In rural India, using renewable energy to generate electricity can improve sustainable livelihoods.

Biplab Mohapatra, Asis Kumar Nayak
College of Engineering Bhubaneswar,Biju Patnaik University of Technology,Odisha,India

Abstract:

India is a developing nation with a quickly rising demand for electricity. Since independence, around 19000 Indian villages have not been electrified. The government of India's Deen Dayal Upadhyaya Gram Jyoti Yojana (DDUGJY) aims to give off-grid rural areas in India a steady source of electricity. We present the optimal Hybrid Energy System (HES) in this work for off-grid rural electrification, when conventional grid power supply is not feasible. The reliable provision of electricity for an off-grid distant location is contingent upon utilizing a combination of nonconventional energy sources and biodiesel generators. The program used for the entire analysis in this case is called HOMERS. The simulation's findings show that the suggested HES would be a workable option for dispersed electric power generation for far The entire analysis is done using HOMER software. The outcomes of the simulation show that the suggested HES would be a workable option for dispersed electricity generation in remote areas and energy is the source of the reduction in overall CO2 emissions from gird-extension.

Keywords: DDUGJY, HES, HOMER, Emission.

1.Introduction:

Industrialization and urbanization are causing a significant rise in energy demand. Approximately 130 million individuals worldwide do not have access to in [1], electricity. Continuing to be the primary worldwide challenge is the provision of reliable and reasonably priced electrical services. Not just India, but the entire world is dealing with this issue. For rural electrification, grid extension is still the recommended method. Financial viability or practical impossibility may accompany the central power grid's expansion to electrify urban and rural areas [2]. Such an isolated place may benefit from off-grid electrification options.

The Deen Dayal Upadhyaya Gram Jyoti Yojana (DDUGJY) was established by the Indian government to provide electrification to rural areas where grid extension is not feasible. In accordance with the For agricultural and residential purposes in rural areas, DDUGJY utilized a separate feeder [3]. The Indian government is concentrating its efforts on fortifying the sub-transmission and distribution network, along with the metering of all distant locations.

The goal of this research project is to determine the combination of nonconventional energy sources from the resources accessible in a specific distant geographic location in order to minimize grid extension.

A hybrid energy system, or HES, combines various nonconventional energy sources in remote areas where expanding the grid would be impractical or financially unfeasible and where fuel prices vary depending on the type of remote site [4].In recent time, the combination of flat PV array, a wind turbine is become more popular and being widely used in all over world alternative of fossil fuel.

Of the 43,264 census villages in Rajasthan, India, 43,151 villages (99.7%) have electricity, leaving 113 villages unconnected [5]. Under DDUGJY, every off-grid village that remains is electrified. We utilized HOMER software in our study project and selected the isolated village of Narayanpura in the Jhalawar district of Rajasthan for electrification. The most popular program for system optimization is HOMER. In order to get the best optimization outcome, we first determine what resources are available at the remote location and then model the production of power using different combinations of renewable energy sources and biodiesel generator. Second, we optimized the hybrid power system using HOMER software, which produced the greatest results.

For instance, Bhattacharya and Hafez looked at the best possible model for a RES-based micro grid system in a fictitious rural area. when the daily base load demand is 600 kW.The daily energy demand is 5000 kWh. In order to generate electricity, a hybrid system combines flat photovoltaic, wind turbine, hydro, and diesel generator resources [6]. AHM Yatim et al. examined a hypothetical residential area in Malaysia with a peak demand of 80 kW and used HOMER software to optimize a hybrid system [7].

In this work, we attempt to address the following problems with HOMER software.

• How cost-effective would it be if power was provided by the hybrid setup?

• What would be the economic benefit if villages adopted a renewable energy system?

An additional benefit is that employing non-conventional energy sources lowers overall CO_2 emissions.

2.Methodology:

2.1 Homer Software

A tool for simulating and assessing hybrid power systems, or micro power technology, which combine traditional batteries, fuel cells, biomass, generator, flat photovoltaics, and other inputs. NREL created it for the purpose of designing and simulating hybrid power systems but correlatives it by engaging HOMER analyses [8]. The framework of HOMER software is shown in fig.1.

The life-cycle cost (LCC) and technical attributes of the system serve as the foundation for the HOMER optimization analysis. The LCC covers the upfront capital expense, the price of setup and use for the duration of the system. HOMER uses resource availability and alternative technologies to simulate meeting the given power demand. The simulation is used to determine which configuration is most appropriate.

We have considered the mixture of the biodiesel generator flat PVarray, wind turbine, converter systems and batteries for backup. In the hybrid system, the bio-diesel generator and the wind turbine is AC-coupled on AC side of the system and the solar PV cell array and the batteries are connected to its DC side of the system.

2.2. System Modeling:

In our research, we choose off-grid Narayanpura village is situated in the Jhalawar district of Rajasthan, India's Jhalrapatan Tehsil. It is located 15 km from the district headquarters in Jhalawar and 23 km from the sub-district headquarters in Jhalrapatan. [9]. First, we select the best hybrid system among the renewable energy sources that are available, and then we use the hybrid system to electrify a remote area. The NASA Surface Meteorology and Solar Energy report states that the RET Screen Data [10] for Narayanpura is displayed in Table 1 below.

Table 1: Location of Jhalawar, Rajasthan, India

Climate data (Unite)	Value
Latitude (°N)	24.597
Longitude (°E)	76.161
Elevation (m)	382
Heating design temperature (°C)	12.65
Cooling design temperature (°C)	37.43
Earth temperature amplitude (°C)	21.75

2.3 Load Assessment:

Compared to urban areas, the demand for power is lower in isolated rural communities. Demand for electricity is divided into two categories.

• Domestic demand (for devices such as table fans, ceiling fans, and fluorescent lamps, among others)

• Demand from agriculture (such as water tapping)

Domestic Use :

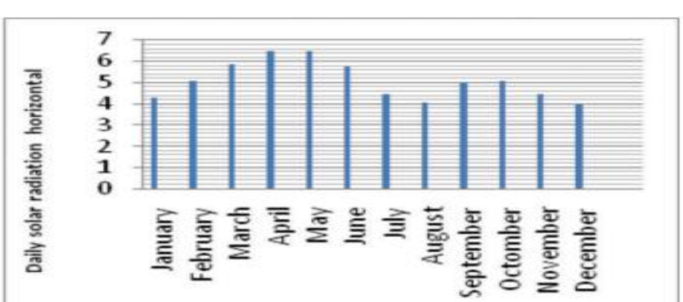
The demand for the village is carefully calculated in this article, and the number of households in the village is based on information from the 2011 Indian census. Demand has been computed. individually for the two distinct seasons that predominate in this isolated area, namely summer (April to October) and winter (November to March), taking into account the home devices and patterns of use for several settlements [11] as indicated in table 2.

Table 2: Estimated Electricity Domestic Demand for Off-Grid Remote Area

Domestic Purpose	Number in use	Power (W)	Demand in summer season		Demand in winter season	
			h/day	Wh/day	h/day	Wh/day
Low energy (LED)	3	5/9/14/20	6	120	7	140
Ceiling fan	1	50	15	750	0	0
Total				870		140
No. of houses	78			63,960		10,920
Shops	10	600	8	4800	7	4200
School	1			1360		1200
Community Centre	1	1000	8	8000	6	6000
Total		1670		78,120		22,320

*Number of houses according census data of India 2011

Agriculture Activities The energy Ew in watt-hour/day (Wh/day) is equal to the multiplication of power Pin watts and times the time period t in hours in per day: E = P(W) × t(h/day) w = 1500 W× 6 hours/day = 9000 Wh/day For seven unit of electric pump, the total Energy will be Ew = 7 × 9000 Wh/day Ew = 63 kWh/day.



3. Economical Modeling:

CASE I: If a rural region is electrified through a grid expansion, but it is not feasible due to the rural area's location being too far from the grid substation or it is located in a crucial area, the cost of electricity (COE) is raised as a result of additional costs that are added to the COE as well as transmission costs.

CASE II: Our goals are to lower the overall net present cost for both setting up and running the ideal system configuration. Our goal was to create a hybrid system using unconventional energy sources. We've thought about the combination of the wind turbine, flat photovoltaic array, converter systems, and backup batteries for the biodiesel generator. The solar PV cell array and the batteries are connected to the hybrid system's DC side, while the wind turbine and biodiesel generator are connected to the system's AC side (see Fig. 4 for a schematic system setup diagram). In this HES simulation, we have taken into account flat photovoltaic arrays, wind turbines, and biodiesel resources. The monthly average of the wind resource and temperature from the NASA resource page according to the local location's longitude and latitude [12].NASA resource data indicates that max. and mini. Solar.Figure 2 displays the radiation ranges, which are 3.80 kWh/m2/d in June and 1.80 kWh/m2/d in November. Figure 3 displays the highest and minimum wind speeds, which are 3.80 m/s in June and 1.80 m/s in November, respectively.

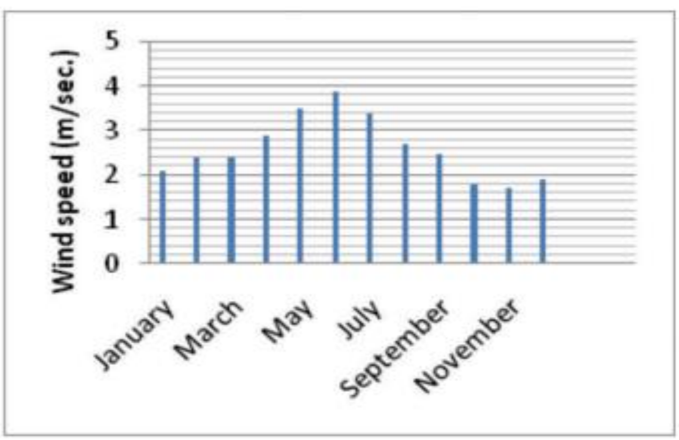
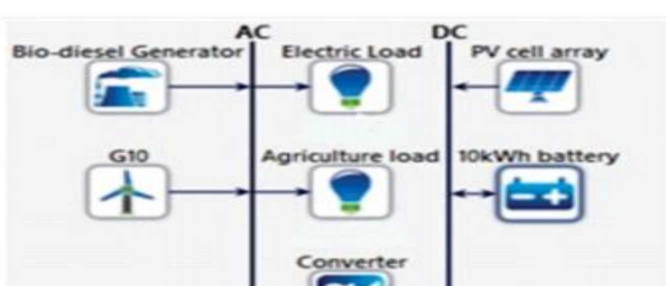


Fig.3 Wind Speed in M/Sec Data



The project's lifetime is estimated to be 25 years with an annual percentage rate of 10%. The capacity, lifetime, system fixed capital cost, replacement cost and the system fixed O&M cost is shown in table 3.

Table3: Estimated Electricity Domestic Demand for Off-Grid Remote Area

Component	Capital	Replacement	O&M	Fuel	Salvage	Total
Flat PV	143.98	00	0.035	00	00	144.01
Wind turbine	104.00	22.97	2.11	00	11.81	117.27
Hydro	29.25	00	3.16	00	00	32.41
Bio-diesel generator	73.12	187.78	13.14	33.53	0.88	306.70
10kWh battery lead acid	0.55	0.38	0.007	00	0.042	0.90
Converter	93.60	30.15	0.042	00	4.72	119.07
System	444.50	241.30	18.49	33.53	17.46	720.37

4. Result & discussion:

This We present the findings of our investigation in this part. The optimization findings are presented first, and then the emission reduction is calculated. The sources of unconventional energy are employed, with the optimal simulation configuration determined by the HES simulation method displayed in Table 4.

Table 4: Hybrid System Architecture for configuration

Configuration	NPC (Cost in Rs. Lakhs)	LCOE (Cost in Rs. Lakhs)	Operating cost	Bio-diesel generator production (kWh/yr)	Excess electricity (kWh/yr)	Unmet load (kWh/yr)	Max. renew penetration
PV/Wind turbine/ Biodiesel/ converter/ battery	720.37	141.05	18.49	29,527	30,823	3.3	915

Configuration		
Production	kWh/yr	Percentage
Flat PV	51,644	60.23
Bio-diesel generator	29,527	34.74
Wind turbine	4,277	5.03

Figure 5 illustrates how the average monthly demand for AC primary load varied over the course of several months, as assessed by the HOMER software. The biodiesel generator is utilized in conjunction with a flat photovoltaic array and peak electricity demand in January through December. The wind turbine is met during peak month. Figure 6 below illustrates the month-by-month pattern o[illegible]'s generation (in kW).

Fig.5 Avg. Ac Primary Load in Various Months

Based on the configuration optimization result, the hybrid system's Life Cycle Expense Ratio (LCOE) is Rs. 141.05. In light of this, the hybrid system's configuration's cost of electricity (COE) is Rs. 4.455/kWh. The state government's tariff for rural areas, which is based on unit consumption each month, is the basis for the COE per unit under CASE I [13]. In CASE II, we select the best hybrid configuration based on non-conventional energy sources and compute the optimal COE of the HES. Table 6 displays the COE for each of the three situations.

Table 6: COE for all different cases

CASE I		CASE II
For consumption up to first 50 units per month	Rs. 3.50/unit	The COE for optimal Hybrid system is Rs. 4.455/unit.
For consumption above 50 units and up to 150 units per month	Rs. 5.45/unit	

5. Emissions:

Table 7 below illustrates how the ideal HES would save 201,165.00 kg of CO2 annually. Dependency on non-conventional energy will result in a decrease in the emission of impure materials and NOX. In Two different types of biofuel were employed in the hybrid system to power a biodiesel generator. The US Environmental Protection Agency has two types of biodiesel: B-20, which is a blend of 20% biodiesel and 80% oildiesel, and B-100, which is 100% pure biodiesel. biodiesel [14

Table 7: Emission Reduction

Quantity	Configuration-Value
Carbon dioxide (CO2)	133.37 kg/yr
Carbon monoxide (CO)	84.88 kg/yr
Unburned hydrocarbon	9.40 kg/yr
Unburned hydrocarbon	6.40 kg/yr
Sulfur dioxide	0.00 kg/yr
Nitrogen oxide	757.34 kg/yr

6. Conclusion:

In summary, our research has produced a workable hybrid solution that can provide towns with off-grid electrical supply. The least expensive combination of a wind turbine, flat photovoltaic array, biodiesel engine, and batteries was used. The conversion of isolated off-grid communities' emissions are decreased with the aid of unconventional energy sources. Deforestation has decreased and petroleum fuel use has decreased as a result of the reduction in CO2 emissions.The following are the key takeaways from this case study: • Using a variety of technologies enhances supply reliability, which makes better commercial sense.

• The cost-effectiveness of electrifying rural areas may not necessarily be dependent on the cost of electricity supply from nonconventional energy sources. if the fuel cost for biodiesel and the fixed cost of the HES increase.

• A rise in the number of off-grid settlements is accompanied with an increase in economically viable communities.

Based on the study above, we may conclude that HES overtakes grid extension as a technically and financially feasible alternative for off-grid electrification in India. Outcomes, If we electrify off-grid loads using a combination of non-traditional energy sources rather than relying just on solar panels and conventional grid expansion, the DDUGJY system is more dependable and efficient.

References:

[1] IEA, Measuring progress towards energy for all: power to the people? Chapter 18, World Energy Outlook, International Energy Agency, Paris, 2012.

[2] Bhattacharyya, SC, Energy access programmers and sustainable development: a critical review and analysis, Energy for Sustainable Development(2012), 16(3): pp. 260-71.

[3] Govt. of India, Official website, http://pmindia.gov.in/en/tag/deendayalupadhyaya-gram-jyoti-yojana/, 10 January, 2016.

[4] Nema P, Nema RK, Rangnekar S. A current and future state of art development of hybrid energy system using wind and PV–solar: a review. Renewable and Sustainable Energy Reviews, (2009), 13(8):2096–103.

[5] Govt. of India scheme available at: http://ddugjy.gov.in/mis/portal/index.jsp. ,7 October, 2016.

[6] Hafez, O. and K Bhattacharya, Optimal planning and design of a renewable energy based supply system for microgrids, Renewable Energy, (2012), pp. s7-15.

[7] Lau, K. Y., MFM Yousof, SNM Arshad, M. Anwari and AHM Yatim, Performance analysis of hybrid photovoltaic/ diesel energy system.

[8] HOMER energy and HOMER pro software. Available at: http://homerenergy.com/, 7 December, 2016.

[9] Govt. of Rajasthan, Welcome to Jhalawar: An Official Website of MiniSecretariat-Jhalawar, http://jhalawar.rajsthan.gov.in,22 July, 2015.

[10] National Aeronautics and Space Administration's (NASA) Surface Meteorology and Solar Energy, http://eosweb.larc.nasa.gov/sse/, 4 November, 2015.

[11] Govt. of India, Census India: Our census Our future, http://censusindia.gov.in/, 16 Octember, 2015.

[12] NASA Surface meteorology and Solar Energy: RET Screen Data. ttps://eosweb.larc.nasa.gov/cgibin/sse/retscreen.cgi?&email=rets@nrcan.gc.ca&step=1&p=&lat=25.10 11438&submit=Submit&lon=76.51316369999995> Last accessed on 15 march, 2016.

[13] The Rajasthan Electricity Regulatory Commission, available at: http://rerc.rajasthan.gov.in/TariffOrders/Order203.pdf., 2014.

[14] United States Environmental Protection Agency, "A Comprehensive Analysis of Biodiesel Impacts on Exhaust Emissions", Draft Technical Report, EPA420-P-02-001, Available at: http://www.epa.gov/otaq/models/analysis/biodsl/p02001.pdf. October 2002