ANALYSIS OF PV WIND BATTERY HYBRID POWER SYSTEM (PWBHPS) USING SIMPLE ZONE PROBABILITIES (SZP) METHOD FOR HOUSEHOLD IN MALAYSIA

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By

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

AC	Alternating Current
AH	Ampere Hour
AM	Air Mass
DC	Direct Current
DG	Diesel Generator
DOD	Depth Of Discharge
EEQ	Electrical Energy Quantities
HAWT	Horizontal Axis Wind Turbine
HOMER	Homer Energy
HPS	Hybrid Power System
HRES	Hybrid Renewable Energy System
LCC	Life Cycle Cost
MNEP	Malaysia's National Energy Policy
MSC	Meteorological Service of Canada
NC	Normally Close
NO	Normally Open
NOCT	Nominal Operating Cell Temperature
NREL	National Renewable Energy Laboratory
PIC	Programmable Integrated Circuit
PV	Photovoltaic
PWBHPS	PV-Wind-BatteryHybrid Power System
PWM	Pulse Width Modulation
RE	Renewable Energy

SOC	State Of Charge
SPI	Systems Performance Indices
STC	Standard Test Condition
SZP	Simple Zones Probabilities
USM	University Science Malaysia
WDHS	Wind Diesel Hybrid System
WTG	Wind Turbine Generator

LIST OF SYMBOLS

A	Swept area of rotor blade
BC	Battery Capacity
C	Capacitor
C_i	Initial capital cost
D_r	Duty ratio
D_c	Maximum rotor at the center
D	Rotor diameter
$\frac{d}{d}$	Kinetic energy per unit time
e	Escalation rate
E_B	The quantities of battery bank
E_{GA}	Energy generated by PV and Wind generator
E_{Ch}	Charging battery
E_L	Load energy
E_O	Over load power
E_P	Annual energy generated by an independent solar system
E_P	Total of PWBHPS output energy
E_W	Wind energy
$E_{d\ h}$	Discharging battery
E_{d1}	Energy of dump load
F_S	Switching frequency
G	Insolation level
H	Height of the rotor
H_1	Hub height 1

H_2	Hub height 2
I	Interest rate
I_D	Diode current that flowing into p-n junction semiconductor
I_L	Inductor current
I_{L_r}	Root mean square inductor current
I_S	Short circuit current
I_S	Current at Standard Test Condition
I_{cha}	Charging time of the battery
I_m	Maximum power point current
I_n	PV array new current output
I_{ph}	Current source from solar cell
$I_r \quad ,s$	Battery rated source current
i_a	Adjusted interest rate
k	Weibull shape parameter
L	Inductor
LCC	Life cycle cost
M_p	Maximum module power
m_f	Mass flow
n	Life span of the system
P_L	Load power
P_O	Mechanical power generated by the rotor
P_R	Rate power
P_T	Wind turbine power output
$P \quad _N$	Non-recurring cost to present worth
$P \quad _R$	Recurring cost to present worth

P_S	System net worth in the final year of its life –cycle period
P_m	Mechanical power
P_n	PV array new power value
P	Payback Period
P	Number of years between two successive payments
R	Recurring rate
R_S	Constant temperature (=0.222)
R_s	Series resistance of the cell
R_{sh}	Shunt resistance of the cell
S	Salvage value
T_S	Temperature at Standard Test Condition
T_c	Cell temperature
T_m	Total module
T_s	Time period
T_a	Ambient temperature
$T_{a,\,ref}$	Reference ambient temperature
t_o	Time for switch on
V_0	Downstream wind velocity at the exit of the rotor blades
V_C	Cut in speed
V_{C0}	Cut off speed
V_O	Open circuit voltage of module
V_R	Rate wind speed
V_S	Voltage at Standard Test Condition
V_a	Air velocity
V_{in}	Input voltage

V_m	Maximum power point voltage
V_n	New voltage output
V_n	PV array new voltage value
V_o	Output voltage
V_{o_r}	Root mean square capacitor voltage
V	Upstream wind velocity at the entrance of the rotor blades
V_1	Wind speed at H_1
V_2	Wind speed at H_2
ΔV_o	Peak to peak ripple voltage
α_S	Short circuit current temperature coefficient
α_S	Temperature coefficient of I_S
β_O	Open circuit voltage temperature coefficient
β_O	Temperature coefficients of V_O
η_B	Charge efficiency of battery bank
η_i	Efficiency of the inverter
α	Exponent base on surface roughness and atmospheric
ΔT_C	Temperature changes
ΔI	PV array output current
ΔI	Current change of PV array
ΔV	Voltage changes of PV array
σ	Hourly self-discharge rate
ΔI_L	Peak to peak ripple current

ANALISIS SISTEM KUASA HIBRID PV ANGIN BATERI (PWBHPS) MENGGUNAKAN KAEDAH KEBARANGKALIAN ZON MUDAH UNTUK ISI RUMAH DI MALAYSIA

ABSTRAK

Perkembangan *Sistem Kuasa Hibrid* telah menyumbang kepada penggunaan tenaga boleh diperbaharui sebagai sumber tenaga alternatif. Jumlah penggunaan tenaga boleh diperbaharui biasanya bergantung kepada jenis beban dan reka bentuk sistem. Tesis ini mencadangkan sistem kuasa hibrid yang akan menggunakan tenaga daripada solar dan angin sebagai sumber utama. Konfigurasi sistem kuasa hibrid yang telah dimodelkan terdiri daripada tenaga solar, angin dan bateri dan ia disambung secara selari dengan grid. Satu teknik baru yang dikenali sebagai *Kaedah Kebarangkalian Zon Mudah* telah dilaksanakan untuk mengoptimumkan prestasi sistem secara menyeluruh. Profil beban yang digunakan dalam kajian ini mempunyai beban puncak pada waktu sinaran matahari. Data tenaga angin dan solar yang dikumpul dianalisis menggunakan Microsoft Excel untuk mendapatkan jumlah kuasa keluaran bagi kebarangkalian kawasan. Lokasi yang bersesuaian telah dipilih sebagai kajian asas kerana ketersediaan data dan potensi untuk memasang sistem hibrid di Malaysia, di mana ia telah direkodkan untuk keamatan sinaran solar dan purata kelajuan angin didapati berada pada 5.5kWh /m^2/hari dan 3m/s masing-masing. Keputusan praktikal adalah berdasarkan kepada 1.4 kW sistem tenaga solar, 2kW turbin angin dan 10 buah bateri 18Ah. Berdasarkan data kelajuan angin dan sinaran solar maka kuasa purata yang boleh dijana adalah hanya 30% daripada kapasiti keseluruhan sistem. Oleh itu, jumlah maksimum tenaga tahunan yang dihasilkan adalah 4013 kWh dan untuk sepanjang 30 tahun dijangka dapat menjana kira-kira 123090 kWh. Hasil purata keluaran analisis kuasa sistem PWBHPS dengan menggunakan kaedah kebarangkalian zon yang mudah, boleh membekalkan permintaan beban sebanyak 66.65%, manakala tanpa mengunakan kaedah kebarangkalian kawasan yang mudah iaitu 53.6% di semua lokasi terpilih. Keputusan menunjukkan bahawa PWBHPS berpotensi paling tinggi diperolehi di Mersing, Johor (iaitu 100%). Di samping itu, PWBHPS boleh digunakan silih berganti secara automatik bersama sistem grid untuk menyediakan permintaan beban. Analisis ekonomi menunjukkan bahawa kos asas bagi 2 kW PWBHPS ialah RM 20,951, dan tempoh bayaran balik adalah lebih kurang 19 tahun, iaitu kos seunit ialah 27 sen per kWh.

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ABSTRACT

The development of Hybrid Power System (HPS) had contributed to the utilization of Renewable Energy (RE) power as an alternative power source. The total usage of RE is normally depend on the type of load and the system design. This thesis proposed the PV Wind Battery Hybrid Power System (PWBHPS) that will utilize energy from solar and wind as a main source. The hybrid configuration that was modeled consists of PV, Wind and Battery and it was connected in parallel with the grid. A new technique which is known as Simple Zone Probabilities (SZP) had been implemented to optimize the overall system performance. The load profile which is employed in this study has a peak load during sun hours (e.g. at noon). The collected daily data of wind and solar was arranged through Microsoft Excel to determine the total output power for zoning probabilities. The suitable locations in Malaysia were selected as a base study due to data availability and the potential to install the hybrid system. It has been recorded that solar radiation intensity and average wind speed in Malaysia are found to be 5.5 kWh/m2/day and 3m/s, respectively. The practical results are based on 1.4 kW photovoltaic, 2 kW wind turbine and 10 batteries of 18Ah where the average power that can be generated is nearly 30% of the total system capacity. The results show that the total annual energy maximum generated is 4013 kWh and for 30 years life span is expected to be 123090 kWh. Results from the developed PWBHPS show the average output power using SZP can supplying a load of 66.65 %, while without SZP of 53.6% at the selected locations. The results show that the highest potential energy hybrid was obtained at Mersing, Johor (100%). This thesis also

describes that the PWBHPS can be used interchangeably automatically with the grid in serving the load. The economic analysis shows that the initial cost of the 2 kW PWBHPS is RM 20,951 and the payback period is calculated to be nearly 19 years, where the cost is 27 cents per kWh.