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Comparison between on-grid and off-grid Solar-Wind Hybrid system using HOMER Software

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ABSTRACT: One of the primary needs for socio-economic development in any nation in the world is the provision of reliable electricity supply systems. The Indian population are increasing day by day and energy demand are also increasing exponentially but the conventional energy sources are limited and exhaustible, not Eco-friendly. Solar energy and wind energy have been deemed clean, inexhaustible, unlimited and environmental friendly, but wind and solar energy is dependent on unpredictable factors such as weather and climatic conditions therefore solar-wind hybrid system is best system for continuous energy supply thought whole year. The main objective of this paper is to compare the on-grid and off-grid solar-wind hybrid system for remote areas economic point of view in India to maximize use of renewable energy generation system at minimum cost of energy.

KEYWORDS: HOMER, On-Grid, Off-Grid, COE

I.INTRODUCTION

The non-conventional sources are available free of cost, pollution-free and inexhaustible. Man has used these sources for many centuries in propelling ships, driving windmills for grinding corn and pumping water, etc. Because of the poor technology then existing, the cost of harnessing energy from these sources was quite high. Also because of uncertainty of period of availability and the difficulty of transporting this form of energy, to the place of its use are some of the factors which came in the way of its adoption or development. The uses of conventional sources are harmful for environment. India is a developing country, there are total 6, 38,596 villages in India, in which 5, 93,732 villages are inhabited. Out of 5, 93,732 villages, 5,127 villages are electrified only for some hours & rest 38605 villages are using traditional sources of energy for lighting and cooking for fulfil the daily needs. In India rural areas are received only 5-10% of electricity to meet their demand. Indian populations are increasing day by day exponentiation their energy needs also increasing.

Energy prices, supply uncertainties, and environmental concerns are driving the India to rethink its energy mix and develop diverse sources of clean, renewable energy. The nation is working towards generating more energy from domestic resources and renewable sources to fulfill the nation requirement for development- energy that can be cost effective and replaced or renewed without contributing to climate change or major adverse environmental impacts. Using hybrid renewable energy (solar-wind combination) is one of the best alternatives to supply the electrical energy at remote areas.

II. SURVEY OF IDENTIFIED AREAS

The Indian government is implementing a programme for providing financial support for electrification of those remote un electrified census villages and un-electrified hamlets of electrified census villages where grid-extension is either not

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feasible or not cost effective and is not covered under Rajiv Gandhi Grameen Vidytikaran Yojana. Such villages are provided basics facilities for electricity/lighting through various renewable energy sources [4].

In India most of people's lives in villages and they are isolated from main city. In which some villages suffer for electricity supply therefore they use the different sources of energy. The survey of lighting fuel and cooking fuel uses in some villages are conducted near to study areas.

The survey conducted in some village regarding source of energy used by villagers for lighting and cooking observe that the villagers in the absence of energy for lighting and cooking used the traditional sources, which are environment pollution point of view very harm full.

On the basis of survey the villagers use the different sources of energy for lighting as shown in table 1 below.

Table: 1
Different sources of energy used by villagers for lighting

S. No.	Village	Candle	Battery	lantern	Panel	Kero.	Elect.	Gen.	Solar	Biogas
1	ASRAWAD	55	25	59	0	60	60	0	38	6
2	DATODA	31	0	56	0	56	22	9	0	0
3	DUDHIA	42	23	77	0	64	84	13	32	0
4	UMRIKHEDA	20	3	29	11	0	30	1	0	5
5	MALIKHEDA	90	35	99	0	100	100	0	0	82
6	9th MILE	30	3	33	0	0	56	1	0	31
7	BADIAKIMA	57	20	65	0	65	65	4	0	47

On the basis of survey the villagers use the different sources of energy for cooking as shown in table 2 below.

Table: 2
Different sources of energy used by villagers for cooking

S. No.	Village	Cow dung	Wood	Charcoal	LPG	Kero.	Elect.	Biogas	Solar
1	ASRAWAD	59	59	2	38	54	0	36	0
2	DATODA	68	68	0	57	32	2	4	0
3	DUDHIA	63	60	1	80	58	9	12	0
4	UMRIKHEDA	30	27	0	30	23	0	1	0
5	MALIKHEDA	100	100	8	79	76	61	67	32
6	9th MILE	56	41	0	52	37	0	3	0
7	BADIAKIMA	65	65	17	49	49	0	51	0

III. STUDY AREA

The population of study area village Umrikheda is around 500 peoples and it is located near to toll Naka on Khandwa Road, Indore, (M.P.), with Latitude 22°43" North, Longitude 75°49" West and time zone GMT+5:30 Indian Time producing an average daily radiation of 5.43 kWh/m^2/d, and average wind speed 2.998 m/sec.

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Fig. 1 A Satellite view of Study area village Umrikheda (Indore), M.P., INDIA

The some villages electrified but suffer power cut during power supply they use the some electric equipments like for lighting and cooking bulb, radio, heater, fan and TV. On the basis of these equipments the total electric load of village Umrikheda during a day (24 hours) are 90 kWh/day. The table below show the 24 hours average electric load Jan to Dec.

Table: 3
Average Electric Load of Study Area for 24 hours of Village Umrikheda (Jan to Dec)

TIME (HOURS)		1	2	3	4	5	6	7	8	9	10	11	12
kW	Jan to Dec	3.50	3.47	3.40	3.39	3.54	3.77	3.96	3.75	4.05	3.93	3.72	3.73
TIME (HOURS)	Jan to Dec	13	14	15	16	13	18	19	20	21	22	23	24
kW		3.93	4.03	3.85	3.87	3.81	4.08	4.04	3.89	4.03	3.80	3.46	3.40

The non-renewable source of energy harm full for environment pollution point of view so the renewable source of energy is best option to in courage the villagers to use the renewable source the hybrid system is proposed. The availability of wind speed and solar radiation as follow shown in table below.

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Table: 4
Average Wind Speed and Solar Radiation in Village Umrikheda (Indore), INDIA

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Wind speed (m/s)	2.57	2.89	2.86	3.38	4.11	4.30	3.06	3.27	2.80	2.17	2.22	2.36
Solar radiation ($kWh/m^2/d$)	4.18	5.65	6.35	6.99	7.20	6.08	4.77	4.12	5.19	5.79	4.70	4.21

IV. HOMER

The Hybrid Optimization Model for Electric Renewable (HOMER) software is used as a tool to carry out the research. The HOMER energy modeling software is a powerful tool for designing and analyzing hybrid power systems. HOMER is a computer model that simplifies the task of designing distributed generation (DG) systems - both on-grid and off-grid. Homer's optimization and sensitivity analysis algorithms allow you to evaluate the economic and technical feasibility of a large number of technology options and to account for variations in technology costs and energy resource availability. It is currently used all over the world by tens of thousands of people. For either grid-tied or off-grid environments, HOMER helps determine how variable resources such as wind and solar can be optimally integrated into hybrid systems.

Daily Load Profile in HOMER Software:

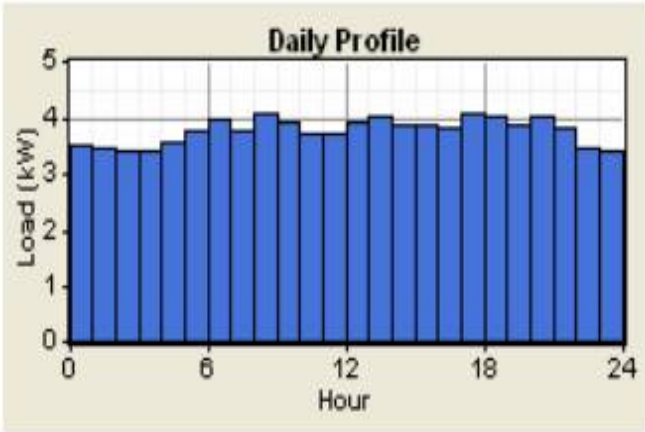

Fig. 2 Daily electric load profile of study area village Umrikheda (MP) INDIA

On the basis of electric load of village Umrikheda a 90 kWh/day ON-Grid Solar-Wind hybrid system is proposed as shown below in fig. 3 the hybrid system is on-grid so power cut problem not face villagers.

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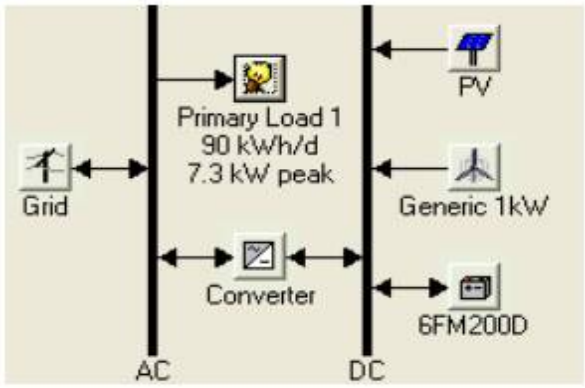

Fig. 3 HOMER based ON-Grid Solar-Wind hybrid model

On the basis of electric load of village Umrikheda a 90 kWh/day Off-Grid Solar-Wind hybrid system is proposed as shown below in fig. 4 the hybrid system is off-grid so some time villagers face power cut problem:

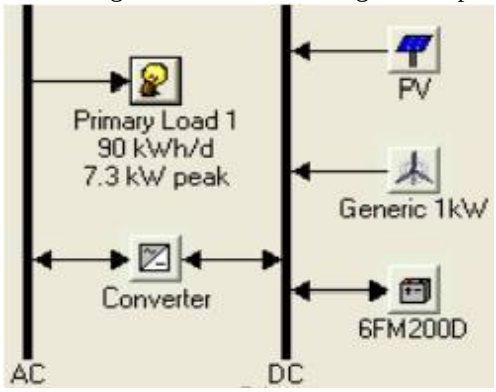

Fig. 4 HOMER based Off-Grid Solar-Wind hybrid model

V. SIMULATION AND OPTIMIZED RESULT

The input data for proposed solar-wind hybrid system are feed in HOMER software, as electric load data of each hour (24 hours), cost data of solar panel, cost data of wind turbine generator, cost data of storage battery and cost data of converters. On the basis of input data HOMER software analysis the number of possible combinations, which are feasible for modeling in this proposed system 3200 combinations are simulated in which the optimized result shown in blue color in fig. 5 as below.

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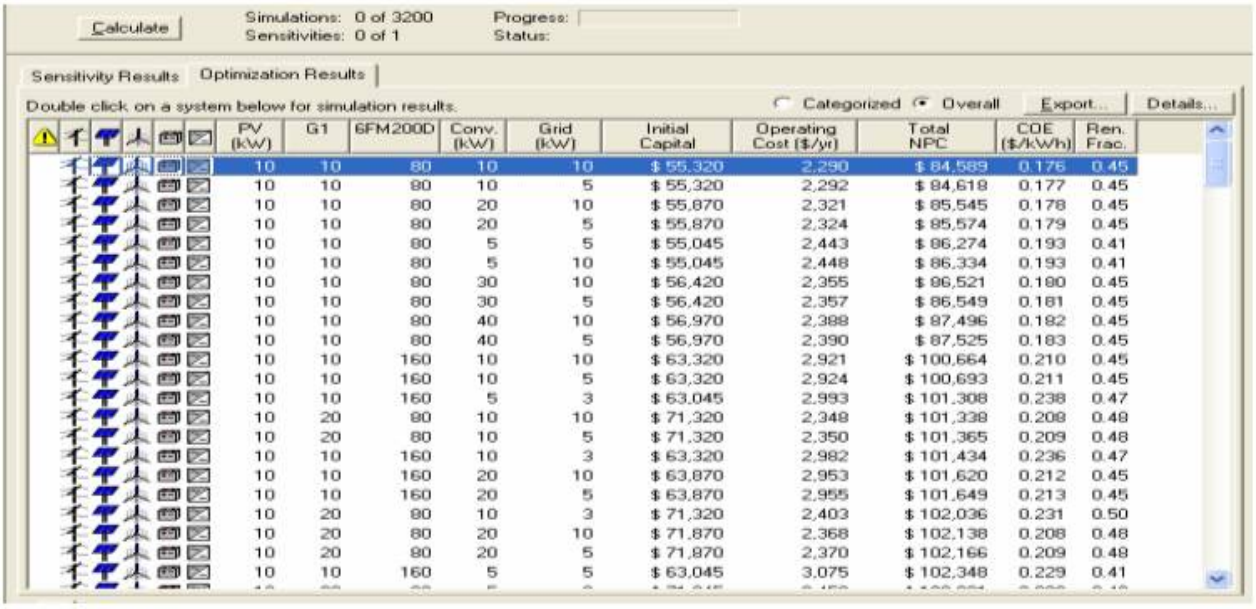
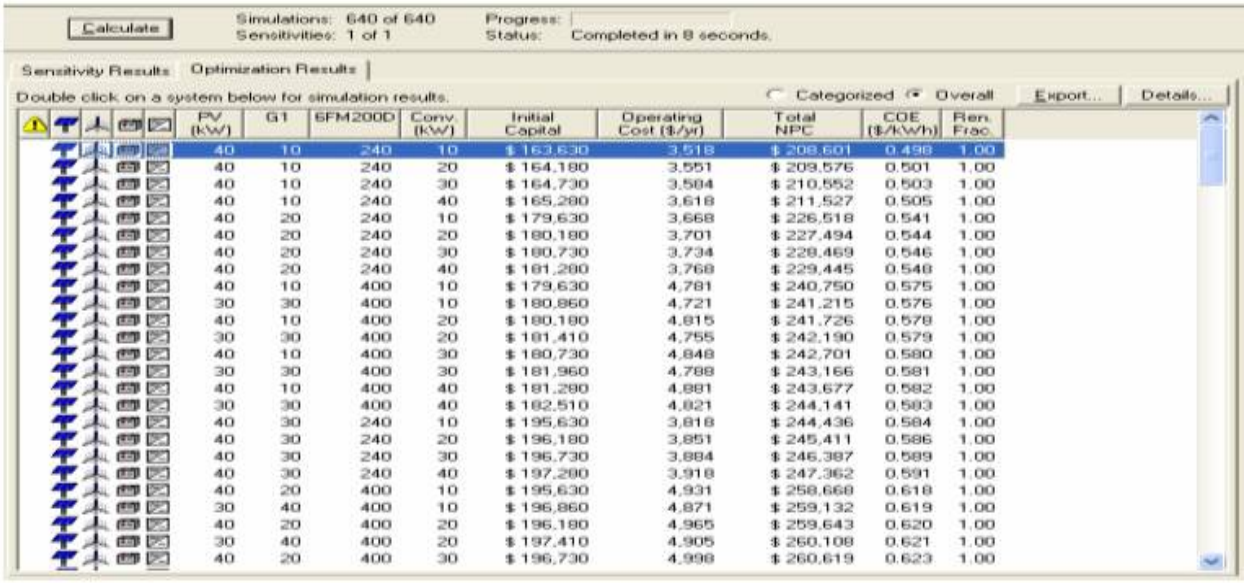


PV (kW)	G1	6FM200D	Conv. (kW)	Grid (kW)	Initial Capital	Operating Cost ($/yr)	Total NPC	COE ($/kWh)	Ren. Frac.
10	10	80	10	10	$ 55,320	2,290	$ 84,589	0.176	0.45
10	10	80	10	5	$ 55,320	2,292	$ 84,618	0.177	0.45
10	10	80	20	10	$ 55,870	2,321	$ 85,545	0.178	0.45
10	10	80	20	5	$ 55,870	2,324	$ 85,574	0.179	0.45
10	10	80	5	5	$ 55,045	2,443	$ 86,274	0.193	0.41
10	10	80	5	10	$ 55,045	2,448	$ 86,334	0.193	0.41
10	10	80	30	10	$ 56,420	2,355	$ 86,521	0.190	0.45
10	10	80	30	5	$ 56,420	2,357	$ 86,549	0.181	0.45
10	10	80	40	10	$ 56,970	2,388	$ 87,496	0.182	0.45
10	10	80	40	5	$ 56,970	2,390	$ 87,525	0.183	0.45
10	10	160	10	10	$ 63,320	2,921	$ 100,664	0.210	0.45
10	10	160	10	5	$ 63,320	2,924	$ 100,693	0.211	0.45
10	10	160	5	3	$ 63,045	2,993	$ 101,308	0.238	0.47
10	20	80	10	10	$ 71,320	2,348	$ 101,338	0.208	0.48
10	20	80	10	5	$ 71,320	2,350	$ 101,365	0.209	0.48
10	10	160	10	3	$ 63,320	2,982	$ 101,434	0.236	0.47
10	10	160	20	10	$ 63,870	2,953	$ 101,620	0.212	0.45
10	10	160	20	5	$ 63,870	2,955	$ 101,649	0.213	0.45
10	20	80	10	3	$ 71,320	2,403	$ 102,036	0.231	0.50
10	20	80	20	10	$ 71,870	2,368	$ 102,138	0.208	0.48
10	20	80	20	5	$ 71,870	2,370	$ 102,166	0.209	0.48
10	10	160	5	5	$ 63,045	3,075	$ 102,348	0.229	0.41

Fig. 5 Simulation results of On-Grid Solar-Wind hybrid system

Result-(A)-As from fig. 5 simulation results obtained for ON-Grid solar-wind hybrid system, the optimized COE (cost of energy) is $ 0.176/(kWh) [Approx 10.9 Rs/kWh] for above described data.
The same input data is used for Off-Grid hybrid system and simulate the model in number of 640 simulation results the optimized shown in blue color as in fig. 6 below.



PV (kW)	G1	6FM200D	Conv. (kW)	Initial Capital	Operating Cost ($/yr)	Total NPC	COE ($/kWh)	Ren. Frac.
40	10	240	10	$ 163,630	3,518	$ 208,601	0.498	1.00
40	10	240	20	$ 164,180	3,551	$ 209,575	0.501	1.00
40	10	240	30	$ 164,730	3,584	$ 210,552	0.503	1.00
40	10	240	40	$ 165,280	3,618	$ 211,527	0.505	1.00
40	20	240	10	$ 179,630	3,668	$ 226,518	0.541	1.00
40	20	240	20	$ 180,180	3,701	$ 227,494	0.544	1.00
40	20	240	30	$ 180,730	3,734	$ 228,469	0.546	1.00
40	20	240	40	$ 181,280	3,768	$ 229,445	0.548	1.00
40	10	400	10	$ 179,630	4,781	$ 240,750	0.575	1.00
30	30	400	10	$ 180,860	4,721	$ 241,215	0.576	1.00
40	10	400	20	$ 180,180	4,815	$ 241,726	0.578	1.00
30	30	400	20	$ 181,410	4,755	$ 242,190	0.579	1.00
40	10	400	30	$ 180,730	4,848	$ 242,701	0.580	1.00
30	30	400	30	$ 181,960	4,788	$ 243,166	0.581	1.00
40	10	400	40	$ 181,280	4,881	$ 243,677	0.582	1.00
30	30	400	40	$ 182,510	4,821	$ 244,141	0.583	1.00
40	30	240	10	$ 195,630	3,818	$ 244,436	0.584	1.00
40	30	240	20	$ 196,180	3,851	$ 245,411	0.586	1.00
40	30	240	30	$ 196,730	3,884	$ 246,387	0.589	1.00
40	30	240	40	$ 197,280	3,918	$ 247,362	0.591	1.00
40	20	400	10	$ 195,630	4,931	$ 258,668	0.618	1.00
30	40	400	10	$ 196,860	4,871	$ 259,132	0.619	1.00
40	20	400	20	$ 196,180	4,965	$ 259,643	0.620	1.00
30	40	400	20	$ 197,410	4,905	$ 260,108	0.621	1.00
40	20	400	30	$ 196,730	4,998	$ 260,619	0.623	1.00

Fig. 6 Simulation results of Off-Grid Solar-Wind hybrid system

Result-(B)-As from fig. 6 simulation results obtained for Off-Grid (solar-wind) hybrid system, the optimised COE (cost of energy) is $ 0.498/ (kWh)[Approx 29.88 Rs/kWh] for above described data.

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VI. CONCLUSION

Overall conclusion: By comparing result (A) and result (B) it is clear that ON-Grid hybrid system is much better then Off-Grid hybrid system for VILLAGE UMRIKHEDA, INDORE, M.P. because off-grid power is costly (Rs. 29.88/Unit) as compare to on-grid system (Rs. 10.9/Unit).

In on-grid system the excess power is sale back to grid that is benefit of on-grid system but in off-grid hybrid system the excess power is totally losses and in low power generation condition the consumers suffer black out of electric power cut.

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