY SUPPLY AT MAI FARM KALUMPANG SELANGOR

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ABSTRACT

Malaysia introduced renewable energy as the 5th fuel strategy in the energy-mix under the National Energy Policy in 2001. Malaysia has huge potential renewable energy resources in the form of solar, pico hydro and wind due to its geological characteristic and proximity to equator. Mai Farm in Kalumpang, Selangor is planning to implement a small scale integrated Solar PV, pico hydro, and wind for electricity to power up its facilities. The site has an average solar irradiation at 5.85 kWh/m^2/day with the highest solar irradiation at 6.08 kWh/m^2/day for month of October which is potential for implementation of solar PV system. The highest wind speed recorded is 5.58 m/sec on month of June. The average wind speed is 4.86 m/sec. The site has a consistent and continuous velocity of water flow coming from the nearest hill via gravity fed 3" PVC pipeline system. This research objective is to investigate the potential energy can be generated and to design an integrated renewable energy system consisting of floating solar PV, pico hydro and wind. The methodology of the research started by gathering data for geographical and meteorological information such as location, elevation, solar irradiation, wind speed and flow data for pico hydro. The load list for Mai Farm also investigated for demand and consumption. All the collected data is used as input to perform simulation and optimization of renewable energy system configurations by HOMER software. Different off-grid configurations of the integrated system proposed are investigated for its levelized cost of electricity (LCOE). The simulation shall be able to assess levelized cost of electricity (LCOE), CO_2 avoidance and excess electricity resulting of the integrated renewable energy system.

ABSTRAK

Malaysia memperkenalkan tenaga boleh diperbaharui sebagai strategi bahan api ke-5 dalam campuran tenaga di bawah Dasar Tenaga Negara pada tahun 2001. Malaysia mempunyai potensi besar sumber tenaga boleh diperbaharui dalam bentuk solar, pico hidro dan angin kerana lokasi geografinya yang berdekatan dengan garisan khatulistiwa. Mai Farm di Kalumpang, Selangor merancang untuk melaksanakan tenaga boleh diperbaharui berskala kecil melibatkan tenaga solar terapung, pico hidro dan tenaga angin bagi menjana kemudahannya. Tapak ini mempunyai purata sinaran suria pada 5.85 kWj/m^2/hari dengan sinaran suria tertinggi pada 6.08 kWj/m^2/hari bagi bulan Oktober yang berpotensi untuk pelaksanaan sistem tenaga solar. Kelajuan angin tertinggi dicatatkan ialah 5.58 m/s pada bulan Jun. Purata kelajuan angin ialah 4.86 m/s. Ladang ini mempunyai halaju aliran air yang seragam dan berterusan yang berasal dari bukit terdekat melalui sistem saluran paip PVC 3" dialirkan melalui tarikan graviti. Objektif kajian ini adalah untuk mengenalpasti tenaga diperbaharui yang boleh dijana dan mereka bentuk sistem tenaga boleh diperbaharui bersepadu yang terdiri daripada system solar, pico hidro dan angin. Kaedah penyelidikan dimulakan dengan pengumpulan data untuk maklumat geografi dan meteorologi seperti lokasi, ketinggian, sinaran suria, kelajuan angin dan kadar data aliran untuk pico hidro. Jumlah beban kuasa yang digunakan oleh Mai Farm juga dianalisa dari segi permintaan dan penggunaan. Semua data yang dikumpul digunakan sebagai input untuk process simulasi dan pengoptimuman dengan menggunakan perisian HOMER. Konfigurasi luar grid dianalisa bagi mendapatkan Kos Elektrik Diratakan (LCOE). Simulasi yng dijalankan dapat menilai Kos Elektrik Diratakan (LCOE), pengurangan CO_2 dan elektrik berlebihan yang terhasil daripada sistem tenaga boleh baharu bersepadu.

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LIST OF ABBREVIATIONS

AC	-	Alternating Current
DC	-	Direct Current
FSPV	-	Floating Solar Photovoltaic
HAWT	-	Horizontal Axis Wind Turbine
HOMER	-	Hybrid Optimization of Multiple Energy Resources
LCOE	-	Levelized Cost of Electricity
PHP	-	Pico hydropower
PV	-	Photovoltaic
RE	-	Renewable energy
VAWT	-	Vertical Axis Wind Turbine

CHAPTER 1

INTRODUCTION

1.1 Research Background

World energy consumption is rising due to population growth and increasing industrialization. Traditional energy resources cannot meet these requirements with notice to their challenges, e.g., greenhouse gas emission and high lifecycle costs. Renewable energy resources are the appropriate alternatives for traditional resources to meet the increasing energy consumption, especially in electricity sector. Integration of renewable energy resources besides storages creates Integrated Renewable Energy System. To access minimum investment, operation costs and also meet the technical requirement, optimal size of Integrated Renewable Energy equipment should be determined. One of the most powerful tools for this purpose is Hybrid Optimization Model for Electric Renewables (HOMER) software that was developed by National Renewable Energy Laboratory (NREL), United States.

Mai Farm which is located in Kalumpang Selangor is a mixed farming with size of 110 acre. Mai Farm main businesses are agriculture such as palm oil and coconut, livestock such as chicken, goat and cow and also aquaculture such as freshwater lobster and freshwater fish. Currently Mai Farm consumes energy from electricity supplied from grid by Tenaga Nasional Berhad for the whole operation.

Mai Farm is planning to develop an integrated renewable energy system to harvest any possible energy at site. List of possible energy are floating solar PV, pico hydropower and wind. The site has an average solar irradiation at 5.85 kWh/m^2/day with the highest solar irradiation at 6.08 kWh/m^2/day for month of October which is potential for implementation of solar PV system. The wind speed average is estimated around 4.86 m/s with maximum in June at 5.58 m/s. The availability of

renewable energy resources contributes high potential for sustainable energy production.

Therefore, the planned integrated power system is expected to sustainably supply continuous energy in the forms of electricity for the farm operations.

Figure 1.1 Location of Mai Farm from satellite image (Google Earth Pro)

1.2 Problem Statement

Power for building and ancillary facilities is a necessary for many farms. If main connection from grid was cut off or not available, a generator is required for alternative source, However, running a generator 24/7 is costly in term of fuel and servicing cost and offers no option to vary the power dependent on load. Hence, the farm requires continuous and sustainable energy supply as a backup.

Due to strategically located, there is an opportunity to harvest solar energy via floating solar PV. A large pond area estimated size about 5 acres is potential site for FSPV. Existing consistent and continuous velocity of water flow coming from the nearest hill via gravity fed 3" PVC pipeline system is potential source for pico hydropower.

Integrated renewable energy system requires optimal planning of its component i.e., number of wind turbines, photo voltaic (PV) array, batteries, capacities of generators, inverters so that the objective functions are minimized/maximized, and all constraints are satisfied. However, this is very complex analysis and utilization of software modelling is preferred. Many software and optimization approach are proposed in various literatures. One of the most powerful tools for optimal sizing of equipment is Hybrid Optimization Model for Electric Renewables (HOMER) software that was developed by National Renewable Energy Laboratory (NREL), United States. Many resources such as WT, PV array, fuel cells, pico hydropower, converter, batteries, and conventional generators are modeled in HOMER. Should the energy system is capable of producing surplus energy, an economic assessment will be performed to determine the feasibility of the proposed implementation.

1.3 Research Objectives

The main objectives of this study will be as follows:

1. To investigate feasibility of integrated renewable energy system consist of floating solar PV, pico hydropower and wind.
2. To investigate the potential of renewable energy generation by different configurations of renewable energy type.
3. Perform techno-economic analysis on the resulting integrated renewable energy system configurations.

1.4 Scopes of the Study

The scopes of this study are: -

1. Data collection is done by: -
    i) Geographical information such as coordinate, area and elevation are obtained from online map.
    ii) Historical meteorological data such as solar irradiance, ambient temperature and wind speed are from meteorological agencies and other from literature.
    iii) Economic or cost factor from literature and/or current market price.
2. Application of Hybrid Optimization of Multiple Energy Resources (HOMER) software to determine the renewable energy system output.
3. Assessment of levelized cost of electricity (LCOE), CO_2 avoidance and excess electricity resulting integrated renewable energy system.

1.5 Significance of the Study

Through this study, it could contribute positively to Mai Farm in term of reducing the consumption of grid supplied electricity, provide power back-up in case of main connection from grid was cut off or not available and would cut the carbon emission to the environment. This benefit is described as below:

1. Provide possible opportunity on integrated renewable energy system utilization in farm and become more self-sufficient and reducing external source of power from grid.
2. Combats the effect of global warming by potential of CO_2 emission reduction
3. To identify the best option for integrated renewable energy system which will be optimized by the HOMER software
4. To identify the techno-economic performance for different scenario is estimated in HOMER based on levelized cost of electricity (LCOE)

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