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Solar DC Microgrid for Rural Electrification

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ABSTRACT

In this paper, we detail the design, analysis, and implementation of a highly distributed off-grid solar photovoltaic DC microgrid architecture suitable for rural electrification in developing countries. The proposed architecture is superior in comparison with existing architectures for rural electrification because of its a) generation and storage scalability,b) higher distribution efficiency (because of distributed generation and distributed storage for lower line losses), c) ability to provide power for larger communal loads without the requirement for large, dedicated generation by extracting the benefit of usage diversity. The proposed microgrid architecture consists of several nanogrids capable of the self-sustained generation, storage, and bidirectional flow of power within the microgrid. Bidirectional power flow and distributed voltage droop control are implemented through the duty cycle control of a modified flyback converter.

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I. INTRODUCTION

Currently used power systems are primarily based on the constraints on distribution systems that were imposed over a century ago. AC power systems enable efficient transformation of voltage from one level to another, allowing power to be carried for long distances with minimum line losses [1]. This has rendered AC power networks the preferred choice for power transmission and distribution. However, limited funds for the construction of large power plants and the high cost of long-distance transmission lines are among the hurdles to meeting growing energy demands, especially in regions that have not been electrified.

According to the International Energy Agency (IEA), 1.3 billion people living in developing countries, i.e., ~ 17.5% of the world's population, do not have access to electricity [2]. The development of mega projects for the rural electrification of these communities in developing countries is constrained by the limitation of resources. Alternatively, various standalone solar photovoltaic (PV) systems have been incorporated as a stop-gap measure to provide rural residents with basic electricity [3, 4]. These systems generally provide between a few watts to a few tens of watts for an average rural house. However, these standalone solutions are suboptimal, as without resource sharing, they do not take advantage of electricity usage diversity. These regions need ample electricity to bear communal loads for facilities such as schools, basic health units and water filtration plants.

This paper presents a design for a stand-alone photovoltaic (PV) system to provide the required electricity for a single residential household in rural area in India. The complete design steps for the suggested household loads are carried out. Site radiation data and the electrical load data of a typical household in the considered site are taken into account during the design steps. The reliability of the system is quantified by the loss of load probability. A computer program is developed to simulate the PV system behaviour and to numerically find an optimal combination of PV array and battery bank for the design of stand-alone photovoltaic systems in terms of reliability and costs. The program calculates life cycle cost and annualized unit electrical cost. Simulations results showed that a value of loss of load probability LLP can be met by several combinations of PV array and battery storage. The method developed here uniquely determines the optimum configuration that meets the load demand with the minimum cost. [5,6]

II. PROBLEM STATEMENT

In rural areas, which are apart from the main transmission line lack of electricity is the main problem.to overcome this problem, we are designing a solar DC micro-grid system.by using this we can overcome this problem.

A. OBJECTIVES

- To provide basic need of electricity at rural are
- To eliminate cost of transmission line by DC microgri
- To improves the environment and promotes clean energy.

III. DESIGN AND CONSTRUCTION

A model of microgrid:
Microgrid is architecture that integrates its resources in a scalable mannerinto the community. Each house contains a roof-mounted solar panel, a few DC loads and battery storage. The bidirectional flow of power is controlled via power electronic converters referred to as central power processing units (CPPUs). A CPPU contains a microcontroller along with a maximum power point tracking (MPPT)-based DC-DC converter and a bidirectional flyback converter.

DC-DC MPPT Converter:
The output power of a PV panel is a non-linear function of temperature and incident irradiance [21]. MPPT techniques are employed to extract the maximum power from the available solar energy. Various schemes for MPPT under uniform and non-uniform irradiance have been discussed in the literature [22, 23]. In this article, the perturb and observe (P & O) algorithm is employed due to its simplicity and low computational complexity [22]. The conversion ratio of the DC-to-DC converter is adjusted such that its output voltage is suitable for supplying power to the load and charging the battery. Based on the time-varying values of the output voltage and current of the PV panel, the controller adjusts the duty cycle of the converter to obtain the desired voltage conversion or MPPT for all operating conditions.

PV system design is a process of determining capacity (in terms of power, voltage and current) of each component of a stand-alone photovoltaic power system with the view to meeting the load requirement of the residence for which the design is made. The designing is done following the steps given below:
Step 1: Site inspection and radiation analysis.

Step 2: Calculation of building load requirement.

steps3: Choice of system voltage and components.

Step 4: Determine capacity of Inverter.

Step 5: Determine capacity of Battery

Step 6: Charge controller specification.

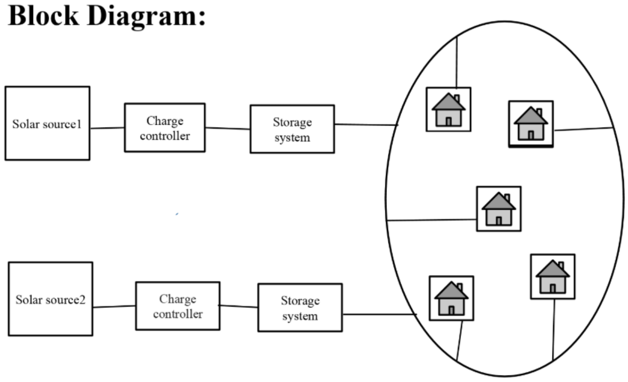
Step 7: DC Cable Sizing.

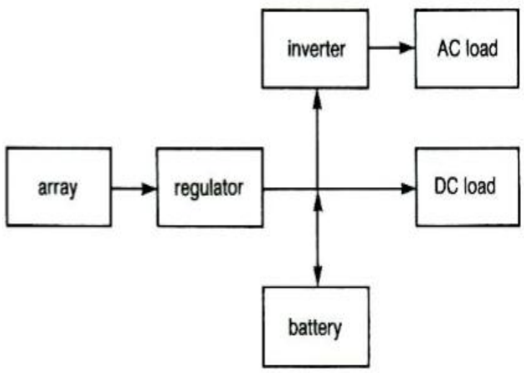
Step 8: Solar PV array specification and design layout.

Step 9: PV Module orientation and land requirement.

Step 10: Cost Analysis

Block Diagram:





WORKING AND STEPS:
We have to design system in two wings. In extreme condition if any one wing have fault occurs then system can run easily on second wing. We have to make circular grid which is easy for distribution.

Solar panels:
The model of solar panel used JJSPV-P0300.
Which is 300W panel. Open circuit voltage is 44v,Short circuit current is 8.6A.

Charge controller:
We have to use MPPT charge controller. Its rating depends on capacity of battery.

Battery:
Generally we have to use lead acid battery. Its specification depends on load.

Cables:
Cables will conform to IS694 and shall be of 650V/1.1Kvgrade. Inter connections; array to junction boxes, junction boxes to Inverter etc. will be selected to keep voltage drop &losses to the minimum. The bright annealed 99.97% pure bare copper conductors result in lower heating thereby increasing cable life and efficiency. These wires are insulated with a special grade PVC compound.

IV. RESULT TABLE

1	General Information		
	Solar PV system capacity in KWp	12	KWp
	No of PV panels of 325 Wp	38	Nos
	Solar Grid tied Inverter capacity in Kw	13.5	KW
	Mounting Structure	GI/AL	
2	Installation cost		
	Solar PV system capacity in KWp	12	KW
A	Total cost of installation in Lakhs	8.4	Lakhs
B	Tax depreciation @ 80%	00	Lakhs
C	I)Tax rebate @ 30% of 00 Lakh	0.00	Lakhs
	II) Govt Subsidy	0.00	Lakhs
D	Effective cost for ROI calculation A-C)	8.4	Lakhs
3	ROI Calculation		
E	MSEB Rate /unit	14.5	Rs/KWh
	Units generation by PV system/day/KW	4	KWh
	Units generation by 10KW PV system/day	72	KWh
F	Annual electricity generation	21600	KWh
G	Cost of annual solar generation (E x F)	3.13	Lakh/Yr
H	ROI = D/G	4	Yr
	Note:		
	1. Here rising electricity costs are not considered.		
	2. Government subsidy is not considered		

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V. CONCLUSION

This paper proposed an optimized DC microgrid architecture for rural electrification with emphasis on the providing power for purposes beyond those related to subsistence-level living.We detail the design analysis and implementation of highly distributed Off grid solar PV dc microgrid architecture suitable for rural electrification in developing country.

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