To Propose a Hybrid Rural Electrification System for Bhasinghpura Village of Phulera, Rajasthan

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Abstract — The main objective of this study is the comparative analysis among the options which are to be used for providing energy access to the rural population of few specific villages as per the energy consumption data collected from those selected villages. The goal of the study is to be carried through a survey which will be conducted for the estimation of energy demand as well as energy use pattern at those areas for which the energy access is to be provided. After the collection of energy demand and energy use pattern data, analysis have to be performed on these data collected, in order to find out the most appropriate as well as the economical technological option for solving the energy access problem associating with selected village. Bhasinghpura village is selected for the analyses which are located in Phulera Tehsil, Jaipur district of Rajasthan state. Providing energy access to these selected rural villages in the state of Rajasthan is done by going through a questionnaire-based survey which will be conducted, in those villages in order to find out the exact energy demands as well as the energy use patterns of those villages, based upon which the renewable energy option will be decided. Calculation in terms of installation cost, number of PV module requirement, land requirement, maintenance cost, total project cost, invertor requirement and operation cost have been done for this village. A comparison study also has been done for the proposed SPV plant with hybrid plant and it is observed that the hybrid system has better electricity generation capacity and installed in low cost as compared to stand alone SPV system.

Index Terms— Hybrid electrification, Solar PV, Power plant

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1. INTRODUCTION

Major sources of renewable energy are wind energy, solar energy, biomass energy and biogas energy etc. In India, more than 200 million people live in rural areas without access to grid-connected power. In most of the remote and non-electrified sites, extension of utility grid lines experiences high capital investment, high lead time, low load factor, poor voltage regulation and frequent power supply interruptions. Thus, to overcome all the disadvantages possessed hybrid system. The main motivation behind this presentation is the combination of two renewable energy sources of energy, so that generation could be increased, be more efficient along with being quite cheap.

Chandel et al. [1] proposed one on-site solar photovoltaic power plant and one-off site solar photovoltaic power plant in order to provide required electricity to garment zone located in Jaipur in Rajasthan state. To select the best option between plants proposed i.e. onsite plant and off-site plant, financial parameters of each plant are calculated. The internal rate of return (IRR), net present value (NPV) at 10 % discount rate, simple payback period, discounted payback period at 10 % discount rate and Levelized cost of energy at 10 % discount rate are 11.88%, 119.52 million INR, 7.73 years, 15.53 years and 14.94 Rs. Per kWh for an on-site power plant and 15.10%, 249.78 million INR, 6.19 years and 11.40 Rs. Per kWh for the off-site power plant. Demoulias [2] determined the optimization of the inverter sizing for a grid-connected solar PV plant. Four parameters are used in analytical methodology in which three are related to the inverter and the other one is with to the location and rated power rating of the plant. Also, analytical expressions for the calculation of the annual energy injected into the ac grid for a given PV plant with a given inverter, are also provided. The validity of the proposed analytical model was tested through comparison with results obtained by detailed simulation and with measured data. Rahman et al. [3] suggested battery bank addition and sizing to a solar PV plant to make maintain system voltages within the limits. In this study, it is proposed an optimization-based algorithm for the sizing of residential battery storage co-located with solar PV, with taking PV incentives such as feed-in tariffs. The main aim of this study is to optimize daily savings and reducing large voltage variation. For this a quadratic program (QP) based algorithm used. For this load and generation data is collected from 145 residential customers in Australia. The results of this analysis are QP-based scheduling algorithm significantly penalizes reverse power flow. Rodrigues et al. [4] broke down a delegate set of nations, including Australia, Brazil, China, Germany, India, Iran, Italy, Japan, Portugal, South Africa, Spain, United Kingdom, and the United States of America, to recognize the ones with the best venture open doors thinking about the new guidelines. There are two contextual analyses incorporated into this paper in which distinctive size of sun-powered photovoltaic frameworks (1kW and 5kW) are utilized. Each contextual investigation incorporates four diverse utilization situations running from 100% self-utilization to 30%. Generally speaking, the outcomes demonstrate that the most benefit can be made in Australia, Germany, and Italy. In these nations, it is conceivable to fourfold the venture amid the 25-year time frame with a 5kW PV framework which is generally 13% higher than most European nations. Besides, this investigation investigates the ebb and flow strategies and states of little-scale sunlight-based PV industry in the chose nations, giving huge advantage to different substances in particular strategy producers, financial specialists, and analysts who are working under the sun-powered vitality space. Sumathi et al. [5] revealed an audit of different strategies for sun based following increases in vitality because of the following and diverse MPPT calculations. The non-renewable energy sources are non-sustainable, constrained and exhaust. Consequently, it is basic to discover elective wellsprings of vitality. As sun-powered vitality is accessible plentifully in nature, it tends to be considered as the best choice to satisfy the vitality need. The test in tapping this vitality is to expand the effectiveness just as to diminish the expense of generation. Hence, an endeavor is made to survey the different Maximum Power Point Tracking (MPPT) calculations, diverse sun oriented following strategies and the vitality picked up by utilizing these techniques. The work centers around the introduction of the sun-based board towards the bearing of most extreme radiation by utilizing a stepper engine interfaced with ARM processor. Lee et al. [6] contemplated the streamlined execution of two unique kinds of a flat pivot wind turbine (HAWT) cutting edges. One is a commonplace sort structured by the cutting-edge component force hypothesis (BEMT); the other is a non-curved sort with steady harmony length. The motivation behind this examination is to research the execution increase of the previous by investigations just as numerical reproductions. The reproductions end up being predictable with the trial information. Pradhan et al. [7] talked about the sustainable mixture control creation framework which is appropriate for Khalardda town set in Odisha. All aspects of the heap realities of the town is formed and accordingly amount of capacity to be made is planned. The specialized, monetary capability of sun-based PV-biomass-biogas half breed framework is considered. This methodology can apply for development of the town in water system, common disasters and cultivating. It very well may be settled that sunlight based and biomass-biogas crossover framework is a suitable green innovation hotspot for country charge.

2 SELECTION OF VILLAGE

The electrification purpose is carried out for the village Bhasinghpura, situated at the distance of 56 km from the Jaipur city and 61 km from district headquarter Jaipur in west direction.

3 ANALYSIS OF LOAD ESTIMATION

3.1 CALCULATIONS FOR VILLAGE BHASINGHPURA

Per day consumption of 20 household = 200 kWh
Therefore, per day electricity consumption per family = 200/20 = 10 kWh
Total number of families = 184
Therefore, per day consumption of whole village = 184 × 10 = 1840 kWh = 0.00184 MWh
Total population = 1241
Therefore, per day per capita electricity consumption = 1840/1241 = 1.48 kWh

3.2 ELECTRICAL ENERGY REQUIRED FROM PV MODULES

Per day electrical energy consumed by 20 families = 200 kWh
For solar photovoltaic power plant losses are considered as 30% therefore 30% additional of the total requirements has to be designed.
Electrical energy required from PV modules =1.3 × 200 = 260 kWh/day

3.3 PV MODULES TOTAL WATT PEAK RATING

Total electrical PV modules total watt peak rating is the ratio of electrical energy required from PV modules and panel generation factor of the location selected.
PV modules total watt peak rating = (Energy required from PV modules)/ (Panel generation factor)
PV modules total Watt peak rating = 260/5.75 = 54.21 kW

3.4 PV MODULES REQUIREMENT

PV modules requirement is the total number of the PV panel which is required to generate the desired power and can be calculated by given formula.
Total Number of PV modules required = (Total watt peak rating) / (PV module peak rated output)
Total Number of PV modules required = (45.21×10^3)/250 = 180.84 ~ 181 modules
Maximum open circuit dc voltage of string = 600 V
Open circuit voltage of PV module = 37.5 V
Number of PV modules connected in series = (Maximum open circuit dc voltage of string) / (Open circuit voltage of PV module)
Number of PV modules connected in series = 600/37.5 = 16 panels
Maximum power dc voltage of PV module = 30.1 V
Maximum power dc voltage at the input terminals of inverter
= Number of PV modules connected in series × Maximum power dc voltage of PV module
= 16 × 30.1 = 481.6 V
Number of PV arrays required = (Total number of PV modules required) / (Number of PV modules connected in series)
Number of PV arrays required=181/16 = 9.06 ~ 10 arrays

3.5 INVERTER REQUIREMENT

The size of inverter is the function of the maximum demand occurring at the load side; therefore, inverter size must be selected in accordance with the peak power requirement of the load.
The maximum demand of 20 families = 200 kW
The inverter must be large enough to handle the total amount of watts garment zone will be using at one time. The inverter size should be 25-30% bigger than total watts of appliances and machines.

Inverter size = 200 ×1.3 = 260 kW
APOLLO GTP-503 inverter is considered for the power plant.
Number of APOLLO GTP-506 inverters required = 3
Total wattage supported by the inverter =Number of inverters × wattage of inverter
Total wattage supported by the inverter = 3 × 90 kW = 270 kW

3.6 LAND REQUIRED

Number of PV modules required = 181 modules
Width of PV module or panel = 992 mm = 0.992 m
Length of PV module = 164 mm = 1.64 m
Number of modules in an array connected in series = 16 modules
Width of PV array = 16 × 0.992 = 15.87 m ~ 16 m
Length of PV module = 1.64 m
Number of arrays in PV field = 12 arrays
Number of arrays in a row = 1
Width of the solar field = 1 × 16 = 16 meters
Number of Rows in solar field = 11
Distance between two arrays = 3 meters
Length of the solar field = 11 × 3 = 33 meters
Land Required for PV field = 33 × 16 = 528 m2 = 0.13 Acers = 631 square yards
[1 Acer = 4047 m2] [1 square yard = 0.8361 m^2]

3.7 PROJECT COST

Project of solar photovoltaic power plant for 20 families of village Bhasinghpura is tabulated in Table 1.

Table 1 Project Cost of PV Power Plant of 50 Kw Capacity

Capital Cost for Solar PV Power plant in Rs. Lakh		
S. No.	Particulars/Years	Cost
1	PV Modules Cost	13.82
2	Land Cost	1.23
3	Civil and General Works Cost	5.12
4	Mounting Structures Cost	8.11
5	Power Conditioning Unit Cost	2.25
6	Evacuation Cost up to Inter-connection Point (Cables and Transformers) Cost	9.13
7	Preliminary and Pre-Operative Expenses including IDC and contingency Cost	2.42
8	Capital Cost	**42.08**
9	Capital cost with 30% capital subsidy	**29.45**

3.8 CALCULATION FOR TEN KW WIND POWER PLANT

Technical Justification for Phulera: These data of speed and humidity is mean data taken from the weather department of India and calculation is done accordingly. The maximum speed of the wind remains here is 8 m/s. Table 2 represents the 10 kW aero generator specifications.

Table 2 10 kW Aero-Generator

S. No	**Wind Speed (m/s)**	**Time (Hours)**	**Lamda (Value)**	**Cp (Value)**	**Power (kW)**	**Energy (kWh)**
1	3	4	2.09	0.515	0.406	1.627
2	4	5	3.14	0.537	1.005	5.028
3	5	6	3.76	0.539	1.9717	11.830
4	6	1	4.18	0.541	3.419	3.419
5	7	2	4.48	0.544	4.687	9.374
6	8	2	4.71	0.545	8.166	16.332
				TOTAL	19.654	47.588

Table 3 shows the expenditure details for proposed hybrid power plant.

Table 3 Expenditure Detail of the Proposed Plants

Particulars	**10kW**
Cost of Aero Generator (Rs)	500,000
Cost of Other Items (Rs)	15,000
Total Equipment Cost (Rs)	515,000
Installation Cost (Rs)	50,000

Total Cost (Rs)	565,000
Interest on Total Cost per year (Rs)	56,500
Maintenance Cost (Rs)	20,000
Total Expenditure Per Year (Rs)	76,500
Total Expenditure Per Day (Rs)	209.58
Total Electricity Generated Units Per Year (Units)	17369.62
Total Electricity Generated Units Per day (Units)	48

3.9 ECONOMIC ANALYSIS OF HYBRID SYSTEM
- Total Cost of 40 kW SPV plant- 27,62,000
- Total cost of 10 kW wind plant – 5,15,000
- Total cost of hybrid system - 32,77,000
- Per day unit of 40 kW SPV plant – 160 units
- Per day unit of 10 kW wind plant – 48 units
- Per day unit of hybrid system - 208 units

3.10 ECONOMIC ANALYSIS OF HYBRID SYSTEM

1. Technical analysis
- Number of units produced in 50 kW SPV plant – 200 units per day
- Number of units produced in hybrid plant (40 kW SPV + 10 kW wind) – 208 units per day
- As for the hybrid energy system we have per day unit generation is high as compared to SPV plant.

2. Economic analysis
- Total cost = installation cost + maintenance cost
- Total cost of 50 kW SPV plant - 2945000 Rs.
- Total cost of hybrid plant (40 kW SPV + 10 kW wind) – 3277000 Rs.
- In the above analysis, we have total cost of hybrid system is less than SPV system. The cost of the system varies from Rs. 3.32 lakhs per kW depending on the ratio of wind and solar components.
- The approximate cost of installation, including civil works, is about Rs. 10,000. Repair and maintenance cost is about Rs. 3000 per kW per annum.

4. CONCLUSION
The present study investigated the technical feasibility and economic viability of renewable energy technology-based energy generation system i.e., solar photovoltaic power (SPV) plants and hybrid power plant (SPV and Wind energy) for Bhasighpura. The amount of energy required for 20 families by the village Bhasighpura is estimated as 200 kWh per day and consumption of electricity is 1.48 kWh/day per capita. To meet the requirement of energy, a solar photovoltaic plant of 50 kW will be required and the amount of electrical energy will be harnessed from these SPV is 260 kWh/day. For calculated amount of energy, 181 modules are required which cover 631 square yards of land area and the total subsidized cost of SPV power plant is approximately 29.45 lac rupees. Under the circumstance of power failure this hybrid system keeps the continuity of supply. A comparative study has been revealed that hybrid system generates 8 units more per day as compared to SPV system and hybrid power plant also operates at lower cost than SPV system.

REFERENCES
1. Chandel M, Agrawal GD, Mathur S, Mathur A (2014) Techno-economic analysis of solar photovoltaic power plant for garment zone of Jaipur city. Case Stud Therm Eng 2:1–7. https://doi.org/10.1016/j.csite.2013.10.002
2. Demoulias C (2010) A new simple analytical method for calculating the optimum inverter size in grid-connected PV plants. Electr Power Syst Res 80:1197–1204. https://doi.org/10.1016/j.epsr.2010.04.005
3. Ratnam EL, Weller SR, Kellett CM (2015) An optimization-based approach to scheduling residential battery storage with solar PV: Assessing customer benefit. Renew Energy 75:123–134. https://doi.org/10.1016/j.renene.2014.09.008
4. Rodrigues S, Torabikalaki R, Faria F, et al (2016) Economic feasibility analysis of small scale PV systems in different countries. https://doi.org/10.1016/j.solener.2016.02.019
5. Sumathi V, Jayapragash R, Bakshi A, Kumar Akella P (2017) Solar tracking methods to maximize PV system output – A review of the methods adopted in recent decade. Renew Sustain Energy Rev 74:130–138. https://doi.org/10.1016/j.rser.2017.02.013
6. Lee MH, Shiah YC, Bai CJ (2016) Experiments and numerical simulations of the rotor-blade performance for a small-scale horizontal axis wind turbine. J Wind Eng Ind Aerodyn 149:17–29. https://doi.org/10.1016/j.jweia.2015.12.002
7. Pradhan A, Rout K, Nayak J, et al (2018) An Economic Rural Electrification Study Using Combined Hybrid Solar and Biomass-Biogas System. Mater Today Proc 5:220–225. https://doi.org/10.1016/j.matpr.2017.11.075