HYBRID POWER SYSTEM

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Hybrid energy system is an excellent solution for power generation in rural areas where the grid is infeasible. Such a system incorporates a combination of one or several energy sources such as solar photovoltaic (PV), wind energy units, diesel generators etc.

HOMER provides solution to such problems. paper also describes the design, simulation, economic feasibility and expected performance of adding a wind and PV energy system to the existing diesel system of the Industry. In this seminar, an attempt has been made to give optimized design and simulation as well as economic feasibility and sensitivity analysis of HYBRID RENEWABLE ENERGY SYSTEM (Retrofitting of wind turbines and solar PV) for the company.

HOMER (Hybrid Optimization model for electric renewable) software has been released by National Renewable Energy Laboratory [19] (USA) -1994 for developing Countries. It is a computer model that simulates and optimizes distributed energy resource (DER) systems. Its speed and simplicity allows users to perform sophisticated analyses with ease and provides insight into the complex nature of hybrid power system design. HOMER can model any combination of wind turbines, solar photovoltaic panels, run-off-river hydroelectric, small modular biomass and conventional generators using diesel, propane or gasoline and battery storage systems.

• To use HOMER, you enter inputs (information about loads, components, and resources), HOMER calculates and displays results, and you examine the results in tables and graphs.

• Using HOMER is an iterative process. You can start with rough estimates of values for inputs, check results, refine your estimates and repeat the process to find reasonable values for the inputs.

• You can use HOMER to simulate a power system, optimize design options for cost-effectiveness, or to perform a sensitivity analysis on factors such as resource availability and system costs.

• HOMER is an hourly simulation model. HOMER models system components, available energy resources, and loads on an hourly basis for one year. Energy flows and costs are constant over a given hour. HOMER can synthesize hourly resource data from monthly averages that you enter in tables, or you can import measured data from properly formatted files.

• HOMER is primarily an economic model. You can use HOMER to compare different combinations of component sizes and quantities, and to explore how variations in resource availability and system costs affect the cost of installing and operating different system designs. Some important technical constraints, including bus voltage levels, intra-hour performance of components, and complex diesel generator dispatch strategies are beyond the scope of an economic model such as HOMER.

Literature Survey:

From last two decades, the issue of sustainable development is gaining steady momentum. The renewable energies being inherently sustainable and environment friendly are gaining popularity. Over the years significant technological advances have been achieved in the area of renewable energy technologies, especially in the field of solar photovoltaic and wind energies. For remote systems such as radio telecommunications, satellite earth stations or at sites that are far away from a conventional power system, the hybrid systems have been considered as attractive and proffered alternative sources. The large number of papers has been published in the area of hybrid technology and its optimization. Some of the papers have been discussed below:

Dr. R. W. Wise, A. N. Agrawal [1] has discussed the effects of integrating wind turbine generators into a hybrid distributed generation systems in extreme northern climate. The dynamic modeling and optimized design of PV array, battery storage bank, diesel generator, and wind turbine generator has been studied using MATLAB simulink.

Klaas van Alphan [2] and Julie Camerlvnck [3] has proposed a modeling study to determine optimal renewable energy systems to be implemented in the Maldives. The simulation program HOMER was used to design the systems to analysis their technical and economical performances. Dr. S. A. Khaparde *et. al.*[4] , Dr. James Manwell, J.G.McGowan [5] [7], Riad Chedid, Saifur Rahman [6], has discussed comparative studies of single source DG and hybrid DG technology on the basis of customer level cost of energy and net present cost and unit sizing of hybrid generation. R. Jayakrishna [16], S. A. Deokar and Dr. R.C. Balapure [17], Dr. W. Z. Gandhare [18] has discussed a case study of a hybrid generation technology and its optimized design and sensitivity analysis.

M.Tariq Iqbal [8],W.Jennings [11], Jorge G. Vera [13], Bogdan S. Borowy *et. al.* [14] has discussed the optimized design technique of hybrid renewable generation technology for rural area and household electrification.

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I. HYBRID POWER GENERATION TECHNOLOGY

Numerous renewable and small-scale distributed generation (DG) technologies have now progressed to the stage where their technical feasibility has been proven and full-scale projects have been successfully implemented worldwide. These technologies hold the potential to help provide basic electricity service to the nearly two billion people who are without access to grid-connected power. This chapter surveys the available DG technologies and models their economic performance in India with particular emphasis on comparing the costs of hybrid DG systems with conventional grid connections for remote rural village-level applications. Modeling inputs are based on demand, fuel availability, costs and local operating conditions found in the India. Results demonstrate that hybrid power systems can economically provide electricity in rural areas if local energy resources are adequate (e.g. wind, solar, biomass). Additional environmental and economic benefits of hybrid DG are also quantified for the case study area and reveal a 40% reduction in diesel fuel use compared to diesel genset only systems

Hybrid Generation

To provide energy services to remote areas, three options are available:

1. Increase central power plant output
2. Fossil fuel-fired distribute generation (e.g. diesel generator sets)
3. Renewable power generation.

Taking each one separately, several drawbacks are apparent, as shown in Figure 2.2. One possible solution that helps to cancel out the drawbacks of diesel and renewable energy technologies is to employ both types in combination, with the objective of exploiting their operating characteristics to minimize costs and maximize availability.

A hybrid energy system is defined as an installation that uses two or more generation technologies in concert. The goal of using multiple technologies is to take advantage of the best operational characteristics of each system and create synergy in their combination. For example, the costs associated with the diesel gensets are dominated by the costs of fuel delivery and the on-going maintenance.

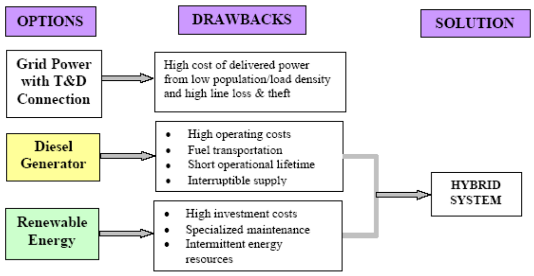

Fig 2.2: Power supply options for rural areas

This contrasts with the wind turbines where costs are dominated by the upfront capital investment, but have low maintenance requirements. Further, a diesel geneset provides good reliability and when combined with wind or PV, the renewables reduce fuel consumption and emissions from the diesel. Hybrid systems for rural electrification can be configured in three different ways: grid connected off-grid with distribution system, and off-grid for direct supply. The first configuration has the advantage of being able to rely on the grid if the hybrid system has problems. Likewise, the grid is strengthened by the power supply near the end of its reach, thus boosting voltage and reducing power cuts. For off-grid configurations, the hybrid can either be connected to many load centers, 200 households in a group of villages for example, or can act as a source of supply for one or two loads, thus obviating the need for a distribution system. A non-connected off-grid system is usually used to charge batteries or supply power to a small rural industry, such as a grain milling operation.

The components of the hybrid system modeled include wind turbines, diesel gensets, inverters, power control equipment (e.g. rectifiers, inverters, and switches), batteries and a dump load. Figure 1.3 displays all the modeled components and how they are connected in schematic graphical form.

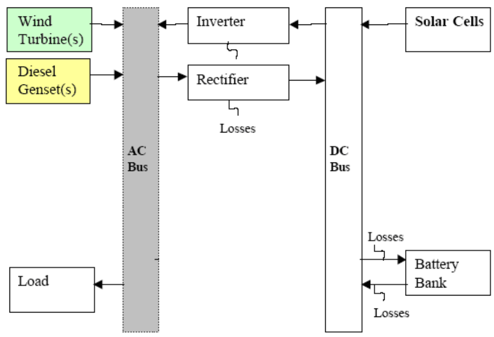

Fig 2.3 Wind–Diesel and PV hybrid system schematic

The turbines and diesel gen-sets feed power into the AC system, which is connected to the consumer load. If the power supplied is above the load demand at any given time, it is sent through the rectifier and changed to DC for storage in the battery bank. Alternatively, the excess power can be sent to the dump load.2 When the wind speed or sun intensity is low, the battery bank sends stored power through the inverter to the AC side, and on to the consumers. Each trip from AC to DC incurs losses, as does the battery storage process; industrial batteries typically have a round trip efficiency of 80%, or 20% losses. To maximize the use of the renewable energy (RE) devices and serve the load most efficiently, three different dispatch strategies can be employed. The first is a 'series' hybrid system in which the diesel and RE source run to charge the battery and all power for the load is drawn from the battery bank. The second type of hybrid system is the 'switched' configuration, where the diesel and RE sources are fed directly to the load and excess power is funneled to the batteries allowing the diesel to be shut off during low load periods. System integrated batteries are also used to supply power for short durations to compensate for the power output fluctuations of the wind turbine(s) and to avoid brief starts of the diesel generator(s). If the batteries run low, the diesel generator starts up to feed the load and recharges the batteries. One aim of this 'load-following' control strategy is to operate the diesel generator primarily when a high fraction of its rated capacity is needed, as this is the most fuel-efficient, and therefore cost-efficient, mode of operation. The third type of system configuration is run without batteries and uses the RE source for power whenever it is available and relies on the diesel to make up the difference. The economic feasibility of a

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hybrid system is determined by local conditions and resource availability.

Advantages and Limitations of Hybrid Generations:
Advantages:

- Less dependent on Grid supply
- A transmission and Distribution loss as well as theft is eliminated.
- Load shedding is avoided.
- High energy efficiency and low maintenance.
- Trouble shooting cost reduced by 70-75% due to increased reliability and reserved capacity.
- Given their extreme flexibility, hybrid designs offer the best upgrade path for future system improvements.
- Reduction in pollution.

Hours	Load KW
00:00 to 01:00	0.110
01:00 to 02:00	0.110
02:00 to 03:00	0.110
03:00 to 04:00	0.110
04:00 to 05:00	0.110
05:00 to 06:00	0.300
06:00 to 07:00	0.860
07:00 to 08:00	1.000
08:00 to 09:00	1.000
09:00 to 10:00	0.750
10:00 to 11:00	0.850
11:00 to 12:00	0.920

For example: It has been estimated that a 200kW renewable energy system gives an annual output of 400000 kWh of electrical energy. Results are

- Conservation of about 250 tones of coal/year
- SO_2 reduction-3 tones/year
- NO reduction- 1 tone/year
- CO_2 reduction- 300 tones/year
- Slug and fly-ash- 30 tones/year
- Particulates -300 Kg/year.

Limitations:

- High level of complexity, higher risk of design errors.
- Capital costs higher than for stand alone system DG and grid system.
- Requires more sophisticated design performance models.

Description of Sangavi Village:

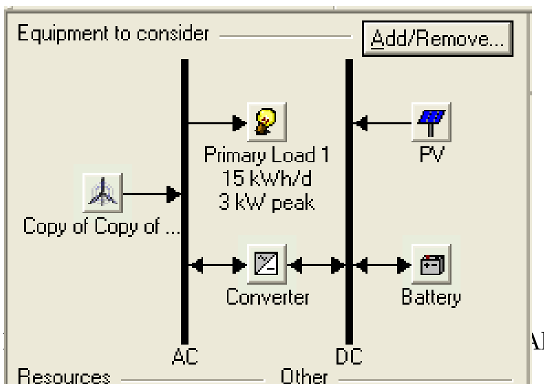
It is in Nashik district near Wadiwarhe. It is approximately 5 km from Wadiwarhe village. Population is around 205 persons belonging to 46 families living in 48 homes. Main occupation is farming. The region is well exposed to south-west and north-east monsoon winds. Annual average wind speed in the area - 5m/s. Annual average solar radiation is ~ 3 kWh/m^2/day.

Priority Needs:

1. Extension of electricity supply
2. Improvements of internal lanes
3. Drinking water

Currently there is no such proper arrangement of the above needs. So need to provide electricity. The following are the options to provide electricity:

1. MSEDCL Ltd.
2. Hybrid power Generation



Following technological options and their combinations were considered to identify the suitable power system for Sangavi Village

a. Solar Photo Voltaic (Solar PV)
b. Wind Turbine Generator (WTG)
c. Batteries

Hours	Load KW
12:00 to 13:00	0.580
13:00 to 14:00	0.470
14:00 to 15:00	0.320
15:00 to 16:00	0.350
16:00 to 17:00	0.500
17:00 to 18:00	0.680
18:00 to 19:00	1.300
19:00 to 20:00	2.000
20:00 to 21:00	2.000
21:00 to 22:00	0.900
22:00 to 23:00	0.560
23:00 to 24:00	0.100

d. Converters

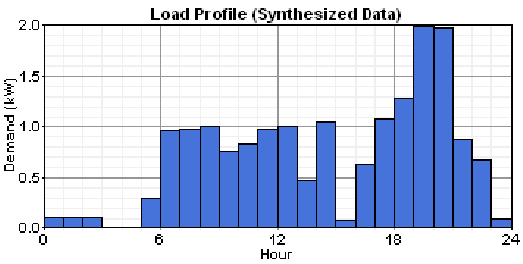
Block Diagram of proposed Power System:

Primary load:

We have considered a peak load of month of April as load profile for whole year. Its hourly load profile of is as follows:

A.
B.
C.
D.
E.
F.
G.
H.

Daily noise:	15%
Hourly noise:	20%
Scaled annual average:	14.5 kWh/d
Scaled peak load:	3.26 kW
Load factor:	0.185



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I. PV

Size (kW)	Capital ($)	Replacement ($)	O&M ($/yr)
1.000	2,500	2,000	0

Sizes to consider:	0, 1, 2, 3 kW
Lifetime:	20 yr
Derating factor:	90%
Tracking system:	Two Axis
Slope:	19.5 deg
Azimuth:	0 deg
Ground reflectance:	20%

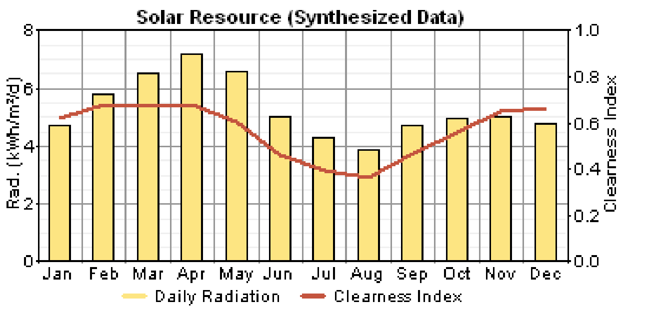
J.

K. Solar Resource

Latitude: 19 degrees 30 minutes North
Longitude: 74 degrees 30 minutes East

Month	Clearness Index	Average Radiation
		(kWh/m²/day)
Jan	0.622	4.700
Feb	0.680	5.800
Mar	0.672	6.500
Apr	0.684	7.200
May	0.606	6.600
Jun	0.460	5.040
Jul	0.395	4.300
Aug	0.368	3.900
Sep	0.473	4.700
Oct	0.562	4.970
Nov	0.650	5.040
Dec	0.664	4.800

Scaled annual average: 5.29, 4.00, 5.00, 6.00 kWh/m²/d

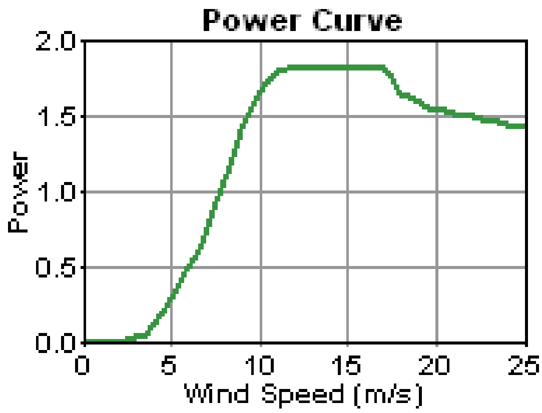


L.

M. AC Wind Turbine: SW Skystream 3.7

Quantity	Capital ($)	Replacement ($)	O&M ($/yr)
8	2,500	2,000	800

Quantities to consider:	0, 1, 2, 3, 4, 5, 6, 7
Lifetime:	15 yr
Hub height:	15 m



N.

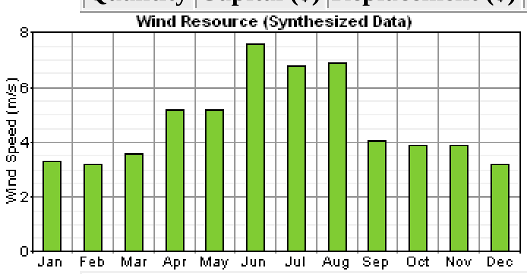
O. Wind Resource

Month	Wind Speed
	(m/s)
Jan	3.29
Feb	3.18
Mar	3.57
Apr	5.18
May	5.19
Jun	7.60
Jul	6.80
Aug	6.90
Sep	4.06
Oct	3.90
Nov	3.90
Dec	3.20

Autocorrelation factor:	0.850
Diurnal pattern strength:	0.250
Hour of peak wind speed:	15
Scaled annual average:	4.74, 4.00, 5.00, 6.00 m/s
Anemometer height:	10 m
Altitude:	465 m
Wind shear profile:	Logarithmic
Surface roughness length:	0.25 m

P. Battery: Hoppecke 24 OPzS 3000

Quantity	Capital ($)	Replacement ($)	O&M ($/yr)
1	60	50	12.00



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Quantities to consider: 0, 12, 24, 36, 48, 60, 72
Voltage: 2 V
Nominal capacity: 3,000 Ah
Lifetime throughput: 10,196 kWh
Min battery life: 5 yr
Round trip efficiency: 86%
Minimum state of charge: 30%
Float life: 20 years
Maximum charge rate :1 A/Ah
Maximum charge current: 610A
Suggested value: 10222 kWh

Q.

R. Converter

Size (kW)	Capital ($)	Replacement ($)	O&M ($/yr)
2.300	251	251	50

Sizes to consider: 0, 2, 4, 6, 8 kW
Lifetime: 15 yr
Inverter efficiency: 90%
Inverter can parallel with AC generator: Yes
Rectifier relative capacity: 100%
Rectifier efficiency: 85%

S. Economics

Annual real interest rate: 10%
Project lifetime: 25 yr
Capacity shortage penalty: $ 0/kWh
System fixed capital cost: $ 7500
System fixed O&M cost: $ 1000/yr

Calculation of System Fixed Capital Cost of ----------

The rate of construction of internal connection is 1---$/km. Therefore for internal construction of 5.1km we need 7500$.

Hence System Fixed Capital Cost is $7500 and System fixed O & M Cost is $1000/yr. In this construction we used 25 poles and ANT Conductor of 5.1km. We used 3 phase and 5 wire system which is also used for street lightning. We also required a transformer of 25 KVA. The cost of required transformer which is 11/.433 25 KVA Dist. Transformer is $4000

Conclusion and Future Scope

Energy is a prime mover of development and to make it available at affordable price for a common man is really a big challenge before the government of India and state government of India. As day-by-day the prices of fuel are increasing, the government should start to use renewable energy resources. Global environmental concerns and the ever increasing need for energy, coupled with steady progress in renewable energy technologies are opening up new opportunities for utilization of renewable energy resources. In particular, advancements in wind & PV generation technologies have increased their views in wind alone, PV alone and hybrid wind/PV configurations. Moreover, the economic aspects of these renewable energy technologies are sufficiently promising at present to include the development of their market. Different design scenarios have been proposed to design integrated renewable energy systems, where combinations of wind and solar resources have been used.

Owing to acute energy crisis that most developing countries including India are facing today, the interest in alternative energy sources has increased manifolds in the recent past. Wind & Solar being a non-polluting and nontoxic energy sources will go a long way in solving our energy requirements.

Wind energy can be utilized to windmills, which in turn drive a generator to produce electricity. Wind can also be used for water pumping. However, in India, few designs were developed but could not sustain. An important reason could be that wind velocity in India, apart from the coastal region, is relatively low and varies appreciably with seasons. This low velocity and seasonal winds imply a high cost of exploitation of wind energy. The solution lies with the proper analysis of Wind pattern and then only proper & commercial wind mill can be designed which can used in small scale capacity at low velocity in rural areas.

Solar energy can be converted into electrical energy by use of photo-voltaic cells which converts incident solar radiation into electrical power by use of semiconductor technology. The solar PV system is easier to operate and requires less training to operating personnel, which makes the technology compatible with this proposed system.

Keeping the above point in view, a case study was conducted at residential complex (including hostel), Nashik. Wind data has been taken from Metrological Department, Pune. The data collected, was complied using HOMER. We studied the wind pattern .It was observed that the wind velocity is quite low. The challenge lies within the proper design of windmill that can be used at this low wind velocity. A V- Enertech Turbine is simple in construction, pollution free, having low operating speed and extremely cost effective. It was found that this S-rotor can be used for small power generation which can be used for domestic purpose in rural based communities. Thus solving the energy crisis to some extent.

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