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Empowering Rural Elementary School by Designing Small Scale PV Panel System

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ABSTRACT: Rural villages in India are increasingly turning to small-scale rooftop solar PV systems as reliable sources of energy. This trend stems from the numerous advantages they offer, including the abundance of solar energy and supportive rural electrification policies. Despite these benefits, however, India has yet to achieve complete rural electrification, which could be attributed to various technical, social, or financial challenges. Consequently, this study aims to explore the potential of deploying solar PV systems for community houses in rural areas. It provides detailed insights into designing PV plants based on factors such as electrical load, required roof area, energy performance, and cost considerations. Moreover, the paper emphasizes the transformative impact of solar energy on rural life, bringing light to previously darkened communities.

KEYWORDS: PV panel, roof top, rural

I. INTRODUCTION

Rooftop solar photovoltaic (PV) systems are widely employed across a spectrum of sizes, spanning from small-scale installations to larger commercial setups [1]. Their widespread adoption can be attributed to their ability to capture abundant solar energy, coupled with the straightforward installation and maintenance procedures [2]. Furthermore, government subsidies and incentives further bolster their appeal, driven by the goal of fostering a cleaner environment in the foreseeable future [3-5].

In recent years, the use of rooftop solar became promising solution for lighting the darker streets and homes of rural communities [2-6]. But however, it is not well adopted. Reasons would be many more covering wider aspects of technology availability, financially affordability, understanding the performance, and its maintenance etc. However, when compared to other popular energy source i.e. biomass, the solar energy systems have more benefits in all the aspects expect in the financial matters [7]. Hence, this paper tries to highlight thedesign, performance, cost involved in developing rooftop solar projects for rural homes based on typical load consumption parameters.

This paper is structured into six sections, each focusing on different aspects related to the deployment of rooftop solar photovoltaic (PV) systems for rural electrification.

Section-I: This section provides a concise introduction highlighting the significance and advantages of solar energy, emphasizing its role in addressing rural energy needs.

Section-II: Here, various rural electrification policies and schemes in India are discussed, showcasing the government's initiatives to promote renewable energy adoption in rural areas.

Section-III: This section presents key statistics related to the current status of rural electrification in India, offering insights into the existing challenges and opportunities.

Section-IV: Analytical discussions are conducted in this section, covering mathematical sizing, roof area requirements, energy generation estimates, and economic considerations of small-scale rooftop solar PV systems.

Section-V: This section proposes different benefits and potential options for optimizing the installation and

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utilization of solar PV systems in rural contexts, considering factors like technology choices and system configurations.

Section-VI: Finally, the paper concludes in this section, summarizing key findings and highlighting conclusions that could facilitate progress in rural electrification efforts in India.

II. RURAL ELECTRIFICATION POLICIES AND SCHEMES IN INDIA

Govt. of India introduced few policies and schemes for the welfare of people living in rural parts of India. The main motto of these policies and schemes is to provide electricity access to the remote areas in India. Policies introduced by Govt. of India are as follows [8, 9]:

- National Electricity Policy 2005
- National Rural Electrification Policy, 2006

Various schemes introduced for promoting rural electrification process are given below [8, 9]:

- Accelerated Rural Electrification Program (AREP)
- BPL Household electrification
- Deen Dayal Upadhyaya Gram Jyoti Yojana (DDUGJY)
- Decentralized Distributed Generation (DDG)
- Kutir Jyoti Program (KJP)
- Minimum Needs Program (MNP)
- Pradhan Mantri Gramodaya Yojna (PMGY)
- Remote Village Electrification Programme
- Rural Electricity Supply Technology Mission (REST)
- Rajiv Gandhi Grameen Vidyutikaran Yojna (RGGVY)
- Village Energy Security Programme (VESP)

III. RURAL SCHOOL ELECTRIFICATION IN INDIA

Rural electrification in India is progressing, albeit with challenges, as the nation strives to achieve universal access to electricity. While a few states have achieved 100% electrification, many others still lag behind, with electrification rates ranging from 35% to 80% [10]. According to survey data from Grameen Vidyut Abhiyanta (GVA) since April 2015, there were 18,452 villages in need of electrification, out of which 15,022 have been electrified thus far. The remaining un-electrified villages stand at 3,430, with 1,035 of them being uninhabited. To address this gap, the Government of India has launched various rural electrification schemes aimed at electrifying 2,395 villages, with work already initiated in 2,293 of them.

Currently, 30 villages are in the process of being energized, while work is yet to commence in the remaining 72 villages [10, 11]. The present state of un-electrified villages is dire, particularly during the night when access to lighting is crucial. A typical scenario depicting the challenges faced in these villages is illustrated in Figure 2.

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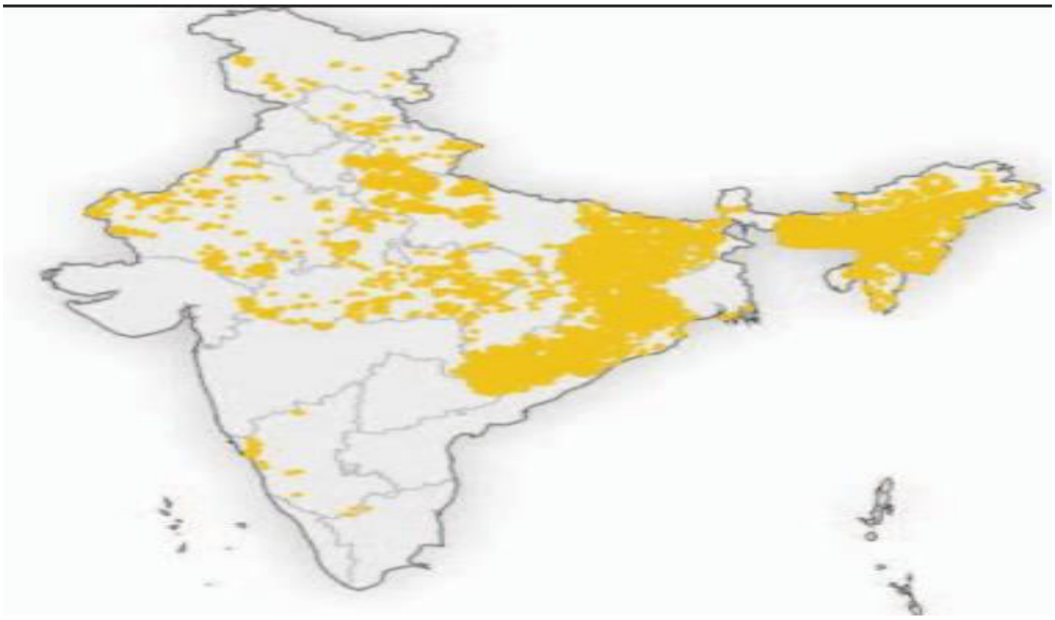

Fig. 1. Map showing the rural electrification status in India (from April 2015 onwards).

Fig. 2. Unelectrified villages under kerosine lamps in rural areas of India. (Source: Reuters)

The proposed small-scale rooftop solar PV system, illustrated in Figure 3, emerges as the optimal solution for bringing electricity to rural housing areas in India. This system effectively caters to the basic power consumption requirements of rural households, encompassing essential needs such as lighting, water pumping, domestic tasks, and entertainment devices. Table I outlines the typical daily electrical load demands of a rural house, revealing a total connected load of 892 W. However, through strategic management of load usage at different intervals throughout the day, the actual energy consumption amounts to approximately 1413 Wh/day. Leveraging this consumption data, this paper presents a comprehensive analysis encompassing mathematical sizing, performance evaluation, and cost estimation tailored to the Indian context, elucidating the viability and benefits of implementing small-scale rooftop solar PV systems.

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Fig. 3. Small scale rooftop solar PV systems and solar street lighting in rural villages school of India.

Fig. 4. Doing the case study in Gudepachgani

IV. LOAD CALCULATION

Name of Application	Quantity	Power	Use per day	WH/day
Tube lights	3	20W	5Hr/D	300WH/D
Fan	1	60W	5Hr/D	300WH/D
Computer	1	100W	2Hr/D	200WH/D
Bulb	2	9W	5Hr/D	90WH/D
Projector	1	300W	1Hr/D	300WH/D
			Total	1190WH/D

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Total load requirement in Approx. is 1200WH/day
We add some 100WH/day for other or for safety so it become 1300WH/day +1.3KWH/day

O/P of inverter is 1300WH/day
When every appliance on together then,
3*20= 60
1*60= 60
1*100=100
2*9= 18
1*300= 300
538 VA

Power of Inverter 538 VA

Good inverter have
Inverter efficiency is 85%

Energy input to inverter = 1300/0.85
=1529.4 WH/day

Inverter output is = 1300WH/day
Inverter input is = 1529.4 WH/day
If efficiency is 85%
500Va inverter required
Input voltage is = 24V

Battery
1529.4 WH/day
1529.4V/V*Amp Hr/day
1529.4/24=63.7295 Ahr/day charge time
The battery should be supply 63.725 Ahr/ charge per day

Battery voltage 24V
(Depth of Discharge) is good
% of charge can we take out from battery

Lead acid = 50% low cost
Lithium ion battery = 80%
63.725/0.50 = 127.45 Ahr

Autonomy = Today + 2 day autonomy
= 3 day
Considering 2 days of autonomy
Battery charge capacity = 127.45*3
=382.35Amp

Market
12V,100 Amp

System Voltage = 24
Battery voltage = 12
24/12=2 battery in series

Total energy requirement
382.35/100 = 3.8 = 4 battery we need Energy input should be high
If efficiency = 80%

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1509.4/0.80 = 1911.75 VAmphr/day

Battery
Battery input is 1911.75 Whr/day
Battery output is 1529.4 Whr/day
No of battery 4, 100 Amp .12V
Efficiency % = 80%

MPPT
MPPT is 100% efficient **Energy input should be high**
If efficiency = 80%
1509.4/0.80 = 1911.75 VAmphr/day

Battery
Battery input is 1911.75 Whr/day
Battery output is 1529.4 Whr/day
No of battery 4, 100 Amp .12V
Efficiency % = 80%

BLOCK DIAGRAM

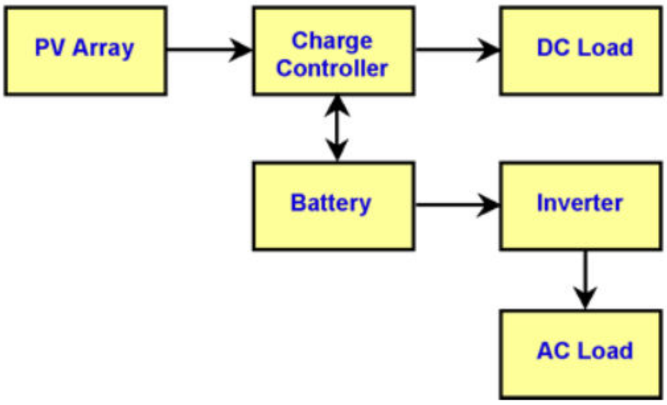

Fig. 5 block dig of PV panel system

Fig.6 .Successfully installation of PV panel system in rural Elementary School Bamberwadi

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V. POTENTIAL BENEFITS AND POSSIBILITIES OF EQUIPING ROOFTOP SOLAR PV SYSTEMS FOR RURAL ELEMENTART SCHOOL

Equipping rooftop solar PV systems for rural elementary schools holds significant potential benefits and possibilities. Firstly, such systems can provide a reliable source of electricity, ensuring uninterrupted power supply for educational activities. This is particularly crucial in rural areas where grid connectivity may be unreliable or absent, enabling schools to function effectively regardless of external power disruptions.

Secondly, rooftop solar PV systems contribute to environmental sustainability by harnessing clean, renewable energy from the sun. By reducing reliance on fossil fuels, these systems help mitigate greenhouse gas emissions and combat climate change. Moreover, they serve as educational tools themselves, offering opportunities for students to learn about renewable energy technologies and environmental stewardship firsthand.

Furthermore, rooftop solar PV systems can lead to cost savings for rural elementary schools in the long run. While there may be initial investment costs involved in installing the systems, they offer the potential for significant reductions in electricity bills over time. This frees up financial resources that can be redirected towards improving educational facilities, hiring qualified staff, or investing in educational materials and programs.

Additionally, equipping rural elementary schools with rooftop solar PV systems can enhance community resilience and empowerment. Schools can serve as community hubs during emergencies, providing access to electricity for charging essential devices, powering emergency lighting, or even serving as shelters. Moreover, involving local communities in the planning, installation, and maintenance of these systems fosters a sense of ownership and pride, empowering communities to take control of their energy futures.

In summary, the potential benefits of equipping rooftop solar PV systems for rural elementary schools are manifold, encompassing reliable electricity supply, environmental sustainability, cost savings, educational opportunities, and community resilience. By harnessing the power of solar energy, these systems have the capacity to positively impact the lives of students, teachers, and communities in rural areas, facilitating a brighter and more sustainable future for all.

VI. CONCLUSION

The implementation of small-scale photovoltaic (PV) panel systems in Gudhe Pachgani, District Sangli, Taluka Walwa, stands as a testament to the transformative power of renewable energy in rural development. By strategically designing and deploying PV systems, we have effectively addressed energy access challenges, fostering socio-economic growth and environmental sustainability in this remote area. Notably, our project extended beyond community empowerment to include the implementation of a PV system in a local school, amplifying its impact on education and innovation. This initiative not only provided the school with reliable electricity but also transformed it into a beacon of sustainable learning, inspiring students to embrace renewable energy technologies and environmental stewardship. Through this holistic approach, our project has not only improved living standards and economic opportunities but has also empowered future generations with the knowledge and tools to build a more resilient and sustainable future for rural communities.

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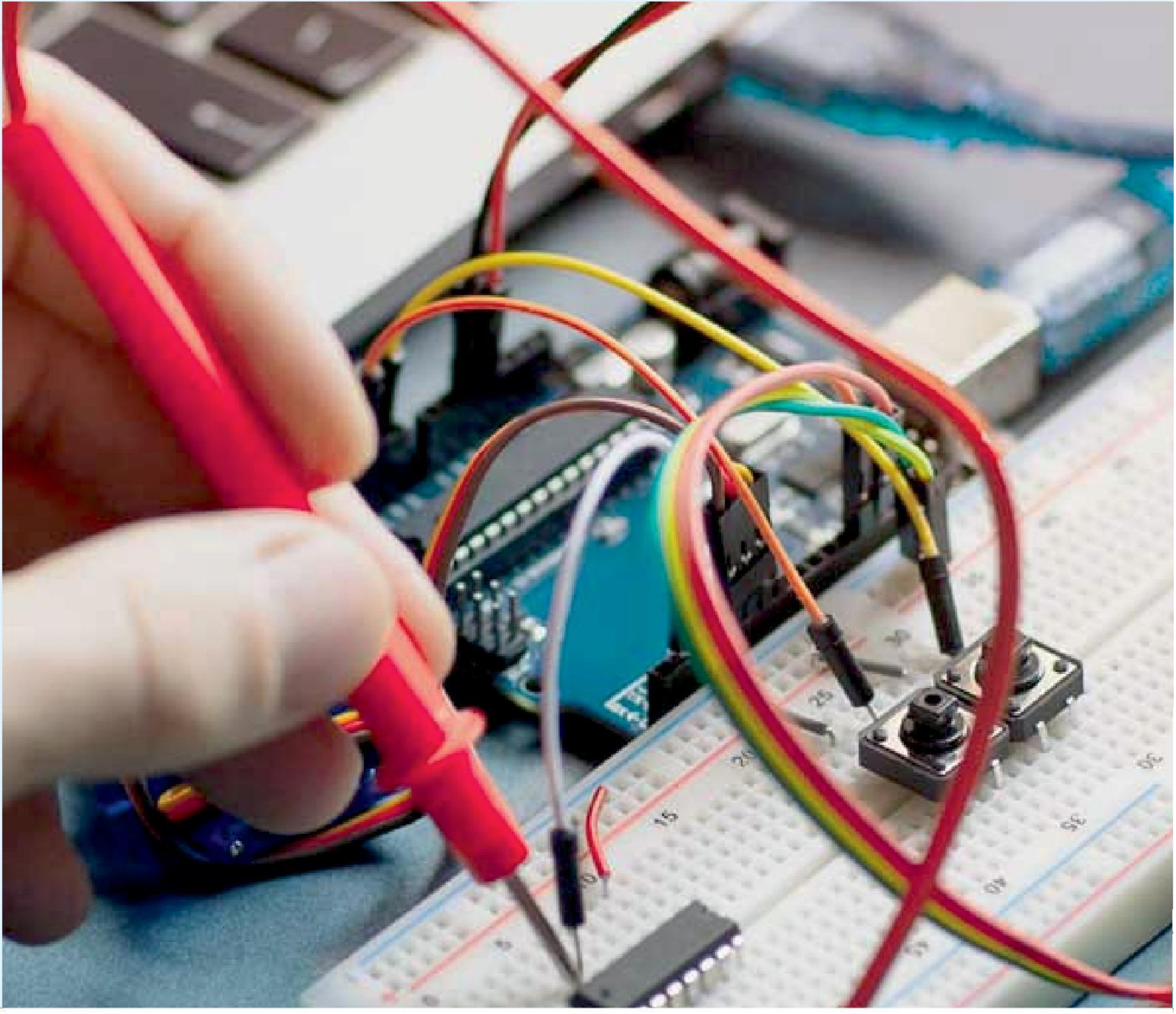

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