INCORPORATED RENEWABLE ENERGY SYSTEM FOR RURAL ELECTRIFICATION

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Abstract

The incorporated system constitutes of photovoltaic, wind and diesel systems to fulfill the shortage of grid power supply for a rural area educational institution. The monthly average solar radiation and wind velocity data from NASA Surface Meteorology and Solar Energy data center had been made baseline for the system.10% increment of diesel price was considered for calculating the unit cost of energy for every year. The survey in the site distinguished that it required 2.78Kw solar panel of 15 panels with 185 Wp capacity, 5.4 Kw of wind energy generator and a diesel generator. The different size of batteries and converters were selected in the HOMER simulation software to obtain the sensitivity analysis and optimum solution. The cost of energy of diesel only and PV/Wind/Diesel/Batteries power system with 21% of solar and wind penetration was found to be 0.190INR/kWh and 0.219INR/kWh respectively for the diesel price of .2INR per liter.

1 Introduction

Renewable energy is becoming a vital resource for electrifying the rural areas especially for rural education institutions where uninterrupted power supply is required. Combined more than one renewable energy will be a better solution to balance the load in the situation of intermittent availability of source i.e. wind and solar - these kind combined systems are called as hybrid system [1]. The optimized hybrid renewable energy system should be developed to fulfill the requirement of the shortage of power [2].

Extreme range of analysis and detailed inspection were conducted to determine the right renewable energy system to fulfill the shortage of power supply. Various papers were analyzed to design and plan the hybrid renewable energy system [1], [2], [4], [5], [6]. Providing the optimized solution to fulfill the shortage of grid power supply using hybrid renewable system is the objective of this paper. HOMER is used to solve the optimization problems in order to handle and control the energy flow to ensure the reliable supply of the requirement.

1.1 Overview of Hybrid System

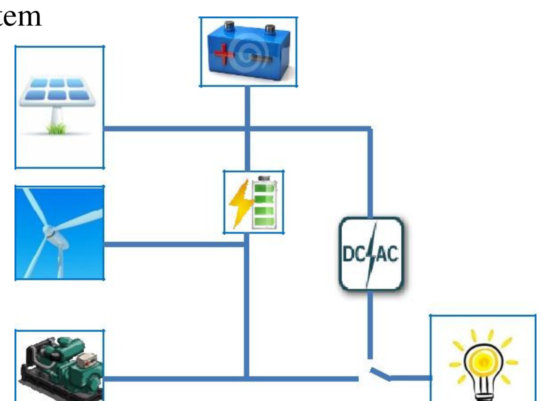


Figure: 1 –Hybrid renewable energy system

Hybrid system is a combination of two or more than two energy conversion systems like Wind +PV+ Diesel[3],[7], [1].This system will address the limits in terms of fuel, reliability, flexibility, emissions and economics too[8]. Designing the hybrid system in such a way to maximize potential usage of renewable sources and resulting to reduce the usage of conventional sources [9]. It will help to balance the requirement of load demand while grid supply is in deficit or not at all available [7], [9].

1.1 Analysis of Hybrid System

Mei Shan Ngan and Chee Wei Tan analyzed the hybrid system with seven different approaches and arrived that a system with wind turbine, diesel, battery and solar combination (80kW PV, 8 units wind turbines and 50 units batteries) can provide continues power and also it will be a reasonable cost saving and emission reducing system [8]. The wind speed and solar radiation were reported for the researched area from 4.21 to 6.97 m/s and 3.61 kWh/sq.mto 7.96 kWh/ sq.m. The combination of hybrid system consists of two 10 kW wind energy conversion systems, 120 sq.m of photovoltaic, battery storage system and diesel backup. The presented system used to meet the demand of 41531 kWh[10].Authors combined the advantages of deterministic and probabilistic approaches. They reported the cost of energy from a PV-battery system is defined to be $ 0.38/kWh and same applies to wind battery system is $ 0.24/kWh [11].Authors finalized that the mean solar radiation was G=5.93kWh/m^2/day and wind speed was 7.13 m/s in the year of 2007. The load demand of the system was mentioned as 100 kWh /day. Cost of Energy was reduced to $0.044/kWh when using the hybrid system instead of Grid and 40% of emission was boiled down [12]. Rowdat Ben Habbasvillage in Saudi Arabia, benefited from wind-PV-diesel hybrid power system by reducing powered by a diesel power plant consisting of eight diesel generating sets of 1,120 kW each. They found a wind-PV-diesel hybrid power system with 35% renewable energy penetration (26%wind and 9% solar PV) to be the feasible system with cost of energy of 0.212 US$/kWh [13]. The given grid-connected hybrid system which is composed of PV modules covers an area of about 400m* 400mand 100 wind turbines of 10 kWeach has the ability to power small village while the grid supply not available or balancing source while insufficient supply from the grid [14].

1.2 About Homer Software

Hybrid Optimization Model for Electric Renewable (HOMER) [15] tool is developed by NREL is used to optimize the net present cost and cost of energy for the given hybrid model. The net present cost is the sum of installing and operating cost over its lifetime .The following equation is used to calculate the Net Present Cost (NPC).

NPC=TAF/CRF (1)
Where
TAC-Total Annualized Cost ($)
CRF-Capital Recovery Factor
CRF=i(1+i)**N/(i + i)**N
Where
N –number of years i-
annual real interest rate
Craig Goodbody et.al was conducted feasibility analysis to investigate the available renewable energy options using HOMER software. The net present cost, the cost of energy, and the CO2 emissions of each potential energy combination were considered in determining the most suitable renewable and non-renewable hybrid energy system [16].ShafiqurRehman*, Luai M. Al-Hadhrami stated that the cost of energy (COE) of diesel only and PV/diesel/battery power system with 21% solar penetration was found to be 0.190$/kWh and 0.219$/kWh respectively for a diesel price of 0.2$/l. The sensitivity analysis showed that at a diesel price of 0.6$/l the COE from hybrid system become almost the same as that of the diesel only system and above it, the hybrid system become more economical than the diesel only system [17].The hybrid power system optimization tool HOMER [18] developed by NREL has been used in the present study and the details of the same are given in next paragraph.

2 Research Method

The proposed hybrid renewable system consists of wind turbine and solar photovoltaic along with battery , diesel generator and inverter are added to fulfill the backup and storage systemshown in figure - 1.

3 Current Energy scenario of Tamilnadu State, India

Renewable energy scenario for India and Tamilnadu as on 31 March 2012 shown in figure – 2

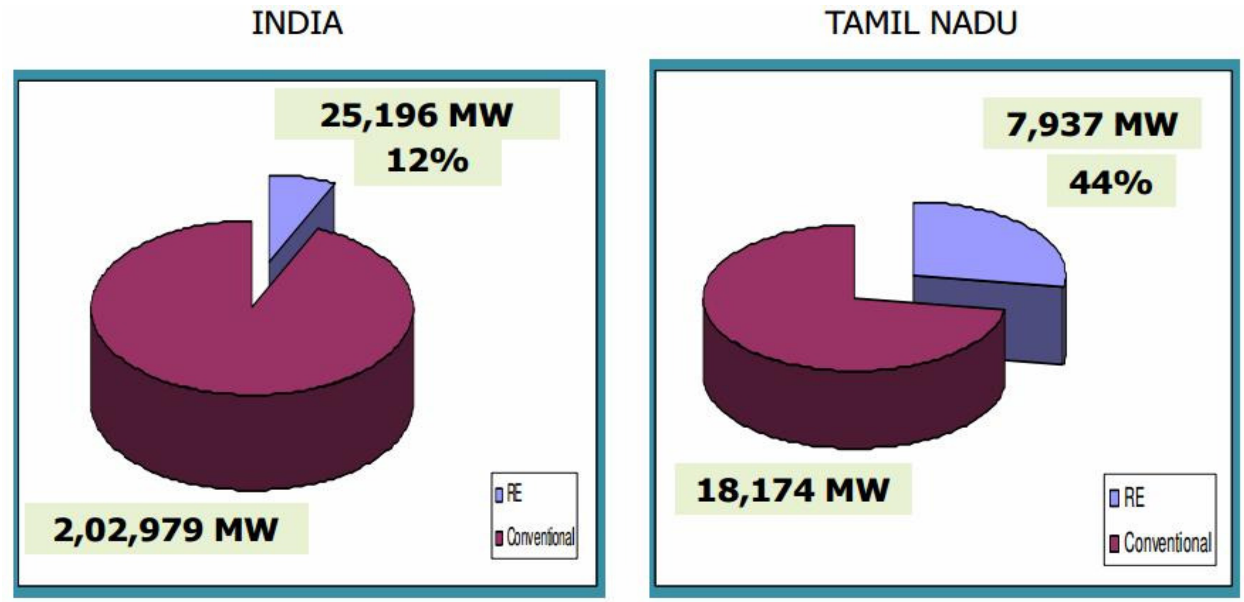


Figure: 2 – Renewable energy scenario for India and Tamilnadu as on 31 March 2012[19]

Tamilnadu state contributes close to 31% of country's renewable energy installed capacity. The state government supports to install distributed renewable energy largely to balance the demand of power supply [19]. High wind capacity addition of 1083.460 Mw is achieved in 2011-12 and capacity addition from 1997 to 2012 is shown in figure – 3[19].

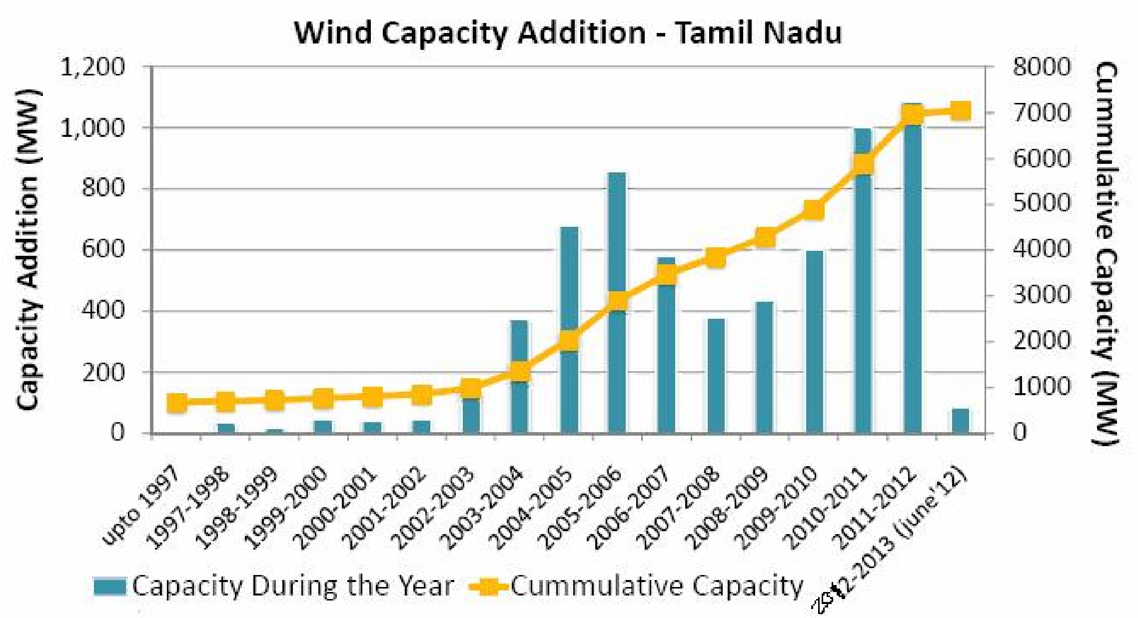


Figure: 3 – Wind capacity addition of Tamilnadu state up to 2013[19]

4 Proposed Site and Availability of renewable

4.1 Proposed Site

A school in Karattupalayam village, Pollachi, Tamilnadu, India is considered for the study area. The latitude of the proposed site is 10.59266N and Longitude is 77.04542E. The school in this village is having 10 classrooms and the load measurement is taken in the school premises and also the load is considered constant throughout the year. Table - 1 gives the load data of the school.

Time	Tube Light(40W)	CFL (5W)	CFL (18W)	Fan (100W)	CRT (500W)	Total Power (W)
01		5no*5=25				25
02		5no*5=25				25
03		5no*5=25				25
04		5no*5=25				25
05			5no*18=90			90
06			5no*18=90			90
07			5no*18=90			90
08			5no*18=90			90
09				5no*100=500		500
10				5no*100=500	8no*500=4000	4500
11				5no*100=500	8no*500=4000	4500
12				5no*100=500	8no*500=4000	4500
13				5no*100=500		500
14				5no*100=500		500
15				5no*100=500	8no*500=4000	4500
16	5no*40=200			3no*100=500	8no*500=4000	4500
17	5no*40=200			3no*100=500		500

18				2no*100=200		200
19				3no*100=300		300
20			3no*18=54			54
21			2no*18=36			36
22			3no*18=54			54
23			2no*18=36			36
24		5no*5=25				25

Table: 1 - Load information of the proposed site

Figure - 4 shows the average daily load profile data for 2012 year and the load is assumed constant throughout the year,from the figure it had been observed that the average energy usage per day is 25.7kWh and peak load is 8.56 kW

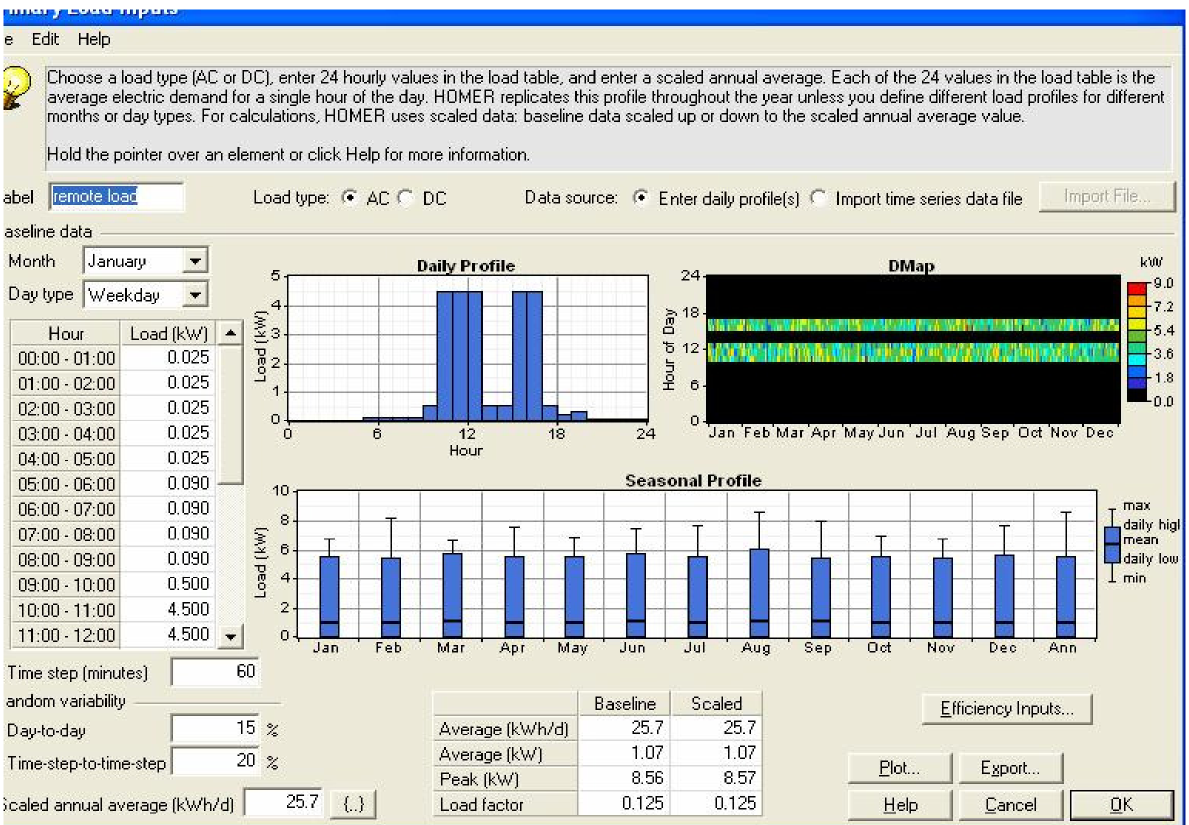


Figure: 4 – Daily load profile information of proposed site

4.2 Availability of renewable energy sources

The available wind speed and solar radiation is taken from NASA meteorological data. About 25 years of data is available in NASA website in that recent one year data in terms of monthly average is taken for the site [20].

4.3 Wind Source

The average monthly mean wind speed between 2.1m/s and 3.1 m/s is shown in figure - 5.The wind velocity is given for 10-meter height. The distribution of wind speed's probabilities at Chittagong is obtained applying the mathematical expression of the Weibull's function [[15], and it is defined by the following formula:

$$f(v) = \frac{k}{c}\left(\frac{v}{c}\right)^{k-1} \exp\left[-\left(\frac{v}{c}\right)^{k}\right] \quad (1)$$

where k is the shape parameter, describing the dispersion of the data, and c is the scale parameter, with units of speed(m/s).The two parameters c and k are related to the average wind speed by the following relation

$$\bar{v} = c\Gamma\left(\frac{1}{k} + 1\right) \quad (2)$$

where G is the gamma function .To fit a Weibull distribution to measured wind data, HOMER uses the maximum likelihood method [[15]. The predicted and actual wind speed probability functions are shown in Figure-5.

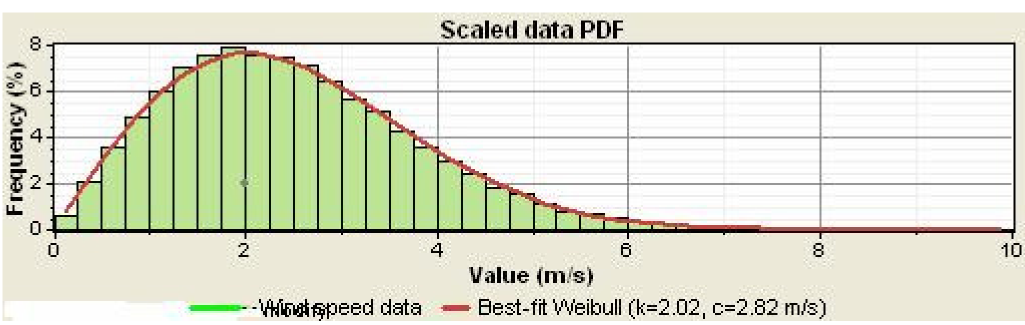


Figure: 5 – Probability density function

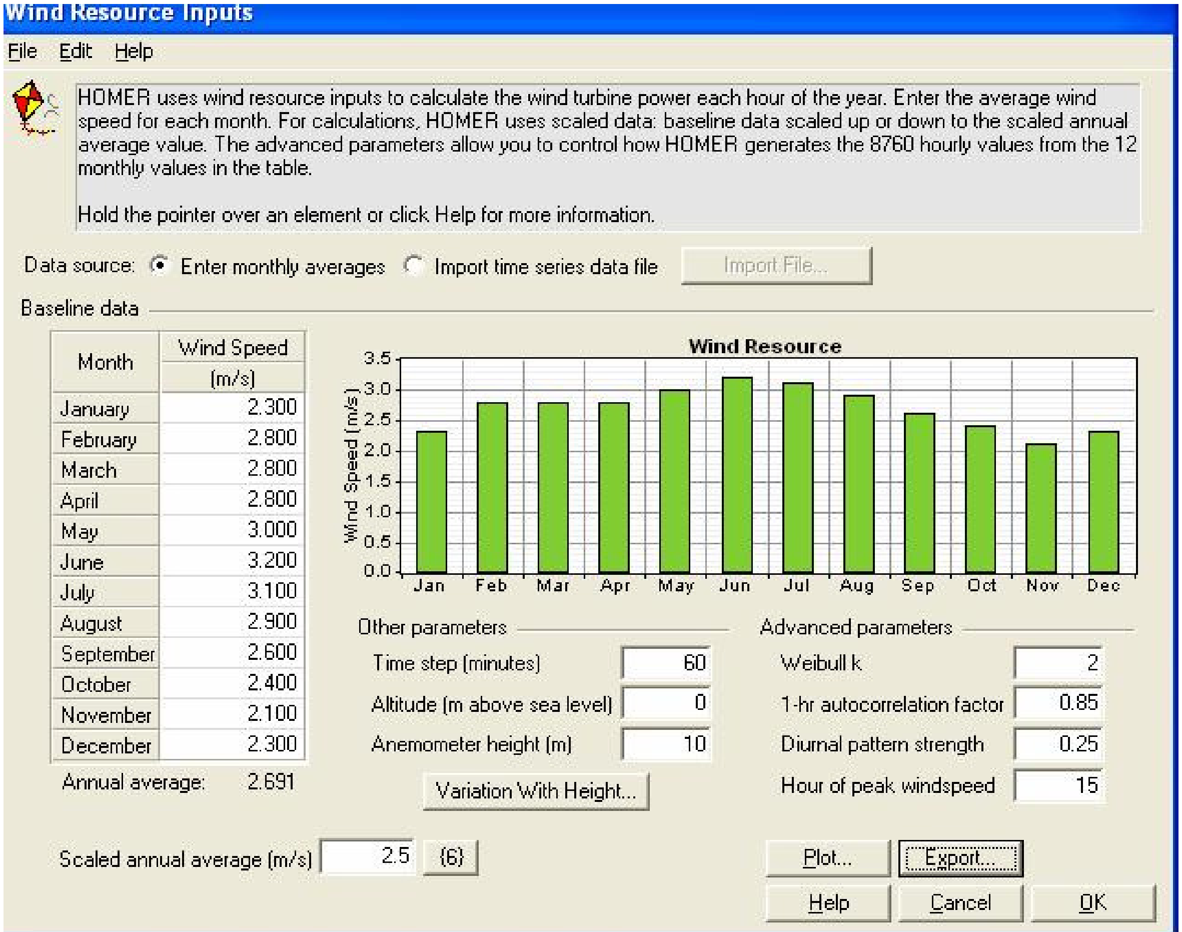


Figure: 6 – Wind resource input to Homer

The average monthly wind resource input given to Homer is shown in figure-6.

The diurnal variation of global wind speed during different months of the year is shown figure-7.

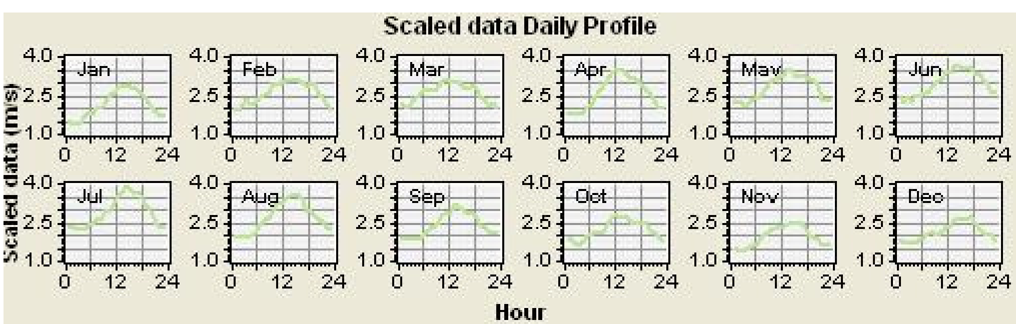
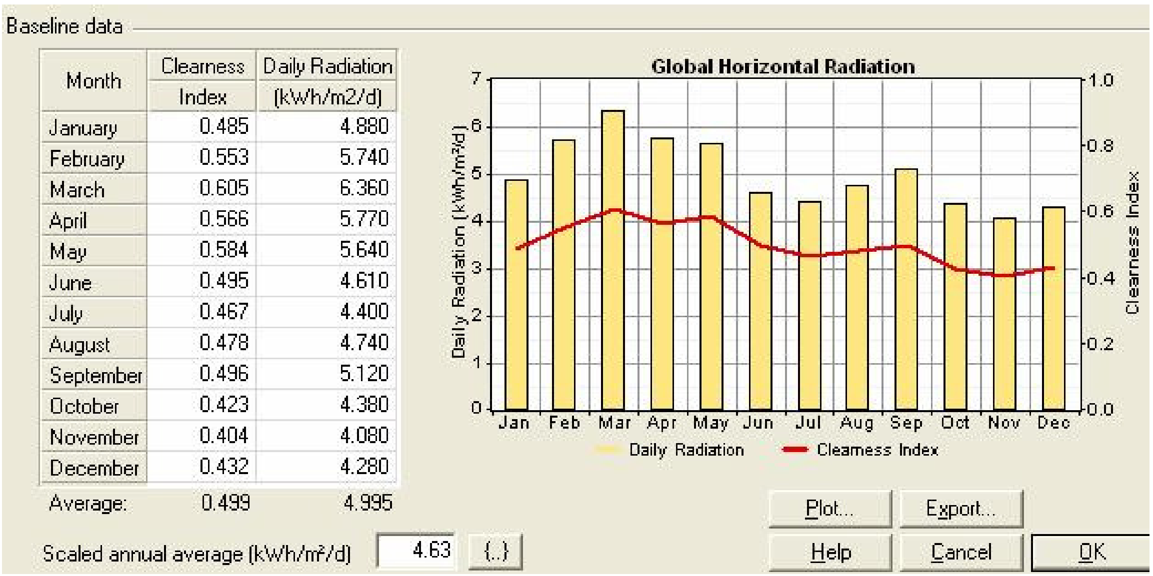


Figure: 7 – Scaled Data Daily Profile for Wind Speed

4.4 Solar Source

Daily global radiation for the site located at latitude of 10.59266N and Longitude of 77.04542E is taken from NASA meteorological data. The simulation tool HOMER introduces the clearness index in the solar radiation data is shown in figure-8.



Baseline data

Month	Clearness Index	Daily Radiation (kWh/m2/d)
January	0.485	4.880
February	0.553	5.740
March	0.605	6.360
April	0.566	5.770
May	0.584	5.640
June	0.495	4.610
July	0.467	4.400
August	0.478	4.740
September	0.496	5.120
October	0.423	4.380
November	0.404	4.080
December	0.432	4.280
Average:	0.499	4.995

Figure: 8 – Global Horizontal Solar Radiation

The figure-9 explains the scaled data daily profile for solar radiation that the radiation was highest during the month of March, February, April and May, lowest in during November, July,December and January.

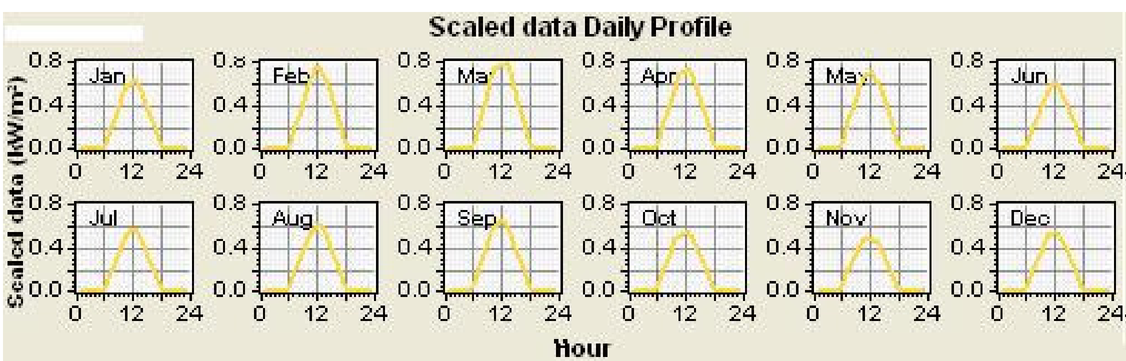


Figure: 9 – Scaled Data Daily Profile for Solar Radiation

5 Constraints Given to the system

Minimum renewable energy fractions considered	=	5.0, 10.0, 15.0, 20.0, 25.0, 30.0%
Diesel prices considered (US$/Liter)	=	1.0,1.2,1.4,1.6,1.8,2.0
Operating reserve as percentage of load	=	10%
Operating reserve as percentage of peak load	=	20%
Operating reserve as percentage of solar power output	=	33.6%
Operating reserve as percentage of wind power output	=	66.4%

5.1 PV module

Sizes to consider (kW)	=	0,1,2,3
Lifetime (Yrs)	=	20
Derating factor	=	80%

5.2 Diesel generator

Generator (kW)	=	0,10
Lifetime	=	15,000hrs
Min. load ratio	=	30%
Diesel Price	=	$ 1.0, 1.2, 1.4, 1.6, 1.8, 2.0/L
Lower heating value	=	43.2 MJ/kg
Density	=	820 kg/m3
Carbon content	=	88.0%

5.3 Battery: Trojan L16P

Quantity	Capital ($)	Replacement ($)	O&M ($/yr)
1	300	300	20.00

Table: 2 –Battery details

Quantities to consider = 0,3,6,8

Voltage = 6V

Nominal capacity = 360Ah

Lifetime throughput = 1075kWh

5.4 Converter

Size (kW)	Capital ($)	Replacement ($)	O&M ($/yr)
4.000	3,600	3,600	40

Table: 3 – Converter details

Sizes to consider = 0,4,6,8kW

Lifetime = 15yrs

Inverter efficiency = 90%

Rectifier relative capacity = 100%

Rectifier efficiency = 85%

5.5 Economics

Annual real interest rate = 6%

Project lifetime = 25yrs

6 Simulation results and discussion

Based on the above input Homer suggested an optimal PV-diesel-battery hybrid power system for the school with 2kW PV panels with (25% solar penetration), 10kW diesel generator with diesel price of 1$/litre, 6 numbers of Trojan L16P batteries and a converter of size 4kW .The suggested optimal system was found to have an initial capital

Cost of 25,991$, operating cost per year of 4,889$, total net present cost (NPC) of 88,493$ and cost of energy (COE) of 0.738$ as shown in Table 4.The hybrid system including wind turbine with wind velocity of 2.5m/s, diesel price of 2$/litre, renewable fraction of 25% gives the increment of cost of energy from 0.738$ to 1.267$ is shown in Table2.267$. The cash flow summary of the proposed system is shown in figure-10.

Table 4

Optimal system

Calculate Simulations: 0 of 384 Progress:
Sensitivities: 0 of 252 Status:

Sensitivity Results | Optimization Results

Sensitivity variables

Wind Speed (m/s) 2.5 Diesel Price ($/L) 1 Min. Ren. Fraction (%) 0.25

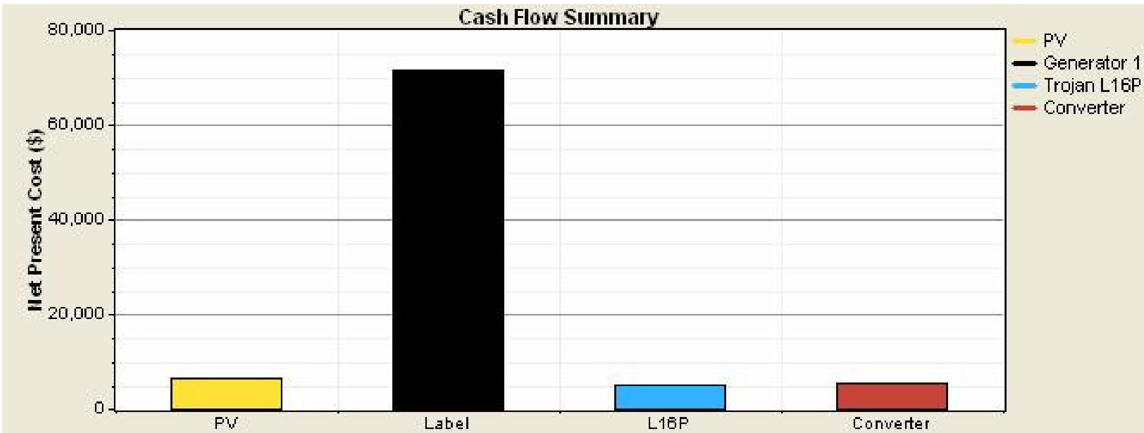
Double click on a system below for simulation results. Categorized Overall Export...

PV (kW)	Ap5.4	Label (kW)	L16P	Conv. (kW)	Initial Capital	Operating Cost ($/yr)	Total NPC	COE ($/kWh)	Ren. Frac.	Capacity Shortage
2		10	6	4	$ 25,991	4,889	$ 88,493	0.738	0.20	0.00
3		10	6	6	$ 30,586	4,541	$ 88,629	0.739	0.29	0.00
1		10	6	4	$ 23,195	5,159	$ 89,146	0.743	0.10	0.00
1		10	8	4	$ 23,795	5,142	$ 89,530	0.747	0.10	0.00
2		10	8	4	$ 26,591	4,944	$ 89,789	0.749	0.20	0.00
3		10	6	4	$ 28,786	4,775	$ 89,823	0.749	0.25	0.00
2		10	6	6	$ 27,791	4,871	$ 90,063	0.751	0.21	0.00
3		10	6	8	$ 32,386	4,594	$ 91,109	0.760	0.30	0.00
3		10	8	4	$ 29,386	4,848	$ 91,360	0.762	0.25	0.00
3		10	8	6	$ 31,186	4,777	$ 92,254	0.769	0.27	0.00
2		10	6	8	$ 29,591	4,939	$ 92,730	0.773	0.21	0.00
3		10	3	4	$ 27,886	5,076	$ 92,780	0.774	0.21	0.00
1		10	6	6	$ 24,995	5,308	$ 92,850	0.774	0.08	0.00
2		10	3	4	$ 25,091	5,373	$ 93,776	0.782	0.14	0.00
3		10	3	6	$ 29,686	5,144	$ 95,447	0.796	0.21	0.00
1		10	6	8	$ 26,795	5,376	$ 95,517	0.797	0.08	0.00
2		10	8	6	$ 28,391	5,318	$ 96,373	0.804	0.15	0.00
2		10	3	6	$ 26,891	5,441	$ 96,443	0.804	0.14	0.00
3		10	3	8	$ 31,486	5,212	$ 98,114	0.818	0.21	0.00
2		10	3	8	$ 28,691	5,509	$ 99,110	0.827	0.14	0.00
3		10	8	8	$ 32,986	5,281	$ 100,495	0.838	0.22	0.00

Energy production analysis

The proposed PV-diesel-battery-converter hybrid system gives the energy of 10240kWh/yr. In that PV module gives26% of total energy and diesel generator gives the 74% of total energy contribution as shown in table 4.The mentioned system in Table 4 is compared with table 2.In table 2 PV-wind- diesel-battery-converter hybrid system gives the energy of 11575kWh/yr. In that PV module gives35% of total energy, wind turbine gives10% and diesel generator gives the

55% of total energy contribution. In the above comparison to reduce the usage of power generated by diesel generator in terms of cost and pollutant gas emissions and to save the environment the selected hybrid system in Table2 comprises of PV-wind- diesel-battery-converter is the best system.



Component	Capital ($)	Replacement ($)	O&M ($)	Fuel ($)	Salvage ($)	Total ($)
PV	5,591	1,743	230	0	-977	6,587
Generator 1	15,000	15,980	1,153	42,538	-3,009	71,662
Trojan L16P	1,800	1,683	1,534	0	-106	4,911
Converter	3,600	1,502	511	0	-280	5,334
System	25,991	20,908	3,428	42,538	-4,371	88,493

Figure: 10 – Cash Flow Summary

Production	kWh/yr	%
PV array	2,703	26
Generator 1	7,537	74
Total	10,240	100

Table 4

Green House Gas emissions

The selected hybrid system in Table-4 gives the Carbon dioxide, carbon monoxide, unburned hydrocarbons, particulate matter, sulfur dioxide, nitrogen oxides emissions are listed in Table 5.The green house gas emissions for the selected hybrid system in Table-6 is listed in Table-7.In the comparison the green house gas emission is less in selected hybrid system in Table-6 and more in the selected hybrid system in Table-4.This is due to the introduction of wind energy system in Table-6 and also it helps to reduce the power generated by diesel generator.

Pollutant	Emissions (kg/yr)
Carbon dioxide	8,763
Carbon monoxide	21.6
Unburned hydrocarbons	2.4
Particulate matter	1.63
Sulfur dioxide	17.6
Nitrogen oxides	193

Table: 5 - Annual GHG emissions for PV-diesel-battery-converter hybrid power system

Table 6

Calculate Simulations: 0 of 384 Sensitivities: 0 of 252 Progress: Status:

Sensitivity Results Optimization Results

Sensitivity variables

Wind Speed (m/s) 2.5 Diesel Price ($/L) 2 Min. Ren. Fraction (%) 0.25

Double click on a system below for simulation results. Categorized Overall Export...

PV (kW)	Ap5.4	Label (kW)	L16P	Conv. (kW)	Initial Capital	Operating Cost ($/yr)	Total NPC	COE ($/kWh)	Ren. Frac.	Capacity Shortage
3		10	6	6	$ 30,586	7,482	$ 126,236	1.053	0.29	0.00
3		10	6	8	$ 32,386	7,523	$ 128,554	1.072	0.30	0.00
3		10	8	6	$ 31,186	7,797	$ 130,855	1.091	0.27	0.00
2		10	6	4	$ 25,991	8,217	$ 131,035	1.093	0.20	0.00
2		10	6	6	$ 27,791	8,104	$ 131,382	1.096	0.21	0.00
2		10	8	4	$ 26,591	8,276	$ 132,389	1.104	0.20	0.00
2		10	6	8	$ 29,591	8,171	$ 134,049	1.118	0.21	0.00
1		10	6	4	$ 23,195	8,736	$ 134,868	1.125	0.10	0.00
1		10	8	4	$ 23,795	8,709	$ 135,124	1.127	0.10	0.00
1		10	6	6	$ 24,995	8,922	$ 139,053	1.160	0.08	0.00
2		10	8	6	$ 28,391	8,758	$ 140,352	1.170	0.15	0.00
2		10	3	4	$ 25,091	9,050	$ 140,779	1.174	0.14	0.00
3		10	8	8	$ 32,986	8,490	$ 141,514	1.180	0.22	0.00
1		10	6	8	$ 26,795	8,990	$ 141,720	1.182	0.08	0.00
2		10	3	6	$ 26,891	9,118	$ 143,446	1.196	0.14	0.00
2		10	3	8	$ 28,691	9,186	$ 146,113	1.218	0.14	0.00
2		10	8	8	$ 30,191	9,339	$ 149,578	1.247	0.11	0.00
3		10	8	4	$ 29,386	9,497	$ 150,785	1.257	0.20	0.00
3	1	10	8	6	$ 39,296	8,809	$ 151,905	1.267	0.33	0.00
2	1	10	6	6	$ 35,901	9,106	$ 152,307	1.270	0.27	0.00

Pollutant	Emissions (kg/yr)
Carbon dioxide	7,401
Carbon monoxide	18.3
Unburned hydrocarbons	2.02
Particulate matter	1.38
Sulfur dioxide	14.9
Nitrogen oxides	163

Table:7 - Annual GHG emissions for PV-wind- diesel-battery-converter hybrid power system

Sensitivity Analysis

Sensitivity analysis is carried out for different wind speeds of 2.0 m/s, 2.5m/s, 3.0m/s, 4m/s, 5m/s, 6m/s and various diesel prices of 1.0$, 1.2$, 1.4$, 1.6$, 2.0$. The resulted sensitivity analysis for diesel price of 2$is shown in figure-11 and also the sensitivity analysis for the wind speed of 6m/s is shown in figure-12 and the optimal system for both the wind speed of 6m/s and the diesel price of 2$per litre is shown in Table 3.In that a 3kW PV, one alpha power 5.4 kW wind turbine, 10kW diesel generator, 8 no's of Trojan L16P batteries and 8kW converter is the most cost effective system compared to various combinations of the above. The initial capital is $41,096,operatin cost ($/yr) is 5,236 and total net present cost is $108,030.This system gives cost of energy of 0.901$/kWh with 72% renewable fraction. If we compare the table 2 and 7 we are understanding that for the 2$/litre of diesel price, 2.5m/s of wind speed the COE is1.267$ and for the same diesel price for 6m/s wind speed the COE is 0.901 and at the same time renewable fraction is from 0.33$ to 0.72$. The green house gas emissions are drastically reduced from 8999.23 kg/yr shown in Table 5 to 3528.66 kg/yr shown in Table10. The cash flow summary of the selected hybrid system shown in Table 7 having sensitivity variables of 6m/s wind speed and 2US$/litre of diesel price are listed in Table8 and energy production of individual system is represented in Table9.

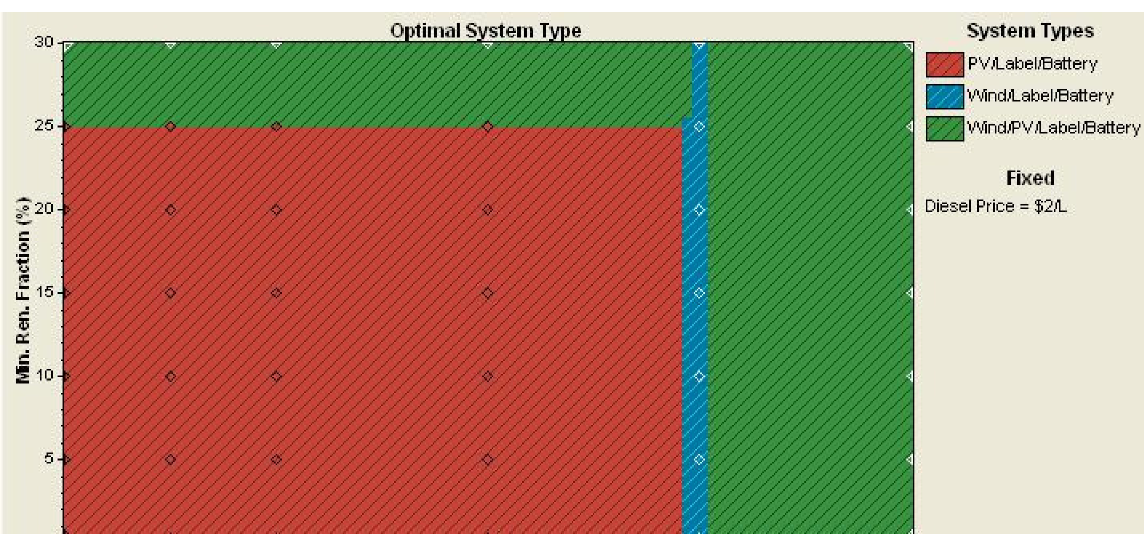


Figure: 11 – Sensitivity Analysis $2 per liter diesel price

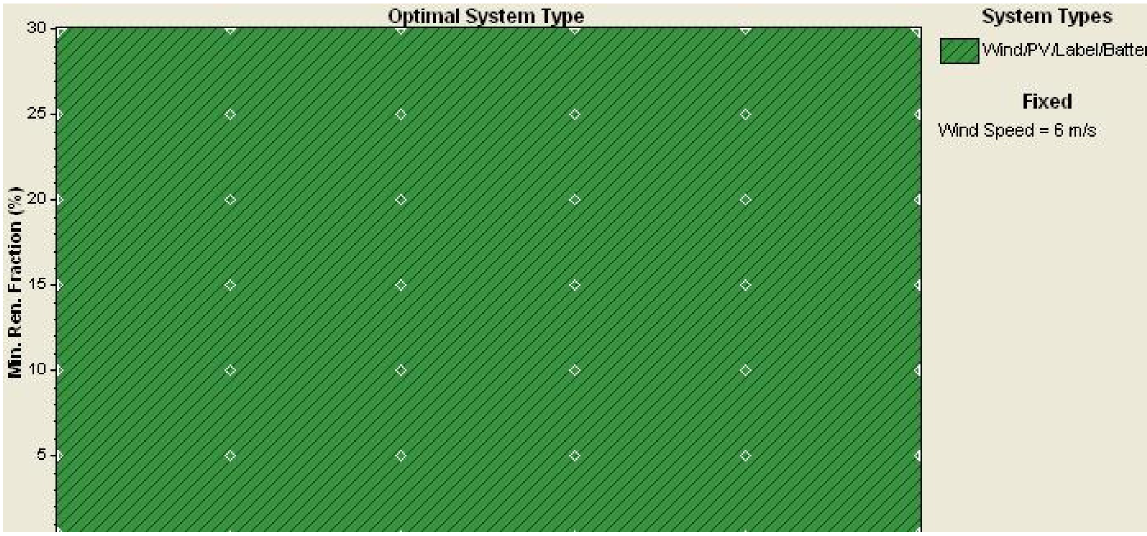


Figure: 12 – Sensitivity Analysis 6 m/s wind speed

Table: 8

Calculate | Simulations: 0 of 384 | Sensitivities: 0 of 252 | Progress: | Status:

Sensitivity Results | Optimization Results

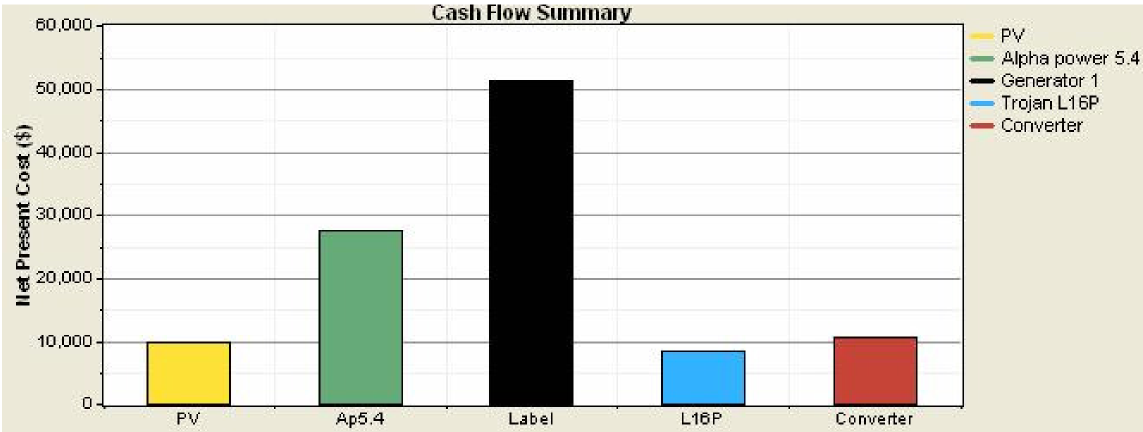
Sensitivity variables

Wind Speed (m/s) 6 | Diesel Price ($/L) 2 | Min. Ren. Fraction (%) 0.25

Double click on a system below for simulation results. | Categorized | Overall | Export...

PV (kW)	Ap5.4	Label (kW)	L16P	Conv. (kW)	Initial Capital	Operating Cost ($/yr)	Total NPC	COE ($/kWh)	Ren. Frac.	Capacity Shortage
3	1	10	8	8	$ 41,096	5,236	$ 108,030	0.901	0.72	0.00
2	1	10	8	8	$ 38,301	5,839	$ 112,938	0.942	0.67	0.00
1	1	10	8	8	$ 35,505	6,296	$ 115,986	0.967	0.62	0.00
3	1	10	6	8	$ 40,496	5,914	$ 116,095	0.968	0.65	0.00
2	1	10	6	8	$ 37,701	6,477	$ 120,494	1.005	0.60	0.00
	1	10	8	8	$ 32,710	7,164	$ 124,294	1.037	0.54	0.00
3	2	10	8	8	$ 49,206	6,010	$ 126,031	1.051	0.78	0.00
3		10	6	6	$ 30,586	7,482	$ 126,236	1.053	0.29	0.00
1	1	10	6	8	$ 34,905	7,203	$ 126,983	1.059	0.54	0.00
2	2	10	8	8	$ 46,411	6,402	$ 128,251	1.070	0.74	0.00
3		10	6	8	$ 32,386	7,523	$ 128,554	1.072	0.30	0.00
1	2	10	8	8	$ 43,615	6,722	$ 129,550	1.080	0.71	0.00
3		10	8	6	$ 31,186	7,797	$ 130,855	1.091	0.27	0.00
2		10	6	4	$ 25,991	8,217	$ 131,035	1.093	0.20	0.00
2		10	6	6	$ 27,791	8,104	$ 131,382	1.096	0.21	0.00
3	2	10	6	8	$ 48,606	6,541	$ 132,223	1.103	0.73	0.00
2		10	8	4	$ 26,591	8,276	$ 132,389	1.104	0.20	0.00
	2	10	8	8	$ 40,820	7,180	$ 132,608	1.106	0.67	0.00
	1	10	6	8	$ 32,110	7,873	$ 132,752	1.107	0.47	0.00
2	1	10	8	6	$ 36,501	7,626	$ 133,988	1.117	0.51	0.00
2		10	6	8	$ 29,591	8,171	$ 134,049	1.118	0.21	0.00

Table 8



Component	Capital ($)	Replacement ($)	O&M ($)	Fuel ($)	Salvage ($)	Total ($)
PV	8,386	2,615	345	0	-1,465	9,880
Alpha power 5.4	8,110	2,821	17,270	0	-525	27,676
Generator 1	15,000	4,442	520	33,359	-1,949	51,373
Trojan L16P	2,400	4,396	2,045	0	-408	8,433
Converter	7,200	3,004	1,023	0	-559	10,668
System	41,096	17,278	21,203	33,359	-4,906	108,030

Table 9

Production	kWh/yr	%
PV array	4,054	13
Wind turbine	25,233	79
Generator 1	2,614	8
Total	31,902	100

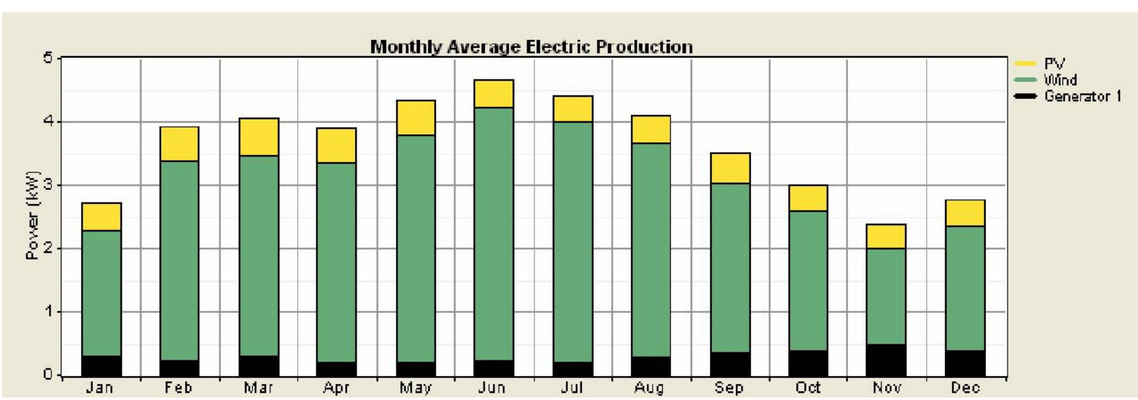


Table 10

Pollutant	Emissions (kg/yr)
Carbon dioxide	3,436
Carbon monoxide	8.48
Unburned hydrocarbons	0.939
Particulate matter	0.639
Sulfur dioxide	6.9
Nitrogen oxides	75.7

Conclusion

Incorporated renewable energy system including wind turbine is compared with system excluding wind turbine. In that system including wind turbine is having various advantages of Energy production, reduced green house gas emission and higher renewable energy fraction and the disadvantages is cost of the system is high and excess energy production is high. To utilize the excess energy we should connect the system with grid or to increase the number of batteries to the wind energy inclusion hybrid system.

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