MODELING OF HYBRID RENEWABLE ENERGY GENERATION CONSISTING OF WIND, FUEL CELL AND ULTRA CAPACITOR

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To God the Almighty, without whom knowledge without faith is fruitless and to my lovely parents and my sisters and brother, who do not let me sense me alone.

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ABSTRACT

Consider to the finish of fossil fuel and the growth of population, the need of creating and utilizing new sources of energy is increased. During the past few decades, scientists have discovered new resources to generate electricity. These kinds of energy are called renewable energies. Alongside all the benefits of new resources they have some disadvantages that cannot use them widely. For example, one of the issues in generating electricity from wind is the variation of wind speed. In the case of having an ideal generation of electricity, the use of stable and power quality curve is necessary. But this variation of wind speed sometimes makes a problem in drawing this curve. In order to solve this problem, this study offered the utilizing of the wind and fuel cells as renewable energy in a hybrid configuration. This configuration can solve problems of renewable energy. In this project, the generating of electricity is hydride from wind turbines and fuel cell. If the speed of wind is not enough to generate the electricity, the fuel cell would start to generate it. However, the fuel cell needs the time to arrive nominal value which ultra capacitor start to generate the electricity in this gap. All the system consists of grid, wind turbine, fuel cell and ultra capacitor was simulated in MATLAB software. The output of system should be a stable carve. It means this hybrid system's generation as a reliable production is used in all wind speed condition. By using this, the disadvantage of using wind is reduced and also the power quality of distribution's grid and electricity production be improved.

ABSTRAK

Kekurangan bahan api sejak kebelakangan ini memberi motivasi untuk mencari sumber tenaga yang baru. Beberapa dekad yang lalu, para ahli saintis telah mempelajari bagaimana penggunaan sumber tenaga dalam penghasilan elektrik. Tenaga yang dimaksudkan ialah tenaga yang boleh di perbaharui. Walaupun tenaga yang boleh diperbaharui mempunyai banyak kebaikan tetapi keburukan yang ada padanya telah menghalang penggunaan sumber tersebut secara berleluasa. Contohnya, kepelbagaian kelajuan angin merupakan isu yang besar dalam tenaga angin. Bagi menghasilkan penjanaan yang sempurna, penghasilan elektrik perlu dilakukan dalam lengkungan yang tepat. Bagi menyelesaikan masalah tersebut, penggunaan sumber tenaga secara hibrid telah diperkenalkan dalam projek ini. Dua sumber tenaga boleh diperbaharui telah digunakan iaitu fuel cell and tenaga angin. Dalam keadaan tenaga angin tidak mencukupi, tenaga akan dihasilkan daripada fuel cell. Dengan kata lain, apabila pengeluaran angin berkurangan, tenaga akan mula dihasilkan daripada fuel cell. Walaubagaimanapun, fuel cell memerlukan masa untuk mencapai nilai yang nominal yang mana masalah ini dapat diatasi dengan menggunakan kapasitor sebagai penyimpan tenaga. Sistem yang terdiri daripada penjana angin, fuel cell dan kapasitor telah di analisis dalam perisian MATLAB. Keluaran sistem tersebut perlu dalam lengkungan yang tepat. Ini bermakna, dalam sistem hibrid ini, penjanaan tenaga boleh dalam semua keadaan angin. Oleh yang demikian, sumber tenaga boleh diperbaharui dapat digunakan secara meluas. Akhir sekali, jumlah kos penghasilan tenaga elektrik akan semakin berkurangan.

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LIST OF ABBREVIATIONS

FC	-	Fuel Cell
UC	-	Ultra Capacitor
NREL	-	National Renewable Energy Laboratory's
WT	-	Wind Turbine
PEM	-	Proton exchange membrane or Polymer Exchange Membrane
DFIG	-	Doubly fed induction generation
IG	-	Induction Generator
MCFC	-	Molten Carbonate
SOFC	-	Solid Oxide Fuel Cell
AFC	-	Alkaline Fuel Cell
PAFC	-	Phosphoric acid Fuel Cell
DMFC	-	Direct Methanol Fuel Cell
ESR	-	Equivalent series resistance
EPR	-	Equivalent parallel resistance
PF	-	Power Factor
VSC	-	Voltage-sourced converters
IEEE	-	The Institute of Electrical and Electronics Engineers

LIST OF SYMBOLS

P_m	-	Mechanical output power of turbine
C_P	-	Performance coefficient of the wind turbine
λ	-	Tip speed ratio of the rotor blade tip speed to wind
β	-	Blade pitch angle (ᵕ)
ρ	-	Air density (kg/m^3)
A	-	Turbine swept area (m^2)
v_{wind}	-	Wind speed ($\frac{M}{Sec}$)
n_{H2}	-	Hydrogen produced (moles/sec)
ηF	-	Faraday efficiency=$96.5e^{(\frac{.009}{i}-\frac{75.5}{i^2})}$
ηc	-	Number of electrolyzer cells in series
i_e	-	Electrolyzer current
F	-	Faraday constant (CK/mol)
T	-	Temperature of operation
z	-	Number of moving electrons
i_0	-	Exchange current
E_n	-	Nernst voltage

α - Charge transfer coefficient

C - Capacitance [F]

$C_{UC\text{-}total}$ - The total UC system capacitance [F]

EPR - Equivalent parallel resistance [Ω]

ESR, R - Equivalent series internal resistance [Ω]

EUC - The amount of energy released or captured by the UC bank [Ws]

ns - The number of capacitors connected in series

np - The number of series strings in parallel

$R_{UC\text{-}total}$ - The total UC system resistance [Ω]

V_i - The initial voltage before discharging starts [V]

V_f - The final voltage after discharging ends [V]

T_m - Shaft mechanical torque

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CHAPTER 1

INTRODUCTION

1.1 Background of Study

With the developed of world, it seemed the energy was the main part for improving economic and social development and also it drives a good living standard. Due to increased access to electricity, it will improve opportunities for industrial development and enhances health and education. Renewable Energy (RE) has a great potential to contribute to development of national sustainable energy infrastructures in many countries in the world. Hybrid Renewable Energy is a combination of more than one type of energy in one system. For instance, Fuel cell and wind can become one hybrid type of Renewable energy generation. A hybrid energy system based on such alternative technologies has been proven to be a feasible solution for stand-alone power generation at remote locations, where the cost of grid extension is prohibitive and the price of fossil fuels increase drastically. Moreover, the hybrid systems such as wind/diesel are now proven technologies and are an option to supply small electrical loads at remote locations as reported by Zhang Hongyi et al. , Lundsager and Bindner [1].

A wind system alone cannot satisfy the load requirement for 24 hours. Stand-alone diesel generator sets are generally expensive to operate and maintain especially at low load levels. In simple system, the diesel runs continuously to cover the difference between the load demand and the wind energy, as a result the diesel generator runs sometimes under light-load conditions. Due to low efficiency of the generator at light load, the fuel saving potential is limited. Wind and diesel have complementary characteristics namely, capital cost of diesel is lower compared with wind turbine system, maintenance requirements of wind are less compared to diesel, and diesel energy is available all the time where as the availability of wind energy is dependent on the wind. Battery technology has reached a very suppurate stage; size, cost and disposal are the constraining factors for its use in remote stand-alone applications. Recent advancements in Fuel Cell (FC) and electrolyzer technology have opened up the option for using hydrogen as an energy storage medium [2] .

Some studies are reported about design, optimum combination and analysis of hybrid renewable energy power generations with energy storage. The overall goal is to identify the current availability of commercial hybrid renewable energy systems and its components by using Homer software. Inputs to HOMER will perform an hourly simulation of every possible combination of components entered and rank the systems according to user-specified criteria, such as cost of energy (COE, US$/kWh) or capital costs. Furthermore, HOMER can perform “sensitivity analyses” in which the values of certain parameters (e.g., solar radiation or wind speed) are varied to determine their impact on the system configuration [3]

Standalone diesel generating system utilized in remote islands has long been practiced in Alaska. Because of high fluctuation diesel price, such a system is seemed to be uneconomical, particularly in the long run if the supply of electricity for rural areas only depends on such diesel generating system. Here the potential use of hybrid

Wind/Fuel cell (FC)/Battery /diesel energy system was analyzed in remote areas. National Renewable Energy Laboratory's (NREL) HOMER software was used to present the techno economic feasibility of hybrid Wind/Fuel cell (FC) /Battery/diesel energy system. The investigation verified the impact of wind/ FC penetration and battery storage on energy production, cost of energy and number of operational hours of diesel generators for the given hybrid configuration. Emphasis has also been placed on percentage fuel savings and reduction in carbon emissions of different hybrid systems. At the end, suitability of utilizing hybrid Wind/Fuel cell (FC)/Battery /diesel energy system over standalone diesel system would be discussed mainly based on different load demand, wind speed, FC and diesel prices . In order to determine the economic and technical feasibility of a wind/fuel cell/diesel system, computer modeling of the different power system options have to be done [4].

1.2 Significance of Study

This project needs to be solved. Notice to this case that it should feed all demand loads with different types of generation with enough power, reliable voltage and frequency in our grid. Thus for having a reliable power system, it needs to assess our system in two status. First of all before start to design each system it is necessary to have an economical assessment. It is mean that, if it was assumed to make a power plant for generating electricity. In this case it's so important the low cost of production. In the other word, the electricity generation in new power plant should not be more expensive in compare to normal generation on that place. Second of all, the new planned system should be able to work in normal and abnormal condition. It means this new system capable to work in practical state. Thus this system has to assess from technical viewpoints. Each parts has own characteristics for having a best work points.

The disadvantages of these renewable types are:

- ✓ In wind turbine: the wind speed is variable and sometimes it stops to blow.
- ✓ Fuel cell: cannot supply load in long duration and takes time to start to generate power.
- ✓ For having a good quality of electricity, should not have any interruption or blackout for delivering electricity to consumers.

1.3 Problem statements

The problem statements of this project are:

a) The disadvantages of these renewable types.

In wind turbine: the wind speed is variable and sometimes it stops to blow

Fuel cell: cannot supply load in long duration and takes time to start to generate power

b) For having a good quality of electricity, should not have any interruption or blackout for delivering electricity to consumers

1.4 Objective of Study

The objectives of this study are:

1) To generate a system consisting of wind, FC and UC.
2) This system should generate power demand (active power) by the best output (sustain generation and fast starting) and deliver this power to grid.

1.5 Scope of Study

The scope and limitation of the study are as follow:

1) Handling of the modeling of wind turbine (WT), Fuel Cell (FC) and Ultra Capacitor (UC) to generate a good quality and quantity of power for deliver to grid.
2) Integrated these three different types to get better results.
3) The simulation by using MATLAB 7.0 Simulink for technical part and using HOMER software to do economical assessment.

1.6 Organization of the Report

This thesis is divided into five chapters. The first chapter is the significance of the study, followed by chapter 2, which discuss about the literature review and previous study. Chapter 3 describes about the methodology of the system. The results and discussions will be discussed in Chapter 4. The last chapter provides the conclusion of the study.

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