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Advanced Optimal for Power-Electronic Systems for the Grid Integration of Energy Sources

Salam Waley Shneen
School of Electrical & Electronic Engineering, Huazhong University of Science and Technology / Wuhan, China
Electromechanical Engineering Department, University of Technology/Baghdad, Iraq
e-mail: salam_waley73@yahoo.com

Abstract

Renewable and clean energies like a photovoltaic (PV) energy and wind energy (WE), they can contribute in decreasing the electric energy cost. Energy storage is necessary in PV and WE hybrid system with the variable nature. A hybrid system (PV, WE and diesel), it uses the aim of minimizing the total cost and ensuring the energy available. In this paper, the modeling and cost analysis of a hybrid system (PV, WE and diesel) considering three types systems: First, diesel with a hybrid system. Second, diesel and battery with a hybrid system. Third, grid, battery and hybrid system. In comparison to all types, for cost analysis, a mathematical model have introduced for each type. There are two parts of this work. First by Homer software, it has been used to find the system feasibility and conduct the economic analysis. Second by Matlab simulation, this paper includes status of grid integration in one day through twenty four. The power generation by wind turbine, the change of wind speed which effect on values of power generation. The power generation by solar cell, the change of temperature and radiation which effect in values of power generation. The battery bank, it uses to energy storage and it is keeping the energy to use it in next times when the energy generation not enough to run the loads. The presence of diesel to compensate for the shortfall in generation to meet the required load capacity. The main advantages of PMSM are high torque density, high efficiency and small size. Photovoltaic power generation system is the PV generation technology is treated as the most promising technology among renewable energies. Photovoltaic (PV) power generation system is a promising source of energy with great interest in clean and renewable energy sources.

Keywords*: Grid Integration, Power Electronic, PV, Wind, Diesel, Battery, PMSM, Fuzzy, PI and PSO*

1. Introduction

Renewable-Energy Sources new strategies like PV and Wind, these applications become more integrated with the grid-based systems [1]. A power-conditioning system used in a grid connected for photo-voltaic (PV) generation plants [2]. A new power-electronic technology for the integration of energy sources to develop a mathematical model of a dc/ac full-bridge switching converter with current control for PV grid-connected system and energy-storage system for the grid system is disconnected for any reason, and the distributed generation still supplies to any section of local loads [3].The available power from the PV system is highly dependent on solar radiation. To overcome this deficiency of the PV system, the PV module was integrated with the wind-turbine system [4]. These are voltages decrease with wind penetration and increase with solar penetration [5]. The renewable energy, Wind energy and PV energy which with power electronics are changing character part in the electricity generation [6].

Increasing orientation for the use of PV in industry and electrical appliances because PV energy is predictable to play big role in future smart grids as distribution renewable source [7]. PV system with PMSM drive is investigated. The PV system application is prospected, in order to highlight the irradiation effect on the PV panel feeding the PMSM [8]. The PV source to an AC voltage source by inverter have the ability for controlling a PMSM [9]. A way control (PI) in addition to the controller integral relative formulated and implemented, using speed control magnet synchronous motor drive system and a permanent pilot phase. While the new strategy promotes traditional PI control performance to a large extent, and proves to be a model-free approach completely, it also keeps the structure and features of a simple PI control [10].The use console mode instead of Fuzzy-PI control to improve the performance of engines PMSM. To control the speed of PMSM motor using fuzzy logic (FL) approach leads to a speed control to

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improve the dynamic behavior of the motor drive system and immune disorders to download and parameter variations [11]. In the drive systems, and gains from the traditional can't usually be set in proportion-integral (PI) controller speed large enough because of mechanical resonance. As a result, Performance degradation and speed control. The proposed FLC has been compared with traditional PI control with respect to the speed of response and dynamic load Torque. Simulation and experimental results have proved that FLC was proposed is superior to the traditional PI. This FLC can be a good solution for the high-performance engine lifts Systems. A modern approach to control the speed of PMSM using particle swarm optimization (PSO) to improve the algorithm parameters observer PI-. Simulate the system under different operating year Conditions are prepared and the experimental setup. Use PSO algorithm and optimization makes a powerful engine, with faster response and higher resolution dynamic and sensitive to load variation [12-15]. Grid is a system that would become the integration of renewable energy sources and while keeping the balance between supply and demand. Applying hybrid energy systems using renewable energy sources. Renewable energies, consisting of photovoltaics and wind as energy sources, batteries to store the excess generated energy and a diesel generator as a back-up system. Hybrid systems based on PV and WE have a long lifetime and normally low maintenance cost, and the application of PV/WG/battery-based hybrid systems. The aim of using a WE/PV/diesel system to get low the total cost and ensuring the energy availability. By using the HOMER software to analysis the system feasibility and conduct the system economical, it used to obtain the optimal design by evaluating all the possible solutions. The system consists of WE and PV as renewable power sources, a diesel for backup power, the batteries to store excess energy and improve the system reliability.

2. The Mathematical Models for System's Components

They have, Mathematical Model PV System, Mathematical Model Wind System, Mathematical Model Diesel System, Mathematical Model Diesel System, Mathematical Model Battery System, Battery price and worth and Mathematical Model PV/WG/diesel/battery system:

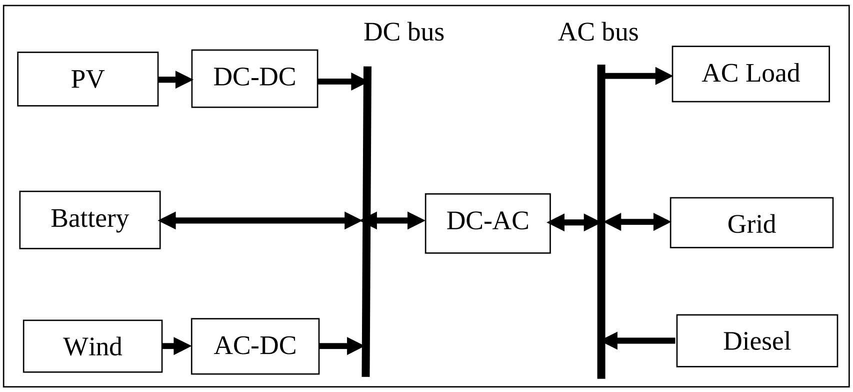


Figure 1. System Topology

2.1. Mathematical Model PV System

PV System, The energy is produced by the solar panels is directly sent to the consumer load. The renewable energy conversion systems (PV). The PV generated power by a particular solar irradiation level and power output, PV output power (W) and solar irradiation (w/m^2). The PV panels are sensitive to temperature which is most influenced by the variations of temperature is the open-circuit voltage. Solar irradiation level, the variation in ambient temperature is taken into consideration.
It can be obtained from the solar radiation by the following formula:

$$p_{pv}(t) = I(t) \times A \times \eta_{pv} \quad (1)$$

$p_{pv}(t)$: The output power of each PV system at time t
A : A denotes the PV area (m^2)
I(t): The solar radiation (kW/m^2)
$\eta_{pv:}$ The overall efficiency of PV panels and DC/DC converter

2.2. Mathematical Model Wind System

Wind System, the energy is produced by the wind turbine is directly sent to the consumer load. The renewable energy conversion systems (wind). The wind turbine generated power by wind speed and power output, Wind turbine output power (kW) and Wind velocity (m/s).

Table 1. Power generation & wind speed

power generation	wind speed
starts	above 3.5 m/s
rated	9.5 m/s
stop	exceeding 25 m/s

It can be obtained from the wind speed by the following formula:

$$P_{Wind}(t) = \begin{cases} 0 & v(t) \leq Vcut_{-in} \text{ or } \; v(t) \geq Vcut_{-out} \\ P_{r-Wind} \dfrac{v(t) - Vcut_{-in}}{v_r - Vcut_{-in}} & Vcut_{-in} < v(t) < v_r \\ P_{r-Wind} & v_r < v(t) < Vcut_{-out} \end{cases} \quad (2)$$

V(t) : wind speed (m/s)
$P_{r\text{-}Wind}$: rated power of the wind generator (kW)
$V_{cut\text{-}in}$: cut-in speed of the wind generator (m/s)
$V_{cut\text{-}out}$: cut-out speed of the wind generator (m/s)
v_r : rated speed of the wind generator (m/s), respectively
and
$p_{Wind}(t) = N_{Wind} \times P_{Wind(t)}$
N_{Wind} :Number of wind generators
$p_{Wind}(t)$:Overall produced power

2.3. Mathematical Model Diesel System

Diesel system, power generator should be excluded to the battery storage calculation. To satisfy load when battery storage is deplete and when wind power and solar power fail at this times operated Diesel generator system.

It can be obtained from the fuel consumption of the diesel generator by the following formula:

$$Cons_D = B_D \times P_N^D \times A_D \times P_D \quad (3)$$

P_D :output power of the diesel
P_N^D : rated power
B_D = 0.0845 (L/kWh): coefficient of the consumption curve
A_D = 0.246 (L/kWh): coefficient of the consumption curve
And

$$C_f = P_{fuel} \times Cons_D \quad (4)$$

C_f : hourly cost of the fuel consumption
P_{fuel}: fuel price

2.4. Mathematical Model Battery System

Battery, The excess energy from wind turbine and solar panels is stored in the batteries via the bi-directional inverters. To cover the energy deficit by the stored energy in batteries. In this type system by storing excess energy to maximize the usage of renewable energy. It is capable of reducing in fuel consumption.

It can be obtained from the state of charge (SOC) (battery bank is in charging state, battery bank is in discharging state) by the following formulas:
Battery bank is in charging state:

$$E_{Batt}(t) = E_{Batt}(t-1) \times (1-\sigma) + [(E_{pv}(t) \times \eta_{Inv} + E_{wind}(t) \times \eta^2{}_{Inv}) - \frac{E_{Load}}{\eta_{Inv}}] \times \frac{\eta_{BC}}{\eta_{Inv}} \quad (5)$$

$E_{Batt}(t)$: charge quantities of battery bank at time (t), (kWh)
$E_{Batt}(t\_1)$: charge quantities of battery bank at time (t-1), (kWh)
σ : hourly self-discharge rate,
η_{Inv} :denotes the inverter efficiency
η_{BC} : charge efficiency of the battery bank
Battery bank is in discharging state:

$$E_{Batt}(t) = E_{Batt}(t-1) \times (1-\sigma) - ([\frac{E_{Batt}(t)}{\eta Inv} - (E_{pv}(t) \times \eta Inv + E_{Wind} \times \eta^2 Inv)]/\eta_{BF} \times \eta Inv) \quad (6)$$

η_{BF}: discharging efficiency of battery bank

2.5. Battery Price and Worth

If the lifetime of each battery (5 years):

$$C_{Batt} = P_{Batt} \times \left(1 + \frac{1}{(1+i)^5} + \frac{1}{(1+i)^{10}} + \frac{1}{(1+i)^{15}}\right) \quad (7)$$

2.6. Mathematical Model PV/WG/Diesel/Battery System

$$C_{cpt} = \frac{i(1+i)^n}{(1+i)^n - 1}\left[N_{wind} \times C_{Wind} + N_{pv} \times C_{pv} + N_{Batt} \times C_{Batt} + N_{\frac{Conv}{Inv}} \times C_{\frac{BatConv}{Inv}} + C_{Diesel}\right] \quad (8)$$

and

$$C_{Mtn} = N_{pv} \times C_{Mtn}^{pv} + N_{Wind} \times C_{Mtn}^{Wind} + C_{Mtn}^{Diesel} \quad (9)$$

2.7. Database with Information System and Algorithm Work

In this work, there are many variables like PV System Variables, Wind System Variables, Diesel Variables, Battery Variables and Load variables. About discuss these variables in all this work system each one variable it has code and this code include symbols to definition these variables suppose the following:

$$\text{PV Power System} = Ppv = Xi \quad (10)$$

$$\text{Wind Power System} = Pwind = Pw = Xj \quad (11)$$

$$\text{Diesel Power System} = Pdiesel = Pd = Xk \quad (12)$$

$$\text{Battery Power System} = Pbattery = Pb = Xm \quad (13)$$

$$\text{Load Power System} = Pload = Pl = Xn \quad (14)$$

Using this symbols, to know behavior a system in one day with help status equations:

$$\mathrm{Pv} = \sum_{0}^{i} \mathrm{Xi} \quad , \qquad \mathrm{i = 0\ at\ T = 0\ to\ 1\ hours(12p.m - 1a.m)and}$$
$$\mathrm{i = 1\ at\ T = 1\ to\ 2\ hours(1a.m - 2a.m)and}$$
$$\mathrm{i = 2\ at\ T = 2\ to\ 3\ hours(2a.m - 3a.m)and}$$
$$\mathrm{i = 3\ at\ T = 3\ to\ 4\ hours(3a.m - 4a.m)and}$$
$$\mathrm{i = 4\ at\ T = 4\ to\ 5\ hours(4a.m - 5a.m)and} \ldots \ldots \ldots \ldots \ldots \ldots$$
$$\mathrm{i = 23at\ T = 23\ to\ 24\ hours(11p.m - 12p.m)}$$

$$\mathrm{Pw} = \sum_{0}^{j} \mathrm{Xj} \quad , \qquad \mathrm{j = 0\ at\ T = 0\ to1\ hours(12p.m - 1a.m)and}$$
$$\mathrm{j = 1\ at\ T = 1\ to\ 2\ hours(1a.m - 2a.m)and}$$
$$\mathrm{j = 2\ at\ T = 2\ to\ 3\ hours(2a.m - 3a.m)and} \ldots \ldots \ldots ..$$
$$\mathrm{j = 23\ at\ T = 23\ to\ 24\ hours(11p.m - 12p.m)and}$$

$$\mathrm{Pd} = \sum_{0}^{k} \mathrm{Xk} \quad , \qquad \mathrm{k = 0\ at\ T = 0\ to1\ hours(12p.m - 1a.m)and}$$
$$\mathrm{k = 1\ at\ T = 1\ to\ 2\ hours(1a.m - 2a.m)and}$$
$$\mathrm{k = 2\ at\ T = 2\ to\ 3\ hours(2a.m - 3a.m)and} \ldots \ldots \ldots \ldots ..$$
$$\mathrm{k = 23\ at\ T = 23\ to24\ hours(11p.m - 12p.m)}$$

$$\mathrm{Pb} = \sum_{0}^{m} \mathrm{Xk} \quad , \qquad \mathrm{m = 0\ at\ T = 0\ to1\ hours(12p.m - 1a.m)and}$$
$$\mathrm{m = 1\ at\ T = 1\ to\ 2\ hours(1a.m - 2a.m)and}$$
$$\mathrm{m = 2\ at\ T = 2\ to\ 3\ hours(2a.m - 3a.m)and} \ldots \ldots \ldots \ldots \ldots$$
$$\mathrm{m = 23\ at\ T = 23\ to24\ hours(11p.m - 12p.m)}$$

$$\mathrm{Pl} = \sum_{0}^{n} \mathrm{Xk} \quad , \qquad \mathrm{n = 0\ at\ T = 0\ to1\ hours(12p.m - 1a.m)and}$$
$$\mathrm{n = 1\ at\ T = 1\ to\ 2hours(1a.m - 2a.m)and}$$
$$\mathrm{n = 2\ at\ T = 2\ to\ 3\ hours(2a.m - 3a.m)and} \ldots \ldots \ldots \ldots \ldots \ldots$$
$$\mathrm{n = 10\ at\ T = 21\ to24\ hours(11p.m - 12p.m)}$$

3. Grid Integration

Grid Integration, Renewable-Energy Sources new strategies like PV and Wind are designed to operate with and interconnected with the electric utility grid. Below are the block diagrams of Grid Integration system.

3.1. Photovoltaic System

Photovoltaic module consists of solar cells which convert light directly to electricity. PV system can be classified into two types. They are PV connected with Grid and PV connected *without* Grid.

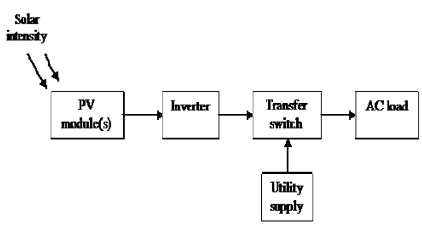


Figure 2. PV connected with Grid

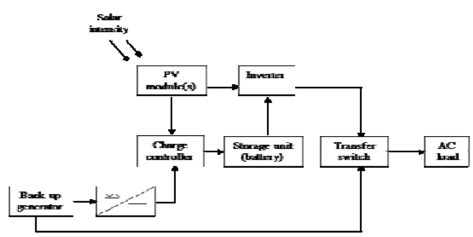


Figure 3. PV connected *without* Grid

3-2 Wind Turbine Generation System (WTGS)

Wind Turbine Generation System (WTGS) is used to convert kinetic energy into electrical energy. As wind case varies, the electrical energy produced from the generator needs to be converted for convenience. An inverter, rectifier, transformer and filter are needed within the Wind Turbine Generation System (WTGS), in order for utility-grade AC power to be transmitted over long distances (Figure 4). A transformer is usually installed at the undermost of the tower to provide voltage diversion from the low voltage by the wind turbine, to medium/high voltage for transit.

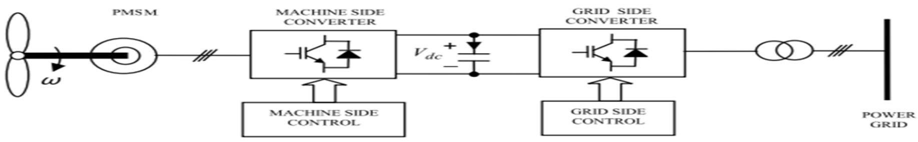


Figure 4. PMSM Wind Energy Conversion System

Most modern Wind Turbine Generation System (WTGS) have intelligent feature to observe and control the system to diverse wind conditions. Like, atmospheric sensors detect wind speed and direction. Other sensors observe the status and strength of the turbine parts to bypass run-to-failure. Wind turbines need to resist extreme weather conditions, such as storms and lightning. In these types of conditions, it is important to ensure that the turbine monitoring system is designed to provide high voltage.

4. Simulation Analysis and Results

Simulation Result, there are two part in this work, 1st by Homer and 2nd by Matlab simulation:

4.1. Simulation Result by using Homer Software

Models a renewable system**,** Models a renewable system that satisfies electricity demand by combining PV, WE and diesel and batteries with grid or without grid. By using homer software, it use to obtain the optimal design by evaluating all the possible solutions:

4.1.1. Simulation Results of Diesel with Hybrid System

First, diesel with hybrid system**,** in this part, Model a renewable system that satisfies electricity demand by combining PV, WE and diesel. By using homer software, it use to obtain the optimal design by evaluating all the possible solutions:

Homer software of PV, WE and diesel as in Figure 5, Result of PV and WE and diesel as in Figure 6.

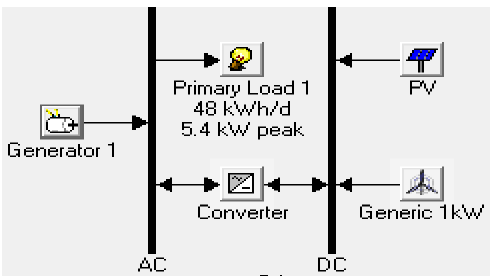


Figure 5. Homer software of PV, WE and diesel

PV (kW)	G1	Label (kW)	Conv. (kW)	Efficiency Measures	Initial Capital	Operating Cost ($/yr)	Total NPC	COE ($/kWh)	Ren. Frac.	Diesel (L)	Label (hrs)
		55		No	$ 25,000	79,566	$ 1,042,115	4.653	0.00	74,664	8,759
	1	55	1.0	No	$ 30,900	79,926	$ 1,052,619	4.700	0.00	74,664	8,759
1		55	1.0	No	$ 30,900	80,256	$ 1,056,843	4.719	0.00	74,664	8,759
1	1	55	1.0	No	$ 35,900	80,562	$ 1,065,758	4.759	0.00	74,664	8,759

Figure 6. Result of PV, WE and diesel

4.1.2. Simulation Results of Diesel and Battery with Hybrid System

Second, diesel and battery with hybrid system**,** in this part, Model a renewable system that satisfies electricity demand by combining PV, WE and batteries with diesel. By using homer software, it use to obtain the optimal design by evaluating all the possible solutions. Homer software of PV, WE and batteries with diesel as in Figure 7 and Result of PV, WE and batteries with diesel as in Figure 8.

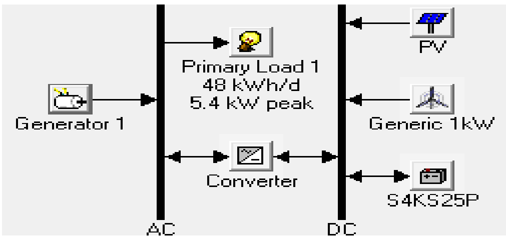


Figure 7. Homer software of PV, WE and batteries with diesel

PV (kW)	G1	Label (kW)	S4KS25P	Conv. (kW)	Efficiency Measures	Initial Capital	Operating Cost ($/yr)	Total NPC	COE ($/kWh)	Ren. Frac.	Diesel (L)
		55	1	1.5	No	$ 27,350	68,570	$ 903,898	4.036	0.00	64,316
	1	55	1	1.5	No	$ 32,350	68,876	$ 912,814	4.076	0.00	64,316
1		55	1	1.5	No	$ 32,350	69,206	$ 917,037	4.095	0.00	64,316
1	1	55	1	1.5	No	$ 37,350	69,512	$ 925,952	4.134	0.00	64,316
		55			No	$ 25,000	79,566	$ 1,042,115	4.653	0.00	74,664
	1	55		1.0	No	$ 30,900	79,926	$ 1,052,619	4.700	0.00	74,664
1		55		1.0	No	$ 30,900	80,256	$ 1,056,843	4.719	0.00	74,664
1	1	55		1.0	No	$ 35,900	80,562	$ 1,065,758	4.759	0.00	74,664

Figure 8. Result of PV, WE and batteries with diesel

4.1.3. Simulation Results of Grid, Battery and Hybrid System

Third, Grid, battery and hybrid system**,** in this part, Model a renewable system that satisfies electricity demand by combining PV, WE and batteries with grid. By using homer software, it use to obtain the optimal design by evaluating all the possible solutions.

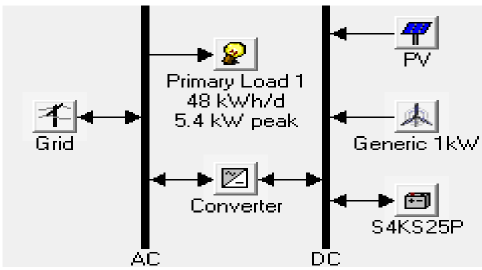


Figure 9. Homer software of PV, WE and batteries with grid

PV (kW)	G1	S4KS25P	Conv. (kW)	Efficiency Measures	Grid (kW)	Initial Capital	Operating Cost ($/yr)	Total NPC	COE ($/kWh)	Ren. Frac.
				No	1000	$ 0	1,752	$ 22,396	0.100	0.00
		1	1.0	No	1000	$ 1,900	1,844	$ 25,476	0.114	0.00
	1		1.0	No	1000	$ 5,900	2,112	$ 32,901	0.147	0.00
	1	1	1.0	No	1000	$ 6,900	2,151	$ 34,391	0.154	0.00
1			1.0	No	1000	$ 5,900	2,443	$ 37,124	0.166	0.00
1		1	1.0	No	1000	$ 6,900	2,481	$ 38,615	0.172	0.00
1	1		1.0	No	1000	$ 10,900	2,749	$ 46,040	0.206	0.00
1	1	1	1.0	No	1000	$ 11,900	2,787	$ 47,530	0.212	0.00

Figure 10. Result of PV, WE and batteries with grid

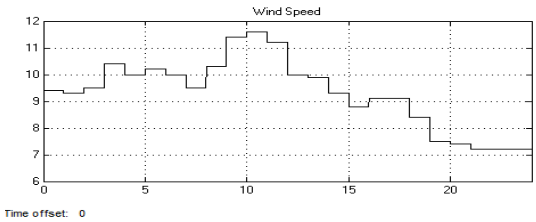
4.2. Simulation Result by using Matlab software

By using Matlab, it use to obtain the optimal design by evaluating all the possible solutions:

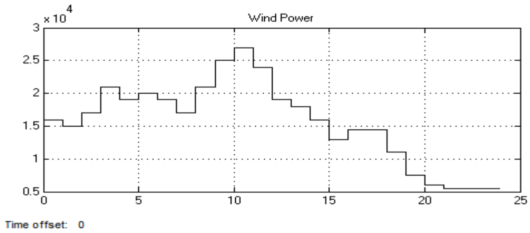
4.2.1. Simulation Results of Wind Energy

It has, Simulation of Wind Power response and wind speed profile used for system simulation.

By using the following values to know behavior a system in one day:
Time = [0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23], Wind speed = [9.4 9.3 9.5 10.4 10 10.2 10 9.5 10.3 11.4 11.6 11.2 10 9.9 9.3 8.8 9.1 9.1 8.4 7.5 7.4 7.2 7.2 7.2]



a. Wind speed profile used for system simulation



b. Simulation of Wind Power response

Figure 11. Simulation Results of Wind Energy

By analysis simulation results, There are some cases to do it as a following analysis WTGS By Using PMSM (Speed, Torque, Current) and (Tm(pu),Wind Speed, Vdc, Grid Voltage and Grad Current). First step, to run the PMSM with different speeds to get a different frequency to select the frequency on the side generation with the rated speed. The simulation result in the table (2), it was clearly to get 50Hz side of generation by using rotation speed 1000 rad/sec which using the simulation system of this work. Simulation Model of PMSM is illustrated in figures (12, 13) which using this step. Second step, to use different values of wind speed with selected the simulation model (wind speed). Third step, using these component systems rectifier, DC bus, Inverter, filter, load & grid with WTG & PMSM. Final step, uses different control systems, like classical PI controller. Expert System Fuzzy Logic Controller and optimization PSO Controller of PMSM to analyze all result.

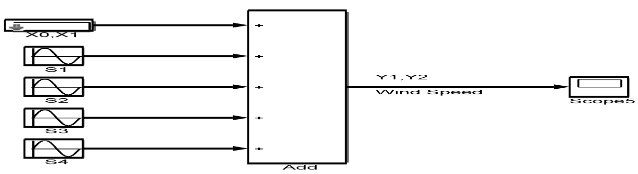


Figure 12. Simulation model of wind speed

Table 2. PMSM with different speeds to get different frequency

Rated Speed(rad/sec)	Time(sec)	Frequency(Hz)
50	0.42	2.38
100	0.2	5
200	0.1	10
1000	0.02	50
1500	0.01666	60

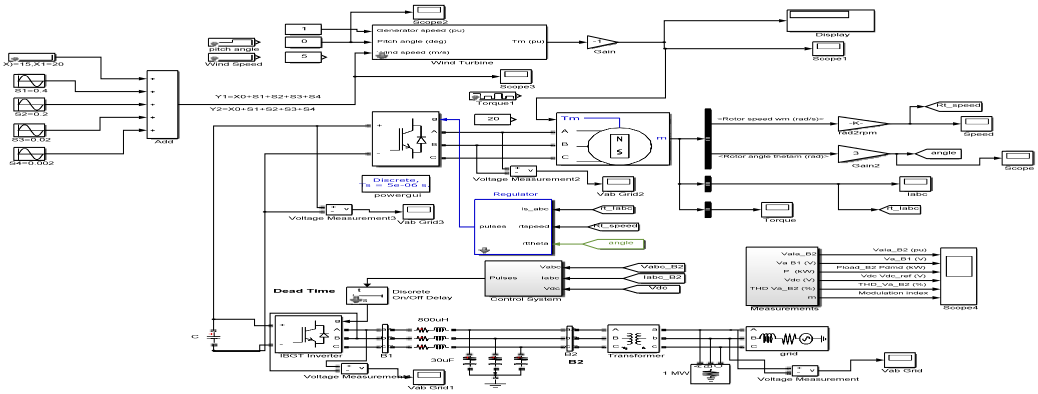


Figure 13. WTG & PMSM. Simulation model with wind speed

At Speed=200,10Hz generation side and 50Hz at Grid side:

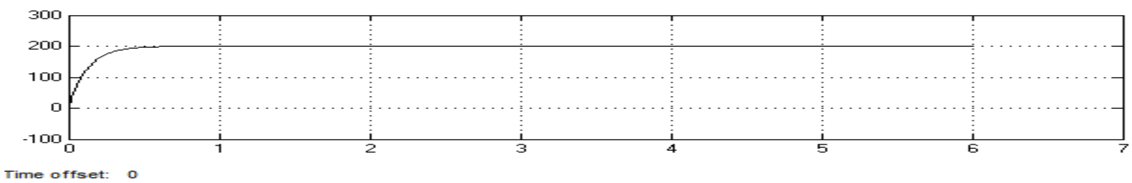


Figure 14. Simulation response of speed

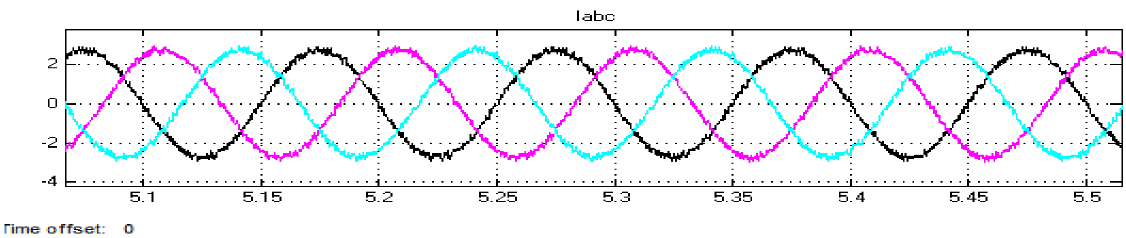


Figure 15. Simulation response of current Iabc

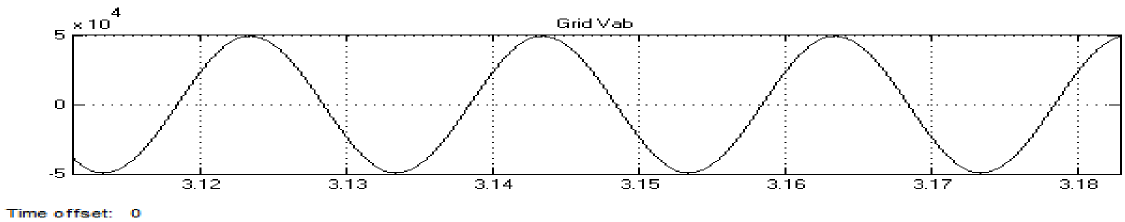
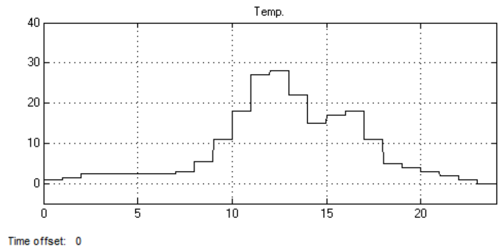


Figure 16. Simulation response of Grid vab

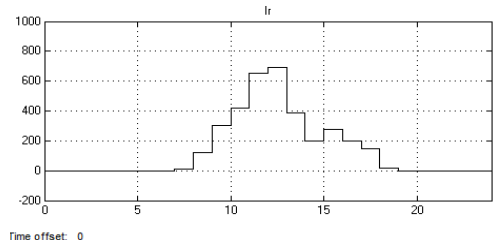
4.2.2. Simulation Results of PV Energy

It has, Simulation of Solar Power response, Solar panel temp profiles used for system simulation and solar radiation profiles used for system simulation. By using the following values to know behavior a system in one day:

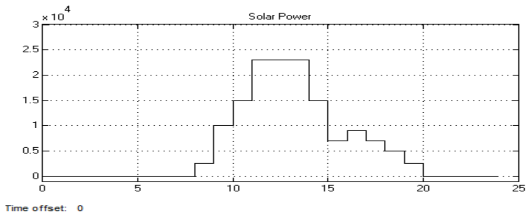
Time = [0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23], Ir = [0 0 0 0 0 0 0 10 120 300 420 690 695 390 200 280 200 150 20 1 0 0 0 0], Temp = [1 1.5 2.5 2.5 2.5 2.5 2.5 3 5.5 11 18 27 28 22 15 17 18 11 5 4 3 2 1 0]



a. Solar panel temp profiles used for system simulation



b. Solar radiation profiles used for system simulation



c. Simulation of Solar Power response

Figure 17. Simulation Results of PV Energy

4.2.3. Simulation Results of Hybrid System

Simulation Model of hybrid system as show in figure 18. Table 3 simulation Results of hybrid system and Simulation Results of hybrid system.

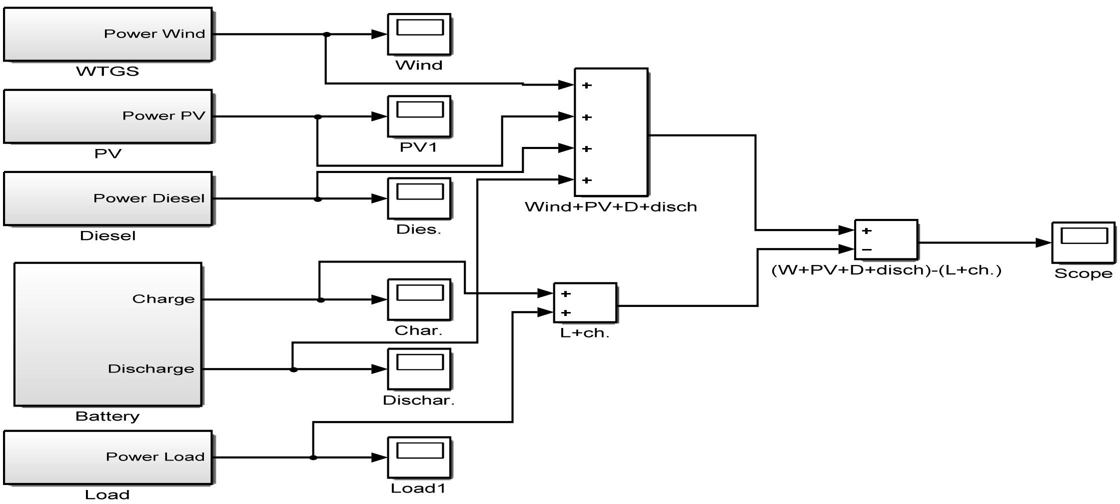
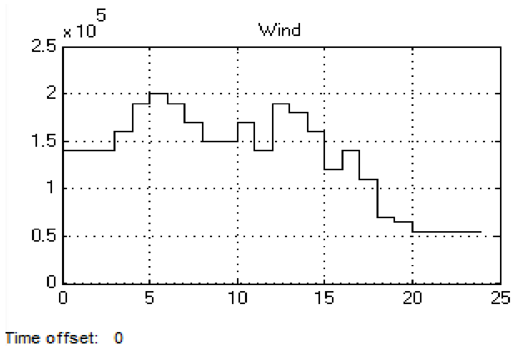
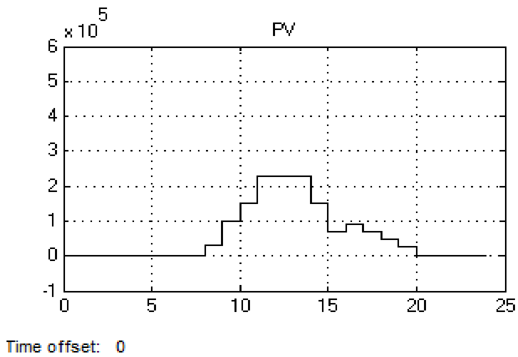


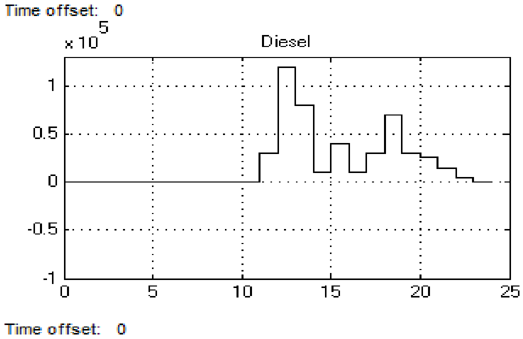
Figure 18. Simulation model of hybrid system

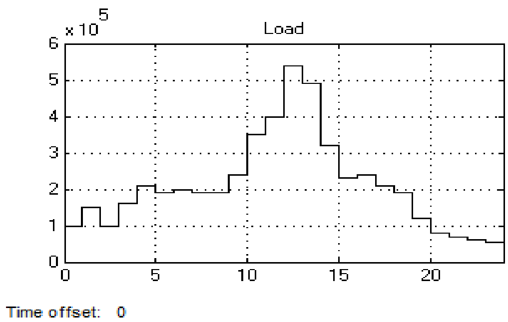
Table 3. Simulation Results of hybrid system

Time(h)	PV (kw)	Wind (kw)	Wind & PV (kw)	Load (kw)	Diesel (kw)	Ch. battery (kw)	Disch.bat. (kw)
12-1	0	14	14	10	0	4	0
1-2	0	14	14	15	0	0	1
2-3	0	14	14	10	0	4	0
3-4	0	16	16	16	0	0	0
4-5	0	19	19	21	0	0	2
5-6	0	20	20	19	0	1	0
6-7	0	19	19	20	0	0	1
7-8	0	17	17	19	0	0	2
8-9	3	15	18	19	0	0	1
9-10	10	15	25	24	0	1	0
10-11	15	17	32	35	0	0	3
11-12	23	14	37	40	3	0	0
12-1	23	19	42	54	12	0	0
1-2	23	18	41	49	8	0	0
2-3	15	16	31	32	1	0	0
3-4	7	12	19	23	4	0	0
4-5	9	14	23	24	1	0	0
5-6	7	11	18	21	3	0	0
6-7	5	7	12	19	7	0	0
7-8	2.5	6.5	9	12	3	0	0
8-9	0	5.5	5.5	8	2.5	0	0
9-10	0	5.5	5.5	7	1.5	0	0
10-11	0	5.5	5.5	6	0.5	0	0
11-12	0	5.5	5.5	5.5	0	0	0









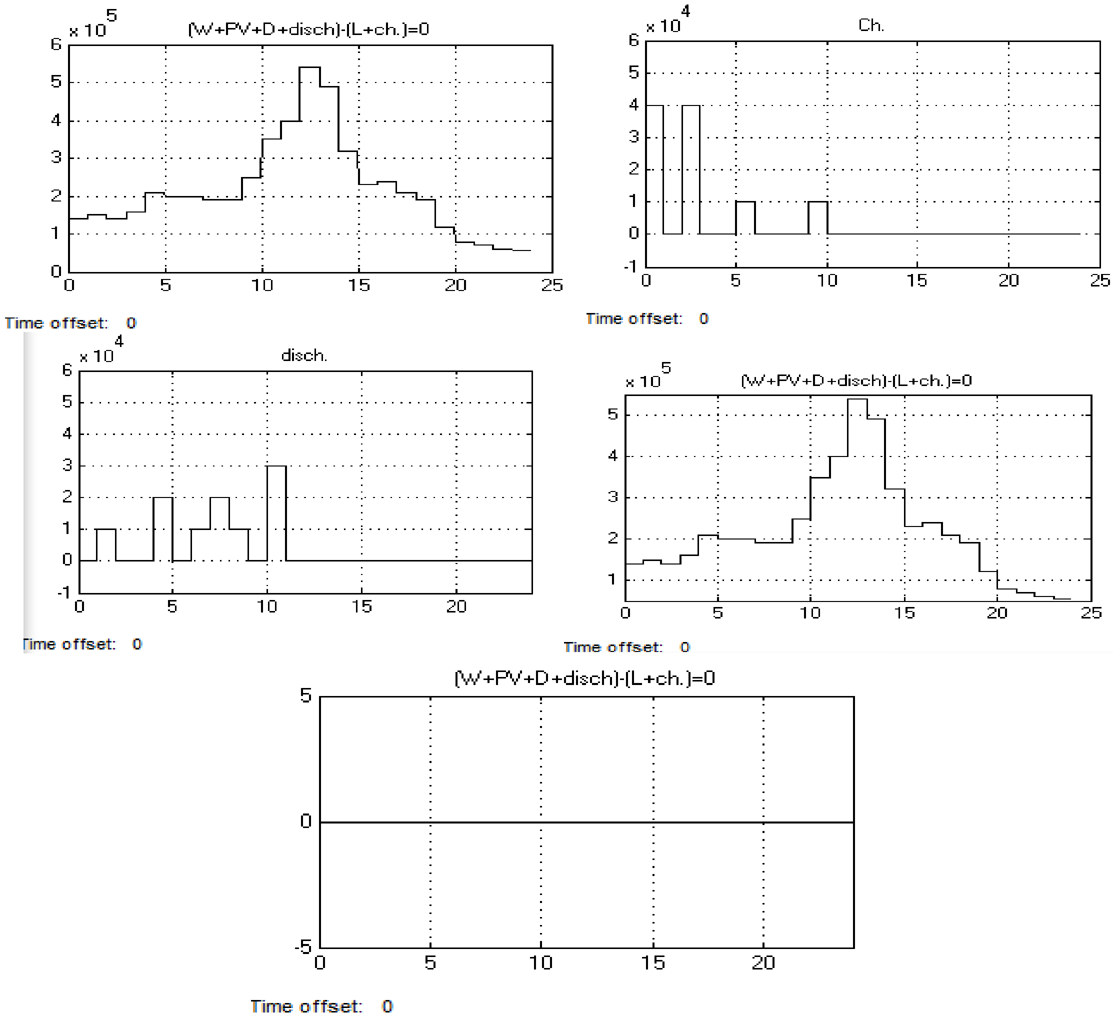


Figure 19. Simulation Results of hybrid system

5. Conclusions

National network that transmits power from generating stations in addition to the ability of renewable energy sources and energy stored in the batteries and the ability of the diesel generator working together to meet the required load capacity. Photovoltaic/Wind/Diesel System with Battery Storage Devices, to produce power independently of the utility grid. Energy storage with the fluctuating nature is necessary in PV/Wind hybrid systems which is considered as a secondary power source when the demand is high. They found that battery and wind generator are the most important components of the PV/WG hybrid system to meet demand loads at night hours. To efficiently use the energy sources integrated in the hybrid system, an appropriate sizing methodology is essential. For a PV/WG/diesel/Battery hybrid system, optimum sizing means the determination of number of PV panels, wind generators, Batteries tanks and diesel generator to satisfy the load demand. PV/WG/diesel/battery systems. The system consists of wind generators and photovoltaic panels as renewable power sources, a diesel generator for backup power, the batteries tanks to store excess energy and improve the system reliability. Optimal sizing of hybrid systems is a very difficult task which needs the development of mathematical models for the components and using optimization techniques.

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