Impact of Solar Energy in Rural Development in India

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***Abstract*—Around 25,000 villages are located in remote and inaccessible areas and hence could not be electrified through conventional grid extension in India. The Ministry of New and Renewable Energy (MNRE) is implementing the 'Remote Village Electrification Programme' (RVEP) to electrify such remote villages by installing solar photovoltaic (PV) home lighting systems in all the states. An evaluation study was carried out by National Council of Applied Economic Research (NCAER) in six states, viz. Assam, Meghalaya, Jharkhand, Odisha, Madhya Pradesh, and Chhattisgarh.**

The functionality of the system varies across the states and across the seasons. During rainy season on an average one luminaire works 2 to 3 hours. During winter and summer on an average one luminaire works 4 to 5 hours. However, performance declines over the years. Use of kerosene is reducing in rural areas. Nearly 53 to 69 per cent reported that there is significant improvement in their children's education, and 37 to 78 per cent reported that there is improvement in the standard of living after the installation of solar lighting. Beneficiaries now spend more time on income generating activities. Crime rate has also declined due to availability of solar street lights in the village.

***Index Terms*—Development, energy, odisha, solar.**

I. Introduction

Rural electrification was not considered as a basic human need like water and food in the past. A number of recent studies provide insight into how rural electrification helps in the betterment of rural society in various ways.

A study the World Bank for 11 countries reveals that rural electrification results great benefits such as improvements of health facilities, better health from cleaner air as household reduce use of polluting fuels for cooking, lighting and heating, improved knowledge through increase access to television and better nutrition from improved knowledge and storage facilities from refrigerator [1].

According to Global Network on Energy for Sustainable Development (GNESD, 2007) without adequate supplies of affordable energy, it is impossible to improve health, education and reduction of poverty. About 1.6 billion of world populations have no access to electricity of which about 80 per cent of these people live in rural areas of developing countries of South Asia, Central America and South America. In 2001, the 9th session of the Commission on Sustainable Development (CSD-9) gave special attention to energy. It concludes that "Enrgy is the central in achieving the goal of sustainable development' [2].

Due to lack of electricity, use of kerosene as well as candles for lighting is common in rural areas. A study by Kaplin, [3] showed that burning of candle for a few hours in a closed room results in lead concentrations sufficient to cause fetal damage or to harm the mental development of children. Lead poisoning can lead to behaviour changes and damage internal organs, especially kidneys.

Children in rural areas spend significant portion of their time in household's activities in day time. They do not have light to study at night. A few hours of electricity to study at night students can result in major improvements in their performance [4]**.** Women in rural areas spend 2-6 hours a day for collecting fire wood due to lack of electricity [5]**.** Therfore, rural electrification may be considered as basic necessity to improve socio-economic condition in rural areas.

Reference [6] provides an assessment of the social significance of rural electrification with solar energy in Kenya. In Kenya only about 4 per cent of rural households were connected with electrical grid in the early 1980s. As of now, solar electricity has emerged as a key alternative to grid-based rural electrification in Kenya. The significance of solar electrification in Kenya, therefore, is closely linked to its role in supporting rural–urban connections for Kenya's rural middle class. The study highlights the following.

Electric light from solar system plays a minor role in supporting direct income generation activities in rural Kenya. Given the distribution of ownership of solar systems, nearly all of these productivity gains are captured by rural middle class families.

Solar photo-voltaic (PV) plays a more substantial role in supporting the use of electric light for key social activities such as evening time studying by children.

Solar electricity in Kenya is widely used for households' applications such as television, radio and cellular telephone charging that helps improve communication.

Reference [7] focuses on how application of PV light for rural electrification helps in increasing rural income as well as the living standards of the rural poor. The basic applied forms of solar PV in rural Bangladesh are solar home-lighting systems installed in households and local market/bazaar (haat). Seven solar modules of 50 WP each, divided into two groups, were installed in two suitable locations of the market. The battery banks and controllers accompanying each group were placed close to two respective solar panels. Similar systems were subsequently installed, serving business such as grocery shops, restaurants, barber shops, tea houses and doctors' clinics.

The success of solar PV microutilities is attributable to several factors. These include the acceptability of a daily tariff structure and the rate of five taka, as well as proper marketing that explains the solar-energy-based system's capabilities, benefits, and constraints in comparison to other available options to potential users. Benefits of the system also accrue because of the use of local institutions. An agreement, which was signed with the Bazaar Management

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Committee, includes the terms and conditions of the service, maintenance procedure, payment, and financial details of the users. The training of a technician to take care of the system on behalf of the collective is viewed favorably by users.

Reference [8] explains the impact of renewable energy for changing the socio-economic status of women. It is not easy to improve the position of women in the society, unless their level of income increases. Poverty alleviation can be realised by the introduction of renewable energy system in a sustainable way. The most important point is the possibility of income generation. This can take place in many ways. The activities may lead to the start of small- and medium-sized enterprises. One example could be picking up of seeds from oil bearing plants. The seeds can be sold in the market. Women can also do the processing and can make and valorize side products like soap.

The linkage between energy and Millennium Development Goals (MDGs) are well established and agreed upon by the international community [9]. The UN Millennium Project also noted that a pre-requisite for meeting the MDGs is to reduce the share of the global population that does not have access to basic levels of elctricity, as well as the population reliant on traditional solid fuel for cooking, to no more than about one billion people by 2015. This Energy vision foresees improved access to modern energy for about 1.5 billion.

A few other studies have specially looked at the role of energy in achieving these goals, even though energy is not a specific MDG [10]. Most of these studies have been geared towards looking at the energy needs of the poor and the role energy plays in achieving the MDG [11].

A study by George, et al. finds that rural electrification plays a critical role on family planning practice in rural Nigeria [12]. Two communities of Bonny and Kula were chosen to study because of the similarity in their population, terrain and climate. Fishing is the major source of livelihood of the people in both these areas. In addition, small scale farming activity is carried out in both places but on a part time basis. There is neither processing nor manufacturing activity in the two areas.

Bonny has regular electricity whereas Kula community does not have electricity at all. The data reveals that family planning is practiced more in the electrified community than the non-electrified one (Kula), and there has been a significant decline in fertility**.**

The extent of electricity consumption of a country is one of the indicators of socio-economic development. Per capita electricity consumption in India is the lowest in the world. In India, about 579 million people, that is 35 per cent of world's population, is living without access to electricity.

The Ministry of New and Renewable Energy (MNRE) of Government of India, has been implementing the Remote Village Electrification Programme (RVEP) in all the states. An evaluation study was carried out by NCAER in six states, viz; Assam, Meghalaya and Jharkhand in 2008 [13] and in Odisha, Madhya Pradesh and Chhattisgarh in 2010 [14]**.**

II. Objectives

In this paper an attempt is made to assess (a) the functionality of the solar PV system provided to households and (b) social impact of the programme on the beneficiaries in villages in the states of Assam, Meghalaya, Jharkhand, Odisha, Madhya Pradesh, and Chhattisgarh.

A. Methodology

The household's survey was carried out by NCAER in 2008 and 2010, to collect information from about 10,000 households from 371 villages spread over 41 districts in Assam, Meghalaya, Jharkhand, Odisha, Madhya Pradesh, and Chhattisgarh. Two well structured questionnaires were developed. One was canvassed at village level and the other at beneficiary household level to assess the functionality of the systems, the pattern of installation of the system and the impact of the programme. Focus Group Discussions (FGDs) were also organised to assess the impact of the programme in rural beneficiaries' households in some selected villages. FGD is a method of qualitative study used for capturing information not covered in the structured questionnaires.

III. Survey Result

The solar home lighting system has been provided through solar power plant and through solar photovoltaic individual home lighting system. In Meghalaya and Chhattisgarh, the solar light has been provided through solar power plant, whereas solar photovoltaic individual home lighting system has been provided in Jharkhand, Assam, Odisha, and Madhya Pradesh.

A. Functionality of the System

Proper functionality of the system is determined by taking into consideration many factors such as module capacity, module installation, fixing of luminaires inside the house, fixing of cable, etc. If the module and luminaires are installed properly and fixing of cable from charge controller to module is also proper, then one CFL can provide light up to 10 hours during a day in normal weather conditions. Two CFL luminaires can provide light up to 4–5 hours a day. One of the major advantages of solar home lighting system is that energy can be stored in battery for two to three days, if the lights are used scarcely. In the present study, an assessment has been carried out to check the duration of light received by the beneficiaries during different seasons.

TABLE I: Average Number of Hours Luminaires Work Per Day by Seasons (Per Cent Responses)

State	During Rainy Season			During Winter Season			During Summer Season		
	> 3 hr	3-4hr	< 4hrs	> 3 hr	3 -4hr	< 4hrs	> 3 hr	3 -4hr	< 4hrs
Meghalaya	99.0	0.0	1.0	0.0	20.5	79.4	0.0	16.2	83.7
Jharkhand	70.9	27.6	1.4	14.1	31.0	54.9	2.1	6.6	91.3
Assam	65.3	32.9	1.8	1.6	20.2	78.2	4.7	20.8	74.6
Odisha	50.4	38.4	11.3	4.6	40.9	54.6	2.6	19.7	77.8
Madhya Pradesh	73.3	25.4	1.4	12.9	53.0	34.1	1.7	11.0	87.4
Chhattisgarh	45.5	22.6	31.9	0.4	39.1	60.5	0.1	21.0	78.9

Sources: [13], [14].

1) Functionality of the system in winter

During winter the functionality of the luminaires looks moderate as only 2 to 14 per cent reported getting light less than three hours in Assam and Jharkhand. About 53 per cent of beneficiaries in Madhya Pradesh reported receiving light between 3–4 hours per day in winters, whereas only 20 per cent reported receiving light between 3–4 hours in Assam and Meghalaya (Table I). Except in Madhya Pradesh, majority of beneficiaries reported receiving light for more than four hours in winter season. The performance of the systems is better in winter and summer because of abundant sun shine. On an average, luminaires work for 4–4.5 hours during winter season (Fig. 1).

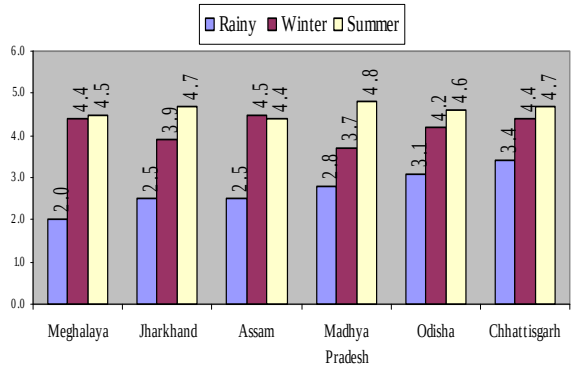

Fig. 1. Average working hours of Luminaries by seasons per day

2) Functionality of the system in summer

The functionality of the system seems to be very satisfactory in summer as 75 to 91 per cent of beneficiaries reported getting light for more than four hours in Assam and Jharkhand. On an average, luminaires work for 4.4 to 4.8 hours per day during summer (Fig.1).

B. Performance of the Systems by Year of Installation

On an average two CFL luminaires can provide light up to 4–5 hours simultaneously in normal weather conditions. The survey finds that the performance of the system during summer is better than during winter and rainy seasons. In Jharkhand about 63 per cent reported getting light for more than five hours, whereas 61 per cent reported getting light between four to five hours in Meghalaya (NCAER, 2008, p. 39). *It is well known that when the system gets old the level of performance declines.* Our findings also supported this statement in some states, as about 52 per cent (who got the system in 2004) reported getting light for more than five hours as compared to 86 per cent (who got the system in 2007) reported getting light for more than five hours in Jharkhand (Fig. 2). The performance of the systems is more encouraging in Odisha. About 76 per cent (who got the system in 2007) reported getting light for more than five hours as compared to 81 per cent (who got the system in 2009) reported getting light for more than 5 hours (Fig. 3).

Similarly, in Meghalaya 28.5 per cent (who got the system in 2003) reported getting light between 4–5 hours as compared to 100 per cent (who got the system during 2006) reported getting light between 4–5 hours (Fig. 4). Hence the performance of the system reduces over the time.

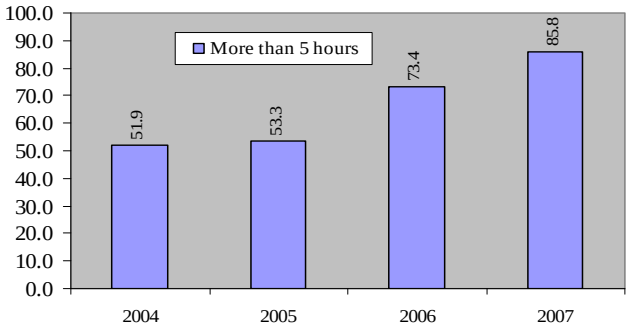

Fig. 2. Linkage of performance of system with year of installation in Jharkhand (% reported)

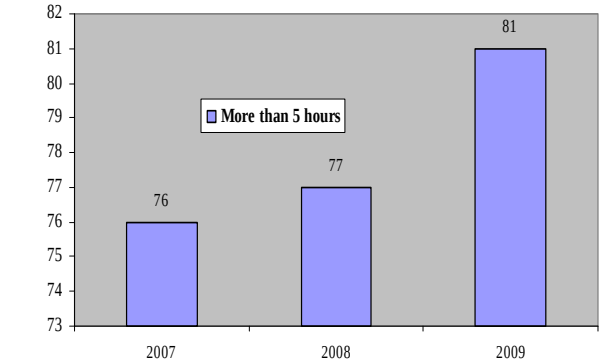

Fig. 3. Linkage of performance of the systems with year of installation in Odisha

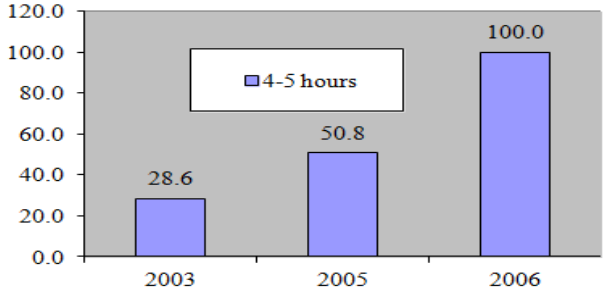

Fig. 4. Linkage of performance of the system with year of installation in Meghalaya (% reported)

IV. Impact Evaluation

A. Expenditure on Kerosene

The survey results highlight that the monthly expenditure on lighting has reduced substantially after Solar Home Lighting System in all the sample states. The beneficiary households have continued to use kerosene for other purposes than lighting the room after the installation of solar PV systems in the households, but in smaller quantity. The expenditure on lighting has reduced by more than half in Meghalaya, Assam and Jharkhand. The reduction of expediture on lighting is relatively less in Madhya Pradesh, Odisha and Chhattisgarh (Fig.5).

Multiple activities are being carried out in the beneficiary households during the time when electricity is available in the evening such as cooking, teaching children and studying, recreation and other household activities. We also asked them to assign the highest rank (1) the activity where maximum time was spent when the light was available at home. About 58 per cent in Jharkhand ranked 1 on teaching

children and studying whereas 60 and 45 per cent of beneficiaries ranked 1 for the same in Assam and Meghalaya, respectively (NCAER, 2008, p. 52). This finding is further supported as 64, 69 and 53 per cent of beneficiaries reported that there is significant improvement in their children's education in Jharkhand, Assam and Meghalaya, respectively. Similarly, 28, 52 and 34 per cent of beneficiaries reported that there was significant improvement in their children's education in Odisha, Madhya Pradesh, and Chhattisgarh, respectively. About 52, 55, 37, 42, 78 and 48 per cent have reported minor improvements in standard of living after installation of solar lighting system in Jharkhand, Assam, Meghalaya, Odisha, Madhya Pradesh, and Chhattisgarh, respectively.

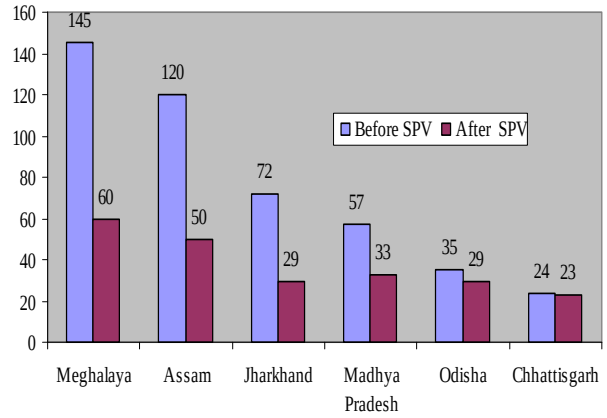

Fig. 5. Monthly Expenditure on lighting before and after SPV was installed per month (Rs.)

Convenience in household work due to installation of solar PV system has been well recognised. The level of satisfaction is more visible as 49, 60, 75, 48, 39 and 35 per cent have reported 'significant improvement' in household work in Jharkhand, Assam, Meghalaya, Odisha, Madhya Pradesh and Chhattisgarh, respectively.

B. Income Generation Activities

Solar home system has been considered very good as it carries many external benefits. It can help create new sources of income in the households. The survey finds that only two to three per cent among the beneficiaries reported that new sources of income generation activities have opened up after getting solar light system. As a consequence, the monthly household's income has gone up by 5 per cent in Jharkhand. However, the increase in income after installation of solar light is not significant in other states.

C. Impact Assessment from Focus Group Discussions

In order to assess the involvement of the beneficiary households in the solar home lighting programme and the type of benefits and satisfaction realised by the households, FGDs were organised in all the six states during the survey among both women and men separately.

The group discussions proved extremely useful in eliciting a range of information, which further supports the quantitative information. In all, 33 FGDs were organised in the six states.

D. Summary of Focus Group Discussions

Some of the participants among women said that they do households activities in the evening, such as grinding of rice, weaving cloth, etc. During day time they go for wage work. Indirect income earning activities are also taking place due to availability of light. The women beneficiaries are highly satified with the system, because it makes it easier for them to cook at night and finish their household's chores comfortably.

Some of the participants said that their kerosene consumption has decreased by 60 to 70 per cent after installation of the solar home lighting system.A few participants said that poor households in their village have totally stopped buying kerosene.

Before installation of the solar streetlights in the village, wild animals like leopards, bears, etc. would frequently enter the village and hunt cattle and would many times attack children. But After the installation of streetlights, they have stopped entering the village. People freely move around even after it gets dark. One woman in Morigaon district of Assam said, 'I can stay at home alone in the evenings now. Earlier I had to call somebody from the neighbourhood to stay with me because of fear from the tiger, when my husband was not at home.

The crime rate was high at night. Snake and insect bites were common in the village. Now such incidents have reduced.

A few participants in village Bangaura (Chhattisgarh) said that in their village children used to study up to primary level only before getting the solar light. But after getting solar light some of the children are studying in the middle level. This implies that drop-out rate has decreased.

FGD participants in Nayapara village (Chhattisgarh) said that the school teacher and forest guard were not staying in the village due to lack of electricity. But now the school teacher and forest guard are staying in the village.

A few of the participants in village Dheba, Kashdol, and Diahampara in Chhattisgarh said that after getting solar light, looking after old and sick people became easier. Social gathering, dancing, and singing also take place in the evening.

Some of the participants said that they could look after their domestic animals better in the evening due to availability of light. They also collect 8–10 solar home lights for marriage ceremony and other social gatherings.

A few of the participants in Chhattisgarh said TV used to be like a dream for the villagers. But now they watch cricket matches on TV.

A few participants, however, said that households in the village spend some more time on activities such as making *bidi* and plates out of leaves, rope and weaving, which helps in improving the household's income.

V. Conclusion

The present study shows that solar home-lighting system in the remote village can influence the life of people very significantly for the better. Substantial reduction in expenditure on kerosene has been found in the households of all income groups due to solar home-lighting system. This scheme is mostly benefiting women and children. Women find it easy to do household activities whereas children get enough light to study at night. Crime rate has

also been declining due to availability of light in the village. Most of the beneficiaries of solar home-lighting system are very happy with the functionality of the system.

The impact of the solar home lighting system is also significant in the case of performance of school going children. A large number of beneficiaries have reported that there is significant improvement in their children's education.

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