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Research Article

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An accelerative step for improving access to electricity in remote villages by promoting Solar Home Lighting Systems – A case from North-East India

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Abstract Renewable energy sources, including solar power, have emerged as the future of global energy security in the face of climate change. The promotion of solar technologies has gained pace in the last few years in India, due to its maturity, modularity, and ease of installation compared to other renewable technologies. Hence, solar has received immense policy support and the public's acceptance. Solar technology contributes to reducing carbon emissions and promoting sustainable energy practices.

A less highlighted fact about solar is that it has been used extensively in India to provide energy access to the most remote and underserved communities. Technologies like Solar Home Lighting Systems (SHLS) have improved access to electricity in remote villages, and enhanced the quality of life of people by enabling them to have lighting for daily activities after sunset, and reduced their dependence on fossil fuels for lighting. This paper examines the efficacy of solar home lights in the rural locations of Assam, a state in the Northeastern part of India. These solar home lights were installed as part of Social Corporate Responsibility (CSR) by the Numaligarh Refinery Limited (NRL) along with The Energy and Resources Institute (TERI) as a knowledge partner.

Keywords Solar, Electricity, Assam

Background and Context

Assam, located in the Northeast part of India, is famous for its tea, silk production, petroleum products, and rich biodiversity. The socio-cultural diversity of its population is reflected in the presence of a variety of ethnic groups, including Assamese, Bodos, Bengalis, Nepalis, Karbis, and others. The majority of the population resides in rural areas.

TERI joined hands with NRL as a knowledge partner in the year 2015. The partnership resulted in a series of clean energy interventions in the Golaghat and nearby districts of Assam. The district Golaghat came into existence in the year 1987. Surrounded by the River Brahmaputra in the north, the state of Nagaland in the south, district Jorhat in the east, and districts Karbi Anglong and Nagaon in the west, Golaghat is a major agrarian economy of Assam. Tea, rice, and sugarcane are the main crops grown in the district, with tea being the largest agricultural industry. In this area, rural communities are involved in agriculture and wage labour, and face several development challenges. Being a part of an elephant corridor in the forested area, electricity access was limited in these villages [1]. TERI and NRL's collaborative efforts have provided solar home lighting systems (SHLS) to about 1129 un-electrified households from the year 2015 to 2021 among 35 villages of 4 districts of Assam. The majority of the SHLS were installed in the Golaghat district. This paper estimates the electricity generated collectively and efficacy through these installed SHLS.

Technical configuration of SHLS

Solar energy is generated through the use of photovoltaic (PV) cells, which convert sunlight directly into electricity. PV cells are made of semiconductor materials. When sun rays of appropriate frequency fall over the PV cells, it stimulates the release of electrons, which create an electric current when connected to a circuit. This electricity can be used for lighting or any other applications.

In principle the SHLS comprises four light points including 2 bright LED tube lights of 3.3W each and 2 LED bulbs 1.5W each; a panel of capacity 30Wp was used in 570 SHLS and 40Wp used in 559 SHLS, Charge Controller 12V/5A, battery rated 12V/18Ah, along with a mobile charging facility [2]. The system is designed to sustain a daily load of basic household lighting necessities for about 5 hours and 2 hours for mobile charging. Additionally, for mobility and outdoor lighting purposes, the SHLS also an including an additional high-quality 4W DC pendent lamp, which can be used indoor and outdoor applications.

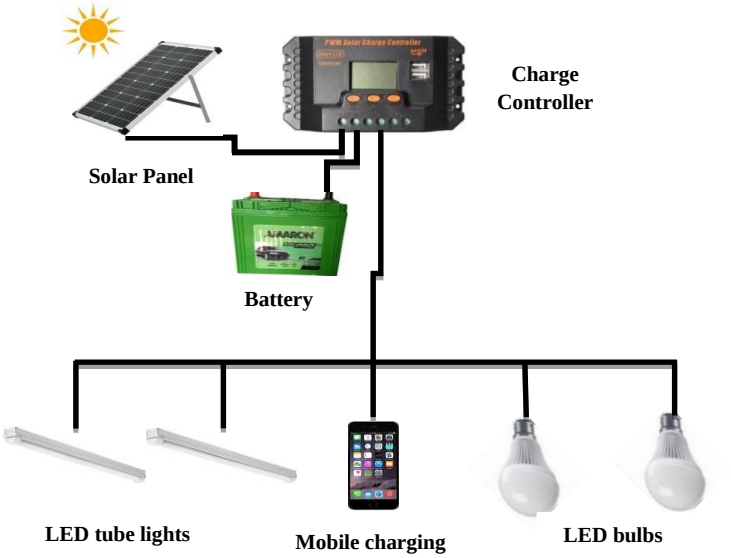

Figure 1: A typical standalone SHLS

SHLS is a cost-effective and reliable solution for domestic illumination in remote rural areas. It performs for a longer period and requires low maintenance. The portability feature of solar lamp enables the community to do chores outside their homes and move in the dark.

TERI's Delivery Model of SHLS

TERI has followed various robust delivery models for of deploying clean energy technologies in the communities for the past few decades. A customized delivery model was developed in this initiative. NRL identified the villages based on their electrification statuses. The unelectrified households were preferred. With the financial support and geographical inputs from NRL, TERI embarked on scoping the study area to identify suitable sites and interested households for demonstrating the systems. TERI after assessing the parameters useful for technology design such as solar insolation and community needs, developed technical specifications. Once the design was finalised, TERI invited reputed technology suppliers through standard operating procedure (SoP) to undertake the technology installation. The selected suppliers were responsible for ensuring quality products in terms of solar modules and balance of the system. One or two local youths were trained by TERI and the supplier to undertake the work in the villages.

Each household is given multiple energy services as mobile charging, immovable light points, and portable lights. However, to maintain the sustainability of operation and to create a sense of ownership of the SHLS, a nominal community contribution INR 1000 per system (6.25% of total price) is collected. This also contributes to making the system more cost-effective.

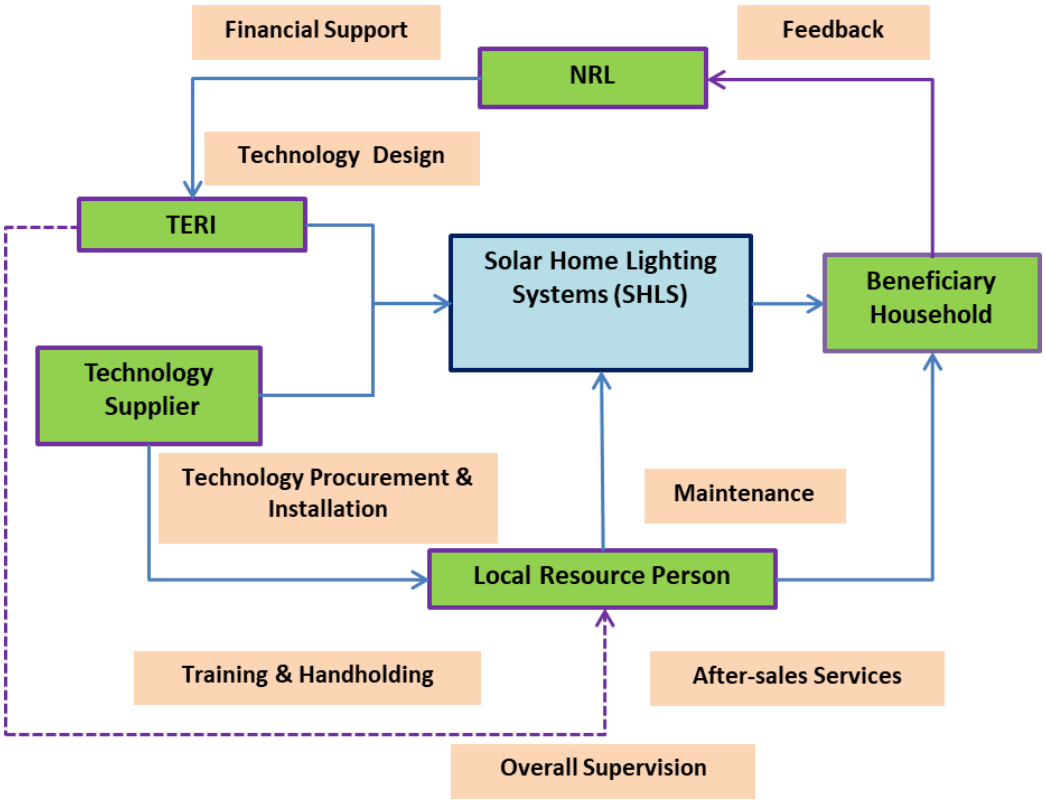

Figure 2: Delivery model

Performance of the SHLS

A cumulative capacity of 39.46 kW was obtained through the installation of 1129 SHLS in the districts Golaghat, Majuli, Karbi Anglong and Jorhat of Assam. Although the majority of SHLS were deployed in villages of district Golaghat at first, gradually the penetration of SHLS expanded based on the necessities of the community.

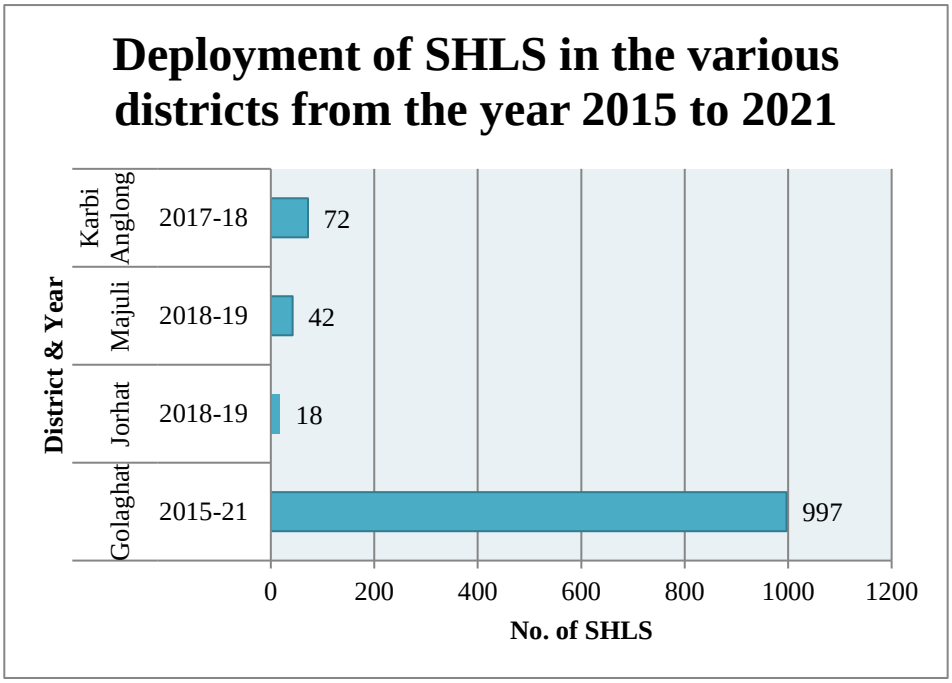

Figure 3: Deployment of SHLS in the various districts from the year 2015 to 2021

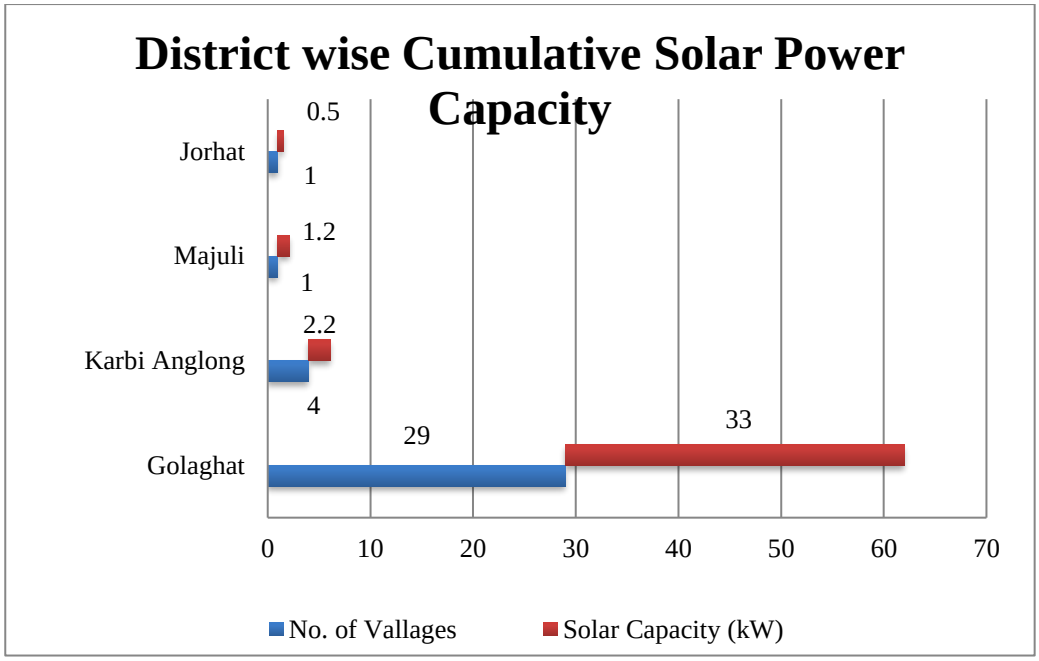

Figure 4: District wise installation of SHLS

Given the climatic conditions of Assam, an average of around 300 sunny days is expected annually. This takes into account the number of rainy and cloudy days and other general climatic conditions. This is sufficient solar insolation to make Assam conducive for the effective deployment and utilization of solar energy technologies.

An estimate for the total power generated from the installations of solar Home Lighting Systems is given below:

$$\textbf{Power Generation (kWh)} = Total\ Solar\ Panel\ Capacity\ (kW) - Energy\ Loss(\%) \times No.of\ Sunny\ hours\ per\ day(No.) \times Total\ Sunny\ days\ per\ Annum(No.)$$

The input parameters for the calculation of power generated is given in Table 1.

Table1. Solar generation input parameters

Solar panel capacity (kW)	39.46
Potential losses (%)	20
Average sunshine hours per day (No.)	5
Annual sunny days (No.)	300

Thus,

$$\textbf{Power Generation (kWh/Annum)} = \frac{39460 - \left(39460 \times \frac{20}{100}\right) \times 5 \times 300}{1000} = 47352$$

Therefore, the total energy generation was estimated to be 47352 kWh per annum.

In order to compute energy consumption, the following formula is used:

$$\textbf{Power Consumtion (kWh)} = (Total\ SHLs\ (No.)\ \times LED\ Bulb\ Capacity\ (W) + (LED\ Bulb\ capacity\ (W) \times Bulb\ Efficiency\ (\%) \times Light\ usage\ hours\ per\ day\ (No.)\ \times Lighyt\ usage\ days\ per\ Annum\ (No.)/1000$$

The input parameters for the calculation of power consumption are given below in Table 2.

Table 2. Input parameters for solar consumption calculation

No. of SHLS	1129
Bulb capacity (Watt)	~ 10 (3 Bulbs of 3.3W each)
Bulb efficiency (%)	30
Illuminating hours (No.)	4
Annual days of use (No.)	365

Thus,

$$\textbf{Power Consumption (kWh/Annum)} = \frac{1129 \times \left(10 + 10 \times \frac{30}{100}\right) \times 4 \times 365}{1000} = 21428.42$$

The consumption of energy was computed to be 21428.42 kWh per annum. It shows that the surplus power of 25923.58 kWh/Annum generated annually could help as backup power during cloudy days, or continuous rainy days [3].

Usefulness

1. The benefits are envisaged from the installation of SHLS in remote village households [4, 5, 6].
2. **Access to Reliable Power**: Usage of SHLS to provide households with access to electricity even in remote areas where grid connectivity is limited or non-existent, or suffers from quality and reliability issues, to improve the quality of life of the population and enabling activities such as education, cooking, and charging of electronic devices and protection from elephants and wild animals.
3. **Economic Options:** Solar Energy provides reliable electricity which can enhance productivity by enabling households to engage in income-generating activities such as small-scale businesses or agricultural processing.
4. **Energy Security:** Use of SHLS provides households with a more reliable and decentralized source of energy and reduces dependence on the conventional grid and fossil fuels.
5. **Cost cutting:** Households can minimise their dependence on expensive sources of back-up energy such as candles or kerosene lamps.
6. **Environmental Benefits:** Solar energy is a clean and renewable energy source, which reduces greenhouse gas emissions and environmental pollution.
7. **Health Safety:** The use of solar energy will eliminate the need for burning fuels indoors, thereby reducing indoor air pollution and the linked to health risks such as respiratory diseases and eye problems.
8. **Safety**: SHLS provides home lights, mobile charging option and portable lights facility to address issues with lack of lights and communication options during dark hours, in an area covered in dense vegetation and challenged by wild animal attacks as elephants, insects, etc.

Conclusion

Renewable energy and sustainability practices have gained prominence to combat climate change and foster sustainable development. Solar PV technologies have gained prominence in India with its modularity, applicability, affordability and public acceptance. Solar technologies have especially contributed to providing electricity access and clean lighting solutions to remote areas where grid connectivity was at the time a challenge [7]. TERI supported by NRL has fulfilled this objective through years of solar interventions in the villages of Golaghat district, and beyond in the North-Eastern state of Assam, India. Solar has greatly helped with improving the quality of lighting at home and in the community through compact Solar Home Lighting Systems [8]. These systems comprising home lights, mobile charging ports, and portable lights addressed issues with lack of lights and communication options during dark hours, in an area covered in dense vegetation and challenged by animal attacks. It also helped reduce the dependence on fossil fuels for lighting, thus saving money and preventing health hazards. The systems have generated around 47352 kWh per annum of which 21428.42 kWh has been consumed for illuminating lights. The surplus leaves scope for power back-up during

cloudy days. The success of the program generated demand from different geographies and created awareness on the positive impacts of solar systems. The deployment of the systems through trained local resources helped with the sustainability of the intervention as well as created additional livelihood options for the community. In the scenario where all the households are electrified, these SHLS provides a reliable power backup source. The systems now contribute to the Country's goal of providing 24X7 power supply to households. This case is an important example of how clean energy interventions could transform lives in remote rural areas. It also shows that while achieving the larger goals of clean energy transition and national commitments on renewable capacity addition, one may not forget the contribution of decentralised off-grid technologies for communities that are challenged by several social and development challenges.

Acknowledgement

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