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Comparative Study of Solar, Wind and Diesel Power System Using Homer Pro

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ABSTRACT: The demand for electricity power is increasing day by day. Renewable energy sources such as wind, solar are universal and ecological. These renewable energy sources are best options to fulfil the world energy demand, but unpredictable due to natural conditions. The use of the hybrid solar, Diesel generator and wind energy system like will be the best option for the utilization these available resources.There is a need optimally and economically design and develop all the possible non-conventional energy resources to reduce the void between supply and demand of electrical power.A hybrid system is designed for Jodhpur in which the designing of grid deals with Diesel genset, wind, solar and converters installation which decreases amount payable to grid. Analysing different cases and according to these cases we can evaluate their power generation, pollutant gases emissions, net present cost and average electrical production cost are estimated using HOMER Pro software.

KEYWORDS: Renewable Energy, HybridPower System, HOMER Pro, Optimization & Sensitivity Analysis

I.INTRODUCTION

Power from conventional means of energy resources has become extremely hazardous for environment in terms of greenhouse gases emissions. These resources are limited and power generation using these resources is expensive. Non-conventional sources of energy (Wind and Solar) can play a very important role in fulfilling the energy demand of the world. Solar power generation using PV is very simple in construction, compact and can be installed domestically for power generation. Many authors have proven that grid connectivity with hybrid system has been more efficient and reliable than standalone system . HOMER Pro is used for the optimization of the proposed hybrid power system.

HOMER is used to analyse the physical behaviour of the power system and its life cycle cost, which includes its installation or capital cost and running cost over the entire life period of that power plant. Lifetime of power plant is also specified in HOMER options for power plant life.

HOMER performs three basic tasks based on raw data provided by the user. These three tasks are simulation, optimization and sensitivity Analysis. HOMER can simulate a variety of power combinations such as PV arrays, wind turbines, utility load, generators and battery backup etc. HOMER Pro features our new optimization algorithm that significantly simplifies the design process for identifying least-cost options for micro grids or other distributed generation electrical power systems.

II.RESOURCES DATA

Data is downloaded from NASA Prediction of worldwide energy resources.

1. Solar GHI (Global Horizontal irradiance)
2. Wind
3. Temperature

1.Solar Resource shows amount of solar radiations that strikes with the earth surface in a typical year. In Homer pro, this is the input parameter for solar GHI resource.

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Table 1Below Table shows the Monthly Average Solar Global Horizontal Irradiance (GHI) Data

Month	Clearness Index	Daily Radiation (kWh/m²/day)
Jan	0.605	3.950
Feb	0.597	4.580
Mar	0.607	5.540
Apr	0.617	6.400
May	0.616	6.820
Jun	0.588	6.630
Jul	0.503	5.600
Aug	0.501	5.300
Sep	0.558	5.310
Oct	0.579	4.680
Nov	0.603	4.080
Dec	0.585	3.600

Annual Average (kWh/m²/day): 5.21

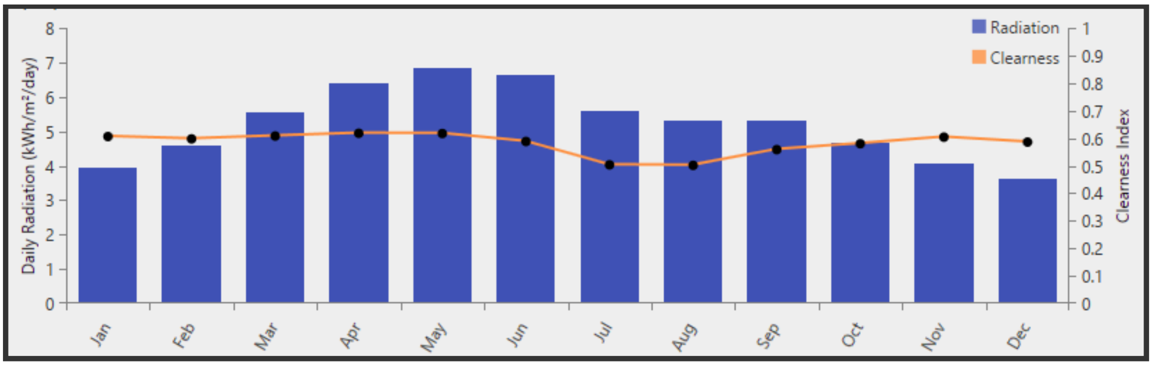

Fig.1: Solar Radiation intensity of whole year

2.Wind data: Wind resource shows the average monthly wind speed of Subject area that is shown below.

Table 2 Below table shows Monthly Average wind speed data of a location

Month	Average (m/s)
Jan	5.080
Feb	4.970
Mar	4.830
Apr	5.230
May	6.800
Jun	6.810
Jul	6.210
Aug	5.440
Sep	4.790
Oct	3.900
Nov	4.300
Dec	4.770

Annual Average (m/s): 5.26

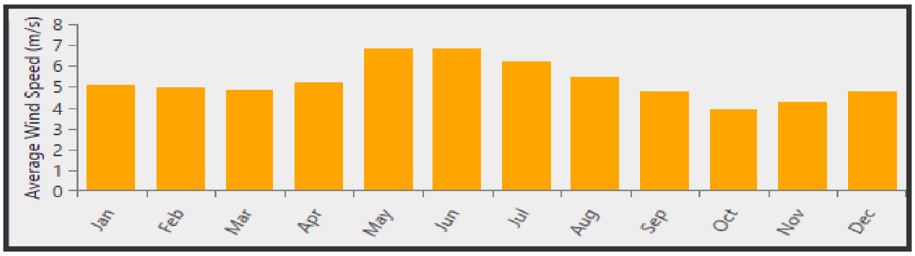

Fig.2: Wind speed data of months from January to December

3.Data related to Temperature : Temperature resource shows the Average monthly Temperature of Subject area that is shown below.

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Table 3 Below table shows the monthly average data of temperature of a selected location.

Monthly Average Temperature Data

Month	Daily Temperature (ºC)
Jan	15.960
Feb	19.100
Mar	25.160
Apr	30.620
May	34.400
Jun	35.010
Jul	32.260
Aug	30.260
Sep	29.810
Oct	27.300
Nov	22.230
Dec	17.700

Annual Average (o_C) = 26.65

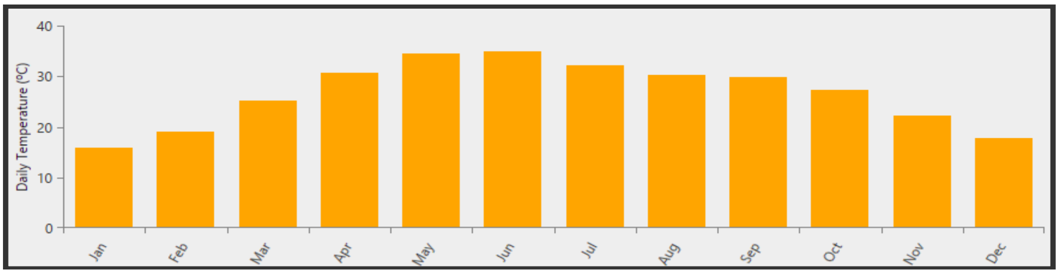

Fig.3: Temperature Data of whole year

III.LOAD PROFILE

Insert electrical load of Hourly resolution in homer which means a time series data for electrical consumption for each hour. Load profile advised the mean energy consumption by the subject area and it is 948.77 kwh/d and the peak is 161.179 KW.

Time Step Size: **60** minutes

Random Variability

Day-to-day (%): **16.742**

Timestep (%): **13.049**

Peak Month: **January**

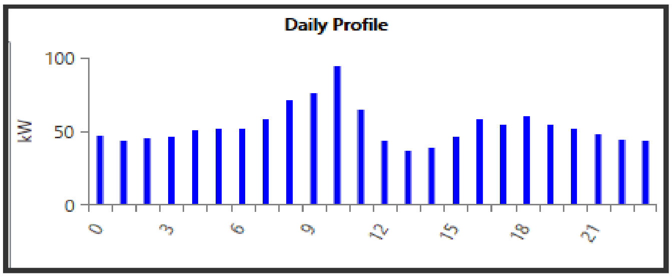

Fig.4: Daily Load consumption of Subject area

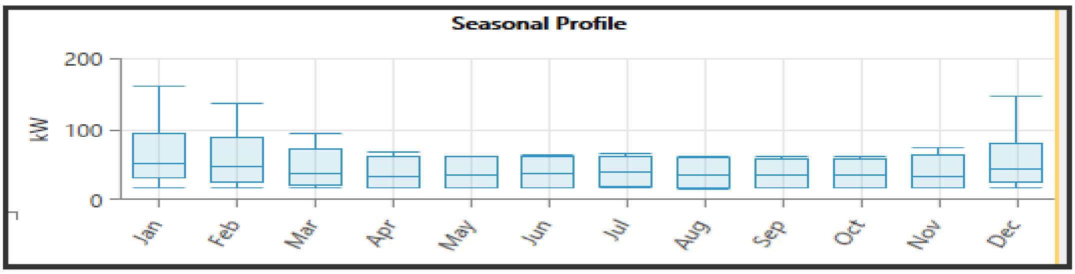

Fig.5: Graph shows how much electrical consumption we have in a year

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Table 4Below table shows the monthly average load of a selected location.

Metric	Baseline	Scaled
Average (kWh/day)	948.77	948.77
Average(kW)	39.53	39.53
Peak (kW)	161.79	161.79
Load factor	.24	.24

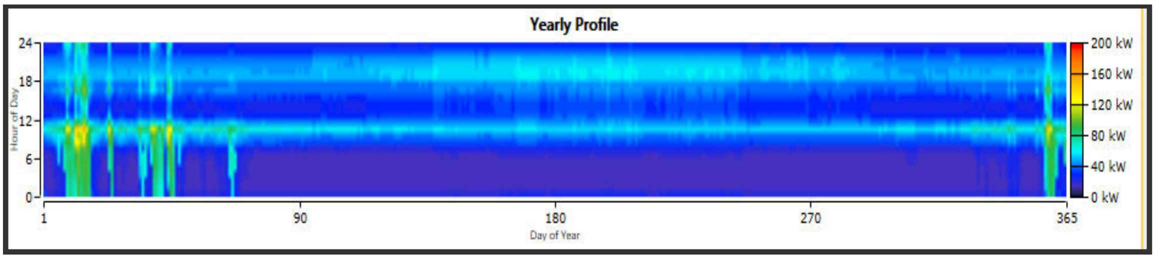

Fig.6 : Plot of Yearly Load consumption of subjected area

IV.OPTIMIZATION RESULTS

HOMER Pro analysis is used to simulate various schematics of power plants and then those schematics are simulated to find most optimized power plant configuration with respect to operating cost, net present cost (NPC), gases emission and economic comparison etc. Now, there are three kinds of results provided in the optimized results.First case includes the combination of Wind and PV with local grid supply and simulation results are shown below

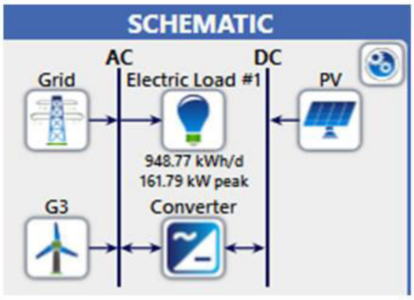

Fig.7: Schematic Diagram of Case 1st

Table 5Below table shows the Categorized HOMER optimization results for Case 1st

Optimization Results

Left Double Click on a particular system to see its detailed Simulation Results.

Architecture						Cost				System	
Huawei30 (kW)	Huawei30-MPPT (kW)	G3	Grid (kW)	Converter (kW)	Dispatch	NPC ($)	COE ($)	Operating cost ($/yr)	Initial capital ($)	Ren Frac (%)	Total Fuel (L/yr)
61.8	30.0	3	99,999	28.5	CC	$1.87M	$0.411	$117,712	$343,818	35.0	0
69.2	30.0		99,999	29.1	CC	$1.90M	$0.425	$130,463	$216,327	25.2	0
		6	99,999		CC	$2.15M	$0.469	$143,028	$300,000	22.3	0
			99,999		CC	$2.24M	$0.500	$173,151	$0.00	0	0

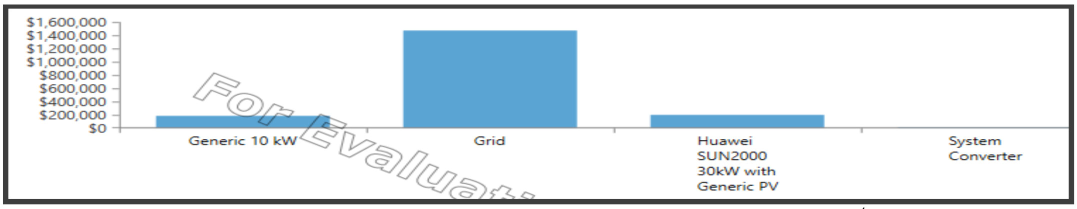

Fig.8: Contribution of each component in Net cost in Case 1st

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Table 6 Below Table shows the contribution of each component in Net cost in case 1st

Component	Capital ($)	Replacement ($)	O&M ($)	Fuel ($)	Salvage ($)	Total ($)
Generic 10 kW	$150,000.00	$47,821.10	$19,391.27	$0.00	($26,950.26)	$190,262.12
Grid	$0.00	$0.00	$1,470,531.71	$0.00	$0.00	$1,470,531.71
Huawei SUN2000 30kW with Generic PV	$185,260.21	$0.00	$7,983.18	$0.00	$0.00	$193,243.39
System Converter	$8,558.11	$3,630.98	$0.00	$0.00	($683.39)	$11,505.71
System	$343,818.32	$51,452.09	$1,497,906.16	$0.00	($27,633.65)	$1,865,542.93

Table7The Economics of Case 1st is shown below

Metric	Value
Present worth ($)	$372,863
Annual worth ($/yr)	$28,843
Return on investment (%)	12.2
Internal rate of return (%)	16.0
Simple payback (yr)	6.00
Discounted payback (yr)	7.63

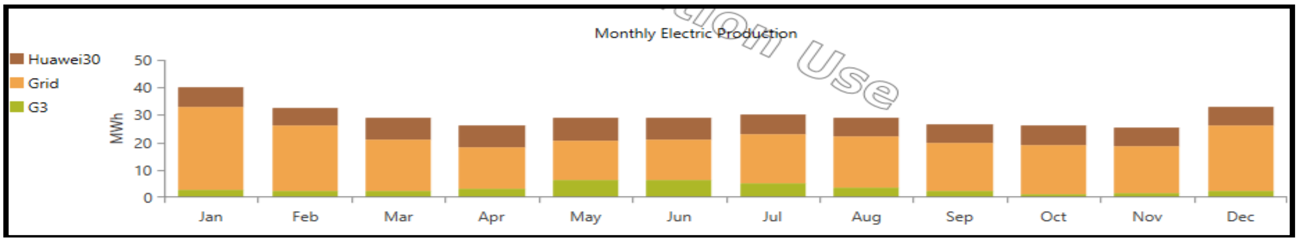

Fig.9: Contribution of Each component in Electrical Production for Case 1st

Table 8Below table shows the components produced electricity in a year for Case 1st

Production	Kwh /year	%
Huawei30	87871	24.7
G3	39470	11.1
Grid Purchases	228542	64.2
Total	355883	100

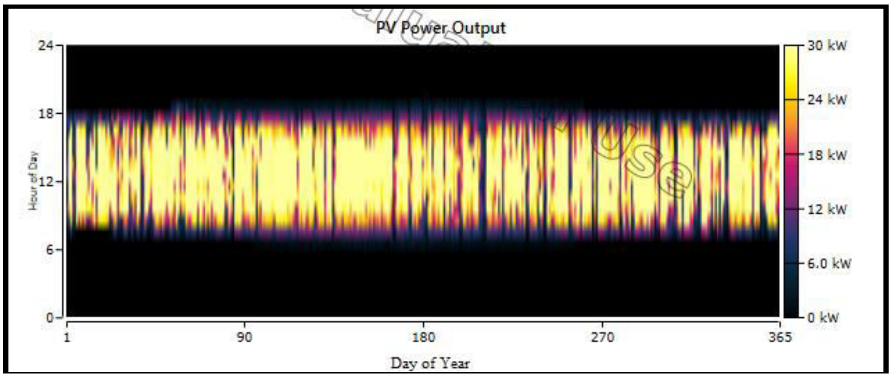

Fig.10: Output of PV of Whole Year in case 1st

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Table 9Below table shows the penetration of PV in whole year for Case 1st

Quantity	Value	Units
Minimum Output	0	kW
Maximum Output	30.0	kW
PV Penetration	25.4	%
Hours of Operation	4,379	hrs/yr
Levelized Cost	0.170	$/kWh

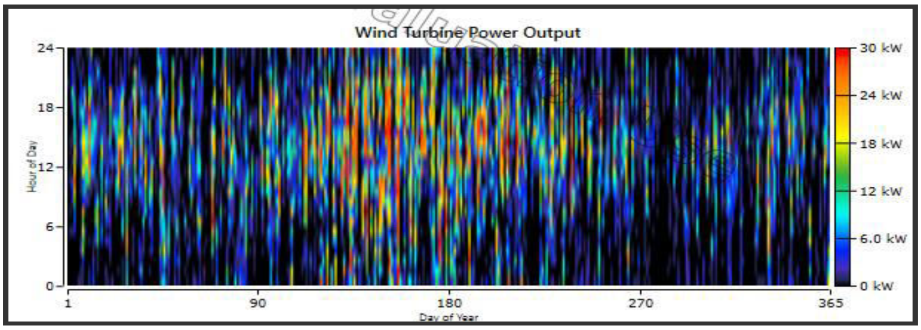
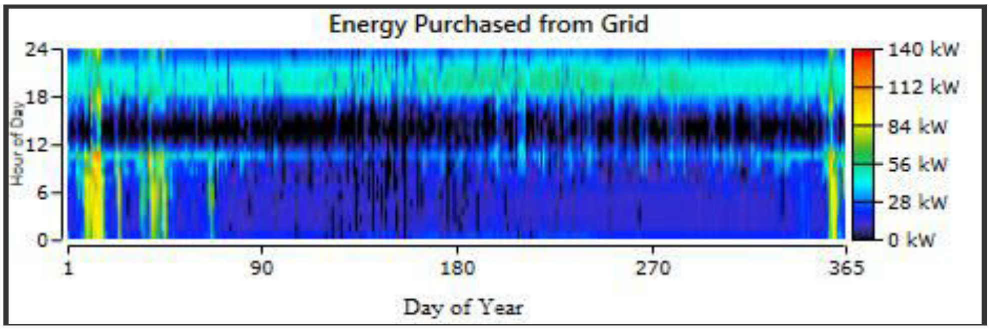


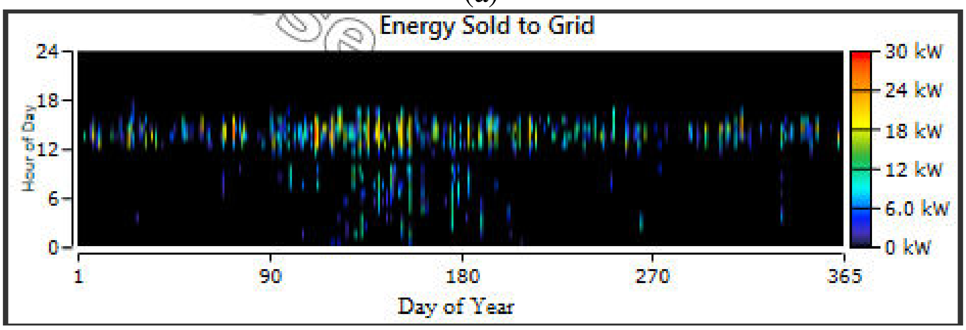
Fig.11: Output of Wind Turbine of whole Year in case 1st

Table 10Below table shows The Penetration of Wind turbine in whole year for Case 1st

Quantity	Value	Units
Minimum Output	0	kW
Maximum Output	60.0	kW
Wind Penetration	22.8	%
Hours of Operation	6,767	hrs/yr
Levelized Cost	0.373	$/kWh



(a)



(b)

Fig.12: Output of Grid of a Year in 1st case

Second caseincludes the combination of PV,Converter with Grid supply and simulation results are shown below :

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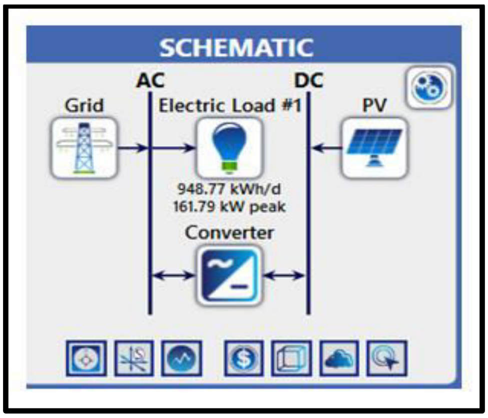

Fig.13: Schematic Diagram of 2nd Case

Table 11 Below table shows the Categorised Homer Results for Case 2nd

Optimization Results
Left Double Click on a particular system to see its detailed Simulation Results.

Architecture					Cost				System	
Huawei30 (kW)	Huawei30-MPPT (kW)	Grid (kW)	Converter (kW)	Dispatch	NPC ($)	COE ($)	Operating cost ($/yr)	Initial capital ($)	Ren Frac (%)	Total Fuel (L/yr)
69.2	30.0	99,999	29.1	CC	$1.90M	$0.425	$130,463	$216,327	25.2	0
		99,999		CC	$2.24M	$0.500	$173,151	$0.00	0	0

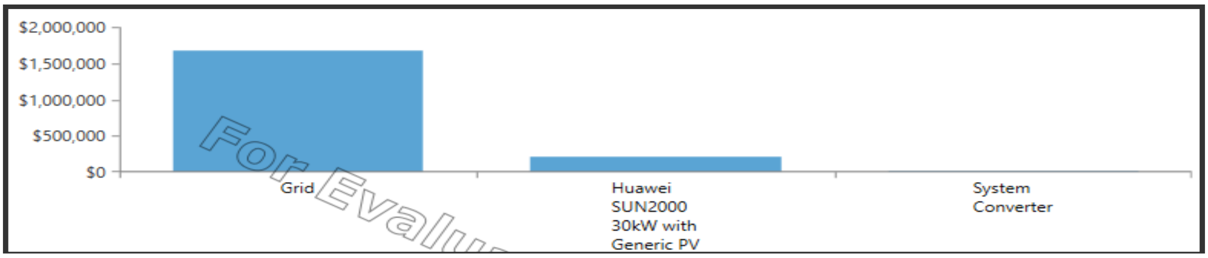

Fig.14: Contribution of each component in Net cost in 2nd case

Table 12 Below Table shows the Contribution of Each component in Net Cost for Case 2nd

Component	Capital ($)	Replacement ($)	O&M ($)	Fuel ($)	Salvage ($)	Total ($)
Grid	$0.00	$0.00	$1,674,604.76	$0.00	$0.00	$1,674,604.76
Huawei SUN2000 30kW with Generic PV	$207,593.75	$0.00	$8,945.57	$0.00	$0.00	$216,539.32
System Converter	$8,732.81	$3,705.10	$0.00	$0.00	($697.34)	$11,740.58
System	$216,326.56	$3,705.10	$1,683,550.33	$0.00	($697.34)	$1,902,884.66

Table 13 The economics of Case 2nd is shown below

Metric	Value
Present worth ($)	$335,521
Annual worth ($/yr)	$25,954
Return on investment (%)	15.7
Internal rate of return (%)	19.6
Simple payback (yr)	5.04
Discounted payback (yr)	6.16

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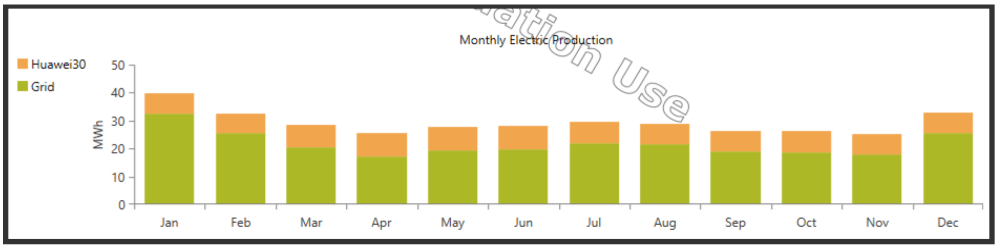


Fig.15: Contribution of Each component in Electrical Production of Case 2nd

Table 8.14 : Below table shows the components produced electricity in a year for Case 2nd :

Production	Kwh /year	%
Huawei30	91816	26.2
Grid Purchases	259076	73.8
Total	350892	100

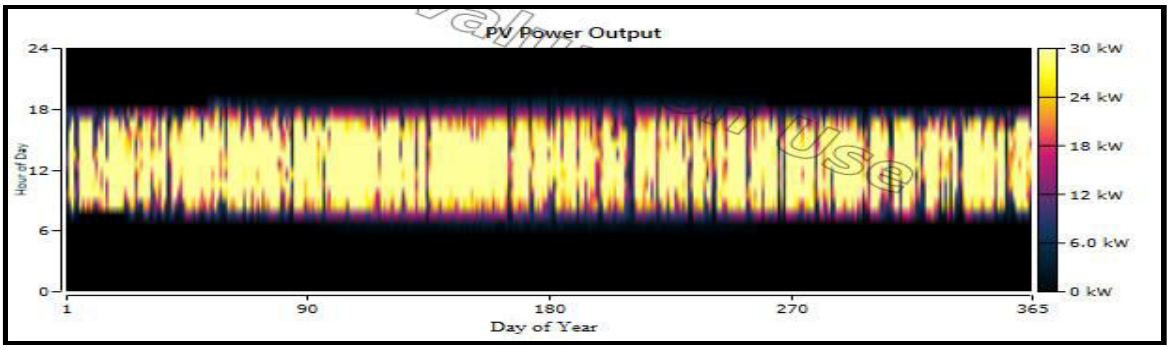
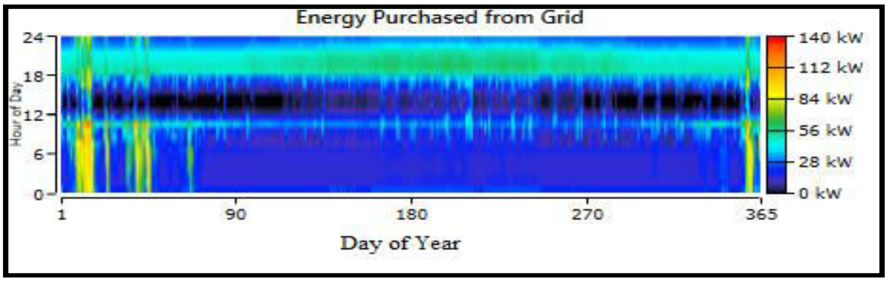


Fig.16: Output of PV of a Year in 2nd case

Table 15 The penetration of PV in whole year for 2nd case is shown below

Quantity	Value	Units
Minimum Output	0	kW
Maximum Output	30.0	kW
PV Penetration	26.5	%
Hours of Operation	4,379	hrs/yr
Levelized Cost	0.182	$/kWh



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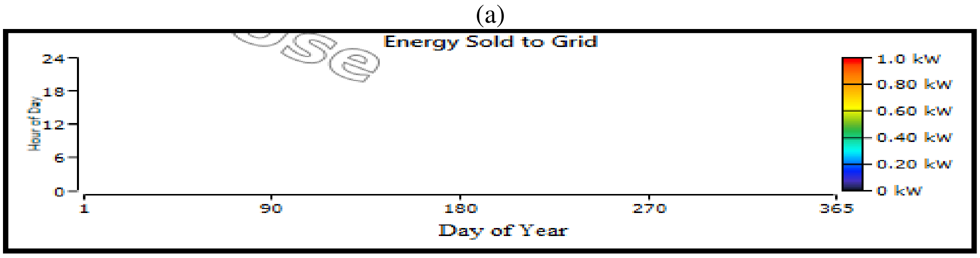

(b)

Fig.17: Output of Grid in 2nd case

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Third case includes the combination of Wind turbine, PV and Diesel generator with local grid supply and simulation results are shown below

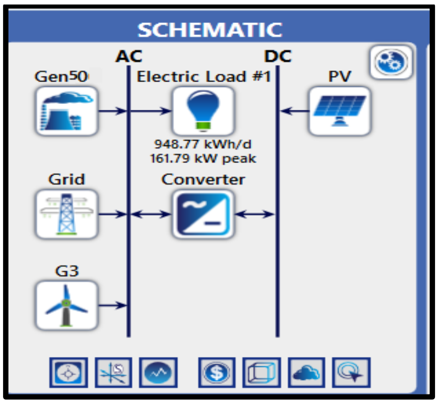

Fig.18: Schematic diagram of 3rd case in Homer

Table 16 Below table shows the Categorized HOMER optimization results for Case 3rd

Optimization Results
Left Double Click on a particular system to see its detailed Simulation Results.

Architecture							Cost				System		Gen50		
Huawei30 (kW)	Huawei30-MPPT (kW)	G3	Gen50 (kW)	Grid (kW)	Converter (kW)	Dispatch	NPC ($)	COE ($)	Operating cost ($/yr)	Initial capital ($)	Ren Frac (%)	Total Fuel (L/yr)	Hours	Production (kWh)	Fuel (L)
59.4	30.0	2	50.0	99,999	28.6	CC	$1.66M	$0.369	$104,270	$311,756	31.1	54,882	4,565	173,440	54,882
54.9	30.0		50.0	99,999	29.1	CC	$1.67M	$0.373	$113,662	$198,325	22.9	62,077	5,155	196,232	62,077
			50.0	99,999		CC	$1.84M	$0.412	$140,619	$25,000	0	90,620	7,054	289,307	90,620
		1	50.0	99,999		CC	$1.85M	$0.412	$137,007	$75,000	3.80	87,598	6,960	278,806	87,598
61.8	30.0	3		99,999	28.5	CC	$1.87M	$0.411	$117,712	$343,818	35.0	0			

Categorized / Overall

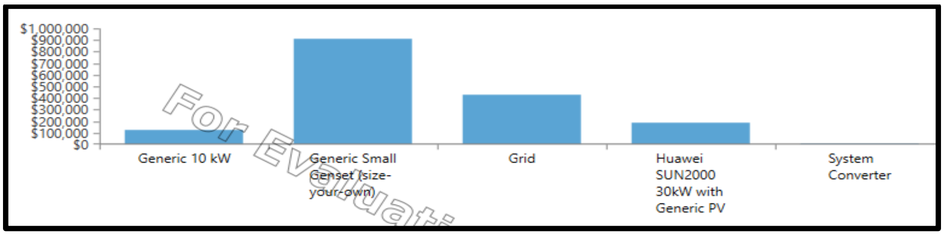

Fig.19 Contribution of each component in Net cost in case 3rd

Table 17 Below Table shows the contribution of each component in Net cost in case 3rd

Component	Capital ($)	Replacement ($)	O&M ($)	Fuel ($)	Salvage ($)	Total ($)
Generic 10 kW	$100,000.00	$31,880.74	$12,927.52	$0.00	($17,966.84)	$126,841.41
Generic Small Genset (size-your-own)	$25,000.00	$88,505.95	$88,521.17	$709,481.60	($2,345.67)	$909,163.05
Grid	$0.00	$0.00	$426,313.98	$0.00	$0.00	$426,313.98
Huawei SUN2000 30kW with Generic PV	$178,176.09	$0.00	$7,677.91	$0.00	$0.00	$185,854.01
System Converter	$8,579.40	$3,640.01	$0.00	$0.00	($685.09)	$11,534.32
System	$311,755.49	$124,026.70	$535,440.58	$709,481.60	($20,997.60)	$1,659,706.77

Table 18 The Economics of 3rd case is shown below

Metric	Value
Present worth ($)	$578,700
Annual worth ($/yr)	$44,765
Return on investment (%)	18.1
Internal rate of return (%)	22.7
Simple payback (yr)	4.38
Discounted payback (yr)	5.14

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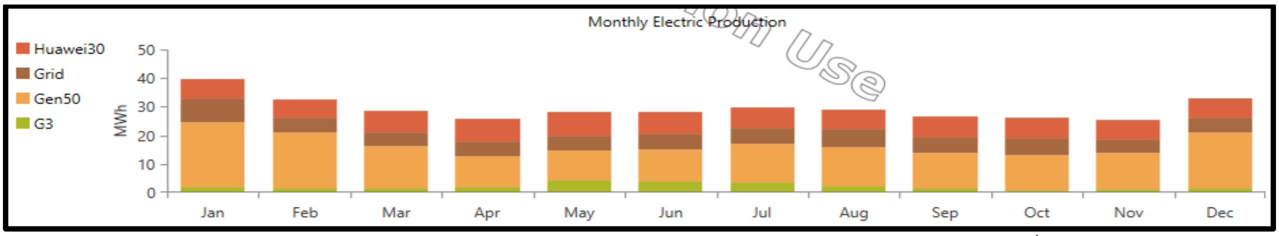

Fig.20: Contribution of Each component in Electrical Production in case3[rd]

Table 19 Below table shows the components produced electricity in a year for 3rd case

Production	Kwh /year	%
Huawei30	86453	24.5
Genset 50	173441	49.2
G3	26313	7.46
Grid Purchases	66339	18.8
Total	352546	100

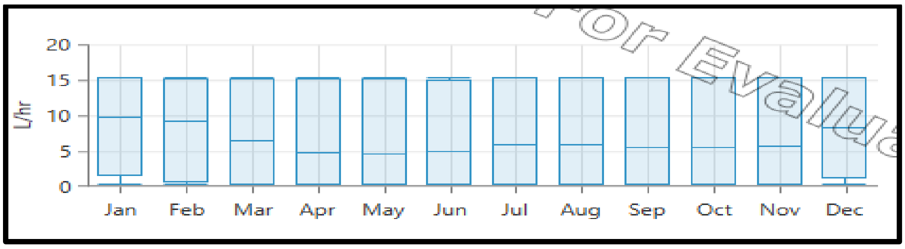

Fig.21: Fuel Consumption of a year

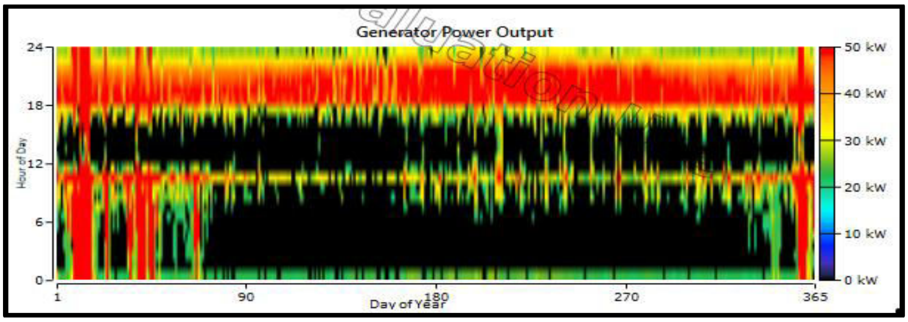

Fig.22: Diesel Generator output

Table 20 Below table shows The penetration of Generator in whole year in 3rd case

Quantity	Value	Units
Electrical Production	173,441	kWh/yr
Mean Electrical Output	38.0	kW
Minimum Electrical Output	21.2	kW
Maximum Electrical Output	50.0	kW

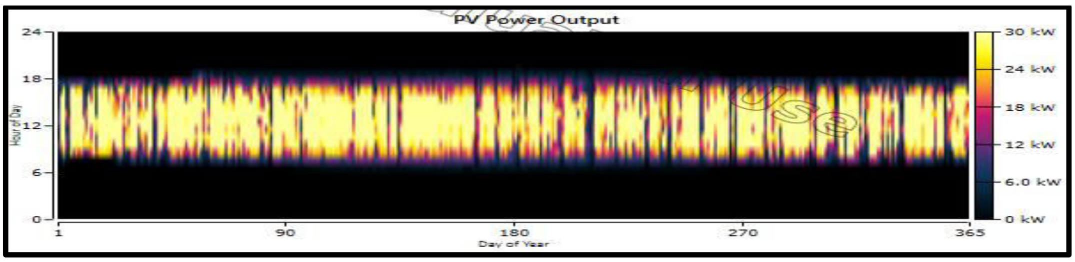

Fig.23: Output of PV of Whole Year in case 3rd

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Table 21 Below table shows The penetration of PV in whole year in 3rd case

Quantity	Value	Units
Minimum Output	0	kW
Maximum Output	30.0	kW
PV Penetration	25.0	%
Hours of Operation	4,379	hrs/yr
Levelized Cost	0.166	$/kWh

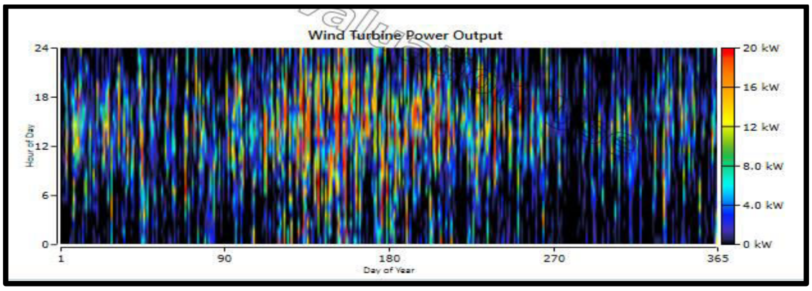
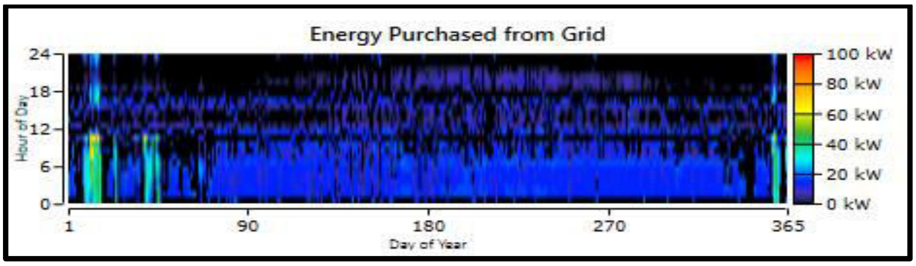


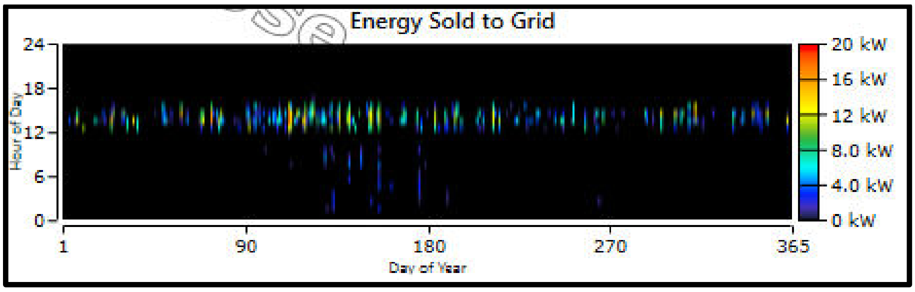
Fig.24 : Output of Wind Turbine of whole Year in case 3rd

Table 22 Below table shows The Penetration of Wind turbine in whole year in 3rd case

Quantity	Value	Units
Minimum Output	0	kW
Maximum Output	20.0	kW
Wind Penetration	7.60	%
Hours of Operation	6,767	hrs/yr
Levelized Cost	0.373	$/kWh



(a)



(b)

Fig.25: Output of Grid of a Year in3rd case

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V. RESULT AND DISCUSSION

The results are sorted in such a way that the third case is the most economical in terms of operating cost, net present cost and cost of energy.

Table 23 NPC and COE of different Configurations

Configuration	Net Present cost (NPC) in $	Cost of energy (COE) in $
Case 1st : PV, Wind turbine, Converter and Grid	1865,543	0.4106
Case 2nd : PV, Converter and Grid	1902,885	0.4251
Case 3rd : Diesel Generator, PV, Wind turbine, Converter and Grid	1659,706	0.3687

We can conclude the third configuration has the Least NPC and COE Hence third Case is the most Economical Optimised result in Homer.The basic objective is to optimize and analyse the minimization of pollution gas emission, NPC, electrical production and consumption, monthly electrical production for proposed hybrid power system. After analysing the obtained results, this proposed model provides the best compromise solution.

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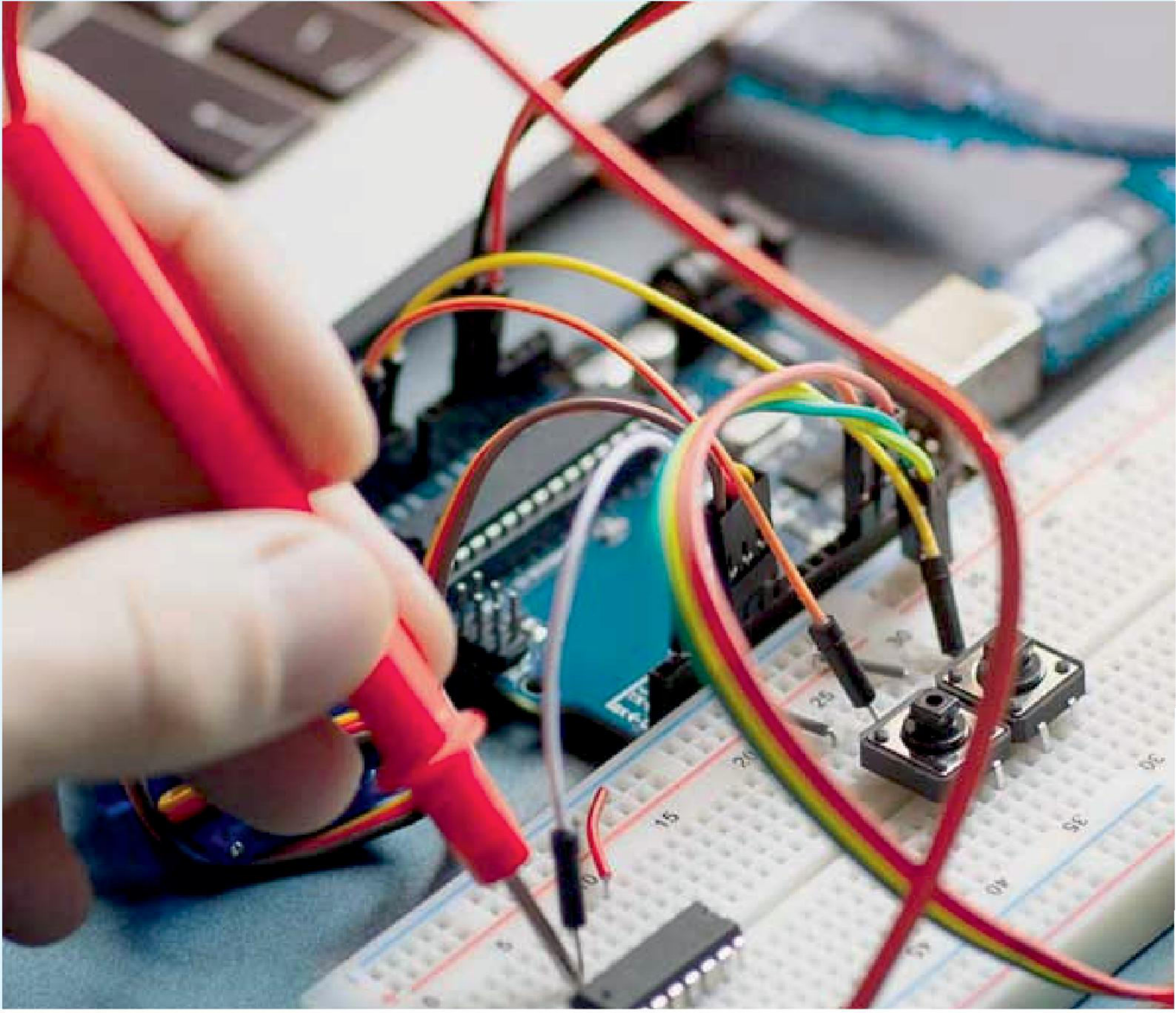

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