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Assessing the Potential of Decentralized Solar Energy for Livelihood Creation and Reducing Migration

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ABSTRACT

Limited availability of energy in rural areas hampers irrigation and obstructs creation of other livelihood opportunities that forces people to migrate. One of the solutions to the problem is utilization of decentralized solar photovoltaic and solar thermal technologies to create livelihood opportunities along with provision for irrigation. The recent examples of public private partnership in Bihar for deployment of solar pumps have enabled irrigation, despite rising diesel prices and limited power availability for few hours in a week. The solar panels generate electricity that can be used directly to operate irrigation pumps or can be used for charging batteries. Solar lamps and other livelihood creating equipments can be operated using the batteries charged. Solar thermal applications in dairy and agro-processing industries can create livelihood opportunities. The innovation or uniqueness in the approach proposed in this paper is of implementing community owned solar photovoltaic or solar thermal technologies. Sharing of the equipments by different users will enhance the economic viability of these technologies. Solar pumps will help farmers to irrigate land and earn livelihood from agriculture while charged batteries can provide energy for micro-enterprises. Solar thermal technologies can enable livelihood creation by enabling farmers to process agricultural produce in rural areas. Solar powered milk processing units can also generate employment.

Keywords: SPV, Decentralized solar electrification, renewable energy

INTRODUCTION

The heart of India resides in villages. Due to population growth, the consumption is increasing significantly resulting in enormous pressure on limited resources. The situation in the energy sector is similar with enormous demand and limited availability. More than two billion people worldwide have currently no access to grid electricity or other efficient energy supply.

Situation is even worse and vicious in rural sector as it is not only hampering the electricity needs but also resulting in problems like migration. So, in locations where electricity is unavailable, other means are necessary to pump water for consumption. One option is a photovoltaic (PV) pumping system. Advantages of PV pumping systems include low operating cost, unattended operation, low maintenance, easy installation, and long life. These are all important in remote locations where electricity may be unavailable. So far, in the development of this research, the focus has been to estimate the available radiation at a particular location on the earth's surface and then analyzed the characteristics of a photovoltaic generator and a photovoltaic network. The purpose of this research is to examine all the available sources of electricity in rural localities and list out agriculture and allied livelihood options that can be generated out of them. This paper, shows the evidence that solar energy (*e.g.* solar pumping) is the most reliable and cost-effective option among many water pumping applications in developing countries like India.The main objective of this study is to:

i. To identify the important agriculture and allied livelihood options aided by decentralized solar energy sources.
ii. To explore and study the possibilities of implementing community owned solar photovoltaic or solar thermal technologies in rural India.
iii. To assess the potentials of decentralized solar energy technologies in employment generation in rural areas through cost-benefit analysis.

Mostly the decrease in the area of irrigated land in the world has been due to the lack of irrigation facilities which has resulted from increased energy crisis. Also the increasing price of oil-based fuel has added to that by reducing the margin of production with the help of oil based pumps. Like most other countries, the energy situation in India is extremely critical and major power stations here are run by coal or natural gas and are not capable of meeting increasing demands. So the electricity generation from the alternative sources has become the crying need for India. India is blessed with renewable energy resources and the availability of alternative energy creates opportunities for utilization in power sector. The utilization of renewable energy has gained popularity

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among the people in India from the early 1990 (MNRE, 2011).

Among different renewable energy sources like solar, wind, biomass and others, the abundant availability of solar energy makes it the most promising one. In view of the dispersion of localities, the low demand, cost of production, transmission and especially distribution of electricity would be prohibitively expensive for these regions. Therefore renewable energy based off grid electrification can be an alternate option for providing electricity in large remote and rural areas of India. In order to fulfill the electrification demand- supply gap, the government has taken initiatives for utilization of renewable energy sources for electricity generation (MNRE, 2011).

Solar PV applications in India

The range of applications for solar PV in India is very different from the global mix. Globally, grid connectivity accounts for nearly 75 per cent of the installed capacity and off-grid lighting and consumer applications for the balance 25 per cent. Currently, PV installations in India, almost entirely consist of off grid connectivity and small capacity applications, used mostly for public lighting, such as street lighting, traffic lighting and domestic power back up in urban areas and small electrification systems and solar lanterns in the rural areas. In recent years, it is also being used for powering water pumps for farming and small industrial areas. Government organizations like railways, telecom and other agencies are the major consumers of PV solar systems in India.

Table 1: The typical applications of solar PV systems are

Product	Rating
Solar lanterns	2.5-5 Wp
Solar PV for individual households	2-15Wp
SPV Blinkers	20Wp
Solar home lighting systems	18/37/74Wp
Solar street lighting systems	74Wp
Traffic signals	Upto 100Wp
Solar power plants for villages	1-5KWp

(MNRE, 2011)

Out of all identified available solar PV systems in India some of them which are feasible in rural localities are described in below sections. Major installations are in form of water pumping system and solar home system.

Other Solar PV applications

These days, the solar PV technology has found numerous applications in India. These applications include home lighting, navigation, traffic lighting, irrigation, milk processing, fencing, research, etc.

Solar PV power is extensively used to power telecommunications and navigational equipment in remote locations in India. The PV system is also used for powering the desk top computers which consists of the solar modules and storage batteries of required capacity, a charge regulator and a DC-AC inverter. Similarly office appliances like fax machines, printers, small telephone exchanges, cordless telephones etc. are being powered from solar PV in field offices of various indigenization.

PV power is also used for water disinfections, fencing, grinding etc. Theoretically there is no limit of application of solar PV in the area where electricity is required to perform the basic operation (MNRE, 2011).

Government initiatives to promote solar PV in India

Table 2: 11th Five-Year Plan Summary for off-grid renewable power

Programme Component	Physical Target for 11 th Plan (in MWe)	Proposed Outlay for 11th Plan(in ₹Crores)
Wind/ Small Hydro Power/ Bio Power	950	900
Solar Power(grid/off-grid)	50	200
Total	1000	2100

(MNRE, 2011)

Table 3. Different plans of Indian government

Plans	Objectives
The National Rural Electrification Policy, 2006	The policy aims at providing access to electricity to all households in the country and a minimum 'lifeline' level of consumption of 1unit (KWh) per household per day.
Semiconductor Policy (2007)	The Semiconductor Policy is meant to encourage semiconductor and ecosystem manufacturing, of which solar PV is also a component.
Generation based incentive scheme	In January 2008, MNRE formed guidelines for generation based incentives for grid connected solar (both thermal and PV) plants.
State level initiatives (e.g.)	Andhra Pradesh ,Karnataka, Gujarat Rajasthan

(ISA, 2010)

Jawaharlal Nehru National Solar Mission (JNNSM)

The launch of the National Solar Mission has given a big impetus to solar energy in India. The highlights of the mission are given below:

- To installed the capacity of 20000 MW by 2022
- Establishment of a single window investor friendly mechanism
- To envisages an investment of ₹ 90,000 crores over the next 30 years
- To initial investment of ₹ 4,337 crores provided by the Government of India

- To target for the first phase of the mission

Addressing rural electrification issues

More than 1.3 billion people worldwide lack access to electricity. Rural electrification through decentralized Off-grid Systems in developing countries provides a review of rural electrification experiences with an emphasis on off-grid electrification and presents business-related aspects including participatory arrangements, financing, and regulatory governance (Bhattacharyya, 2013).

Decentralized (off-grid) rural electrification is based on the installation of standalone systems photovoltaic (PV), wind, small-scale hydropower, biomass in rural households, or the setting up of electricity distribution mini-grids fed either by renewable or mixed (renewable LPG/diesel) systems.

Controlling migration solutions

According to the 2006 Human Development Report of the United Nations Development Program (UNDP), 1.2 billion people have no access to safe water and 2.6 billion live without access to sanitation. Millions of women and young girls are forced to spend hours collecting and carrying water, restricting their opportunities and their choices. The effects are felt most in rural areas where access to drinking water as well as to irrigation services for agricultural purposes and livestock are a basic milestone that could improve quality of life and economic development. Direct solar pumping technology is one of the most suitable technologies that can be used to provide water supply in rural areas, where a steady fuel supply is problematic and skilled maintenance personnel are scarce (COSPP, 2008).

Following solutions in order to control migration from villages due to lack of livelihood options has been listed out:-

- The solar panels generate electricity that can be used directly to operate irrigation pumps or can be used for charging batteries.
- Solar charged batteries can provide energy for micro enterprises
- Solar thermal applications in agro-processing industries can create livelihood opportunities.
- Implementing community owned solar photovoltaic or solar thermal technologies. Sharing of the equipments by different users will enhance the economic viability of these technologies.
- Solar thermal technologies can enable livelihood creation by enabling farmers to process agricultural produce in rural areas.
- Solar powered milk processing units can also generate employment.

Conceptual Framework

The conceptual framework is the visual representation of the paper analysis. Major focus of this framework is on solar technologies to generate livelihood options, community involvement, and decrease in migration as discussed earlier. This framework constitutes two sets of variables independent and dependent. The first set of independent variable is the indicators of problem and of whose solution depends on the following dependent variables:

- Migration (controlling)
- New Livelihood Options (solution)

These defined set of variables determined the migration conditions in rural settlements. Solar photovoltaic technologies indicate the new technologies that can be utilized for creating and supporting more livelihood options. Migration is as a result of limited capacities of communities to retain their human resource and limited livelihood options in villages which can be controlled by new opportunities generated as a result of decentralized solar technologies under this framework. These dimensions as a whole lead to controlling of migration because of new livelihood options which reflects the topics covered.

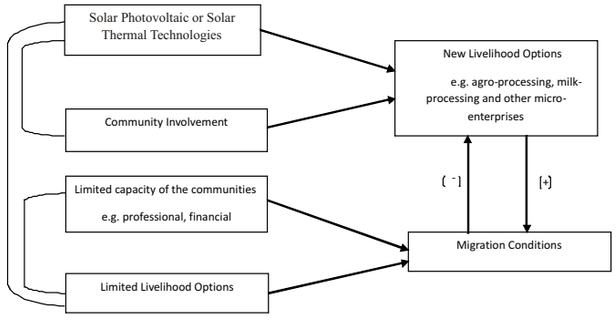


Figure No.1. Community based solar energy system linking with rural livelihood and migration

The main motto while designing this framework was to take the solar technologies to rural sector in the same manner as expected and covering all factors for controlling problem of migration. This framework is applicable while designing any remote area of India.

METHODOLOGY

The study has been designed to access the potential of decentralized solar energy technologies in employment

generation in rural areas. To meet these objectives secondary data collection has been done through interaction with concerned authorities and data available based on previous research as well as data from various government sources. Case study, SWOT Analysis and cost-benefit analysis have been used to generate results. Also a conceptual model has been developed to support result generation. Exploratory research design was used for the study. The data were collected. From secondary sources (Internet, Journals, Books, data from government websites, documents from MP Urja Vikas Nigam as well as interaction with officials). SWOT and cost-benefit analysis was mainly carried out for decentralized solar PV rural electrification.

RESULT AND DISCUSSION

The secondary data collected from different sources were analysis primarily subjected to two main analyses namely SWOT as well as cost-benefit analysis which were useful in linking the SPV technologies to the livelihood opportunities of the local communities.

SWOT analysis of decentralized solar energy in India

The diagnosis of the decentralized solar energy was structured through a SWOT matrix (Table No.6), in which the weaknesses, strengths, threats and most relevant opportunities that must be faced by the Indian decentralized solar energy system are shown.

Table 4: SWOT analysis of decentralized solar energy in India selected for study

STRENGTHS	WEAKNESSES
o Suitability to low income and remote areas customers who don't have access to grid electricity o Capable of supporting micro-enterprises, irrigation and allied activities energy demands	o Dependencies on government, donor agencies, for contribution as subsidy. o Strong body is needed for the proper management and monitoring of the subsidy.
OPPORTUNITIES	**THREATS**
o Possibility to cover entire village o Able to provide the basic lighting to the off grid villages in less time. o Retains human resource by more livelihood opportunities generation through community involvement.	o Operation and maintenance o Subsidy might not reach the needy people if not properly managed and monitored.

(Scha□fer & Mikroenergie-Systeme, 2011)

The above analysis clearly shows the future prospects generating livelihood from decentralized solar energy in Indian context. This analysis shows how supporting a renewable energy technology is useful in controlling migration.

Cost Benefit Analysis

After SWOT analysis of decentralized solar energy in rural areas the secondary data collected was grouped according to the dimensions taken under consideration for cost benefit analysis. The result of which was tabulated under following headings:-

- Financial Analysis of SPV versus Diesel System
- Basic advantage and disadvantage comparison of SPV versus Diesel System
- Comparison of break even points of SPV versus Diesel System
- Impacts on different aspects of human life

Table 5: Financial Analysis of SPV versus Diesel System

Financial Analysis of SPV versus Diesel systems

	Solar Pumpset (3 HP) 3000 Wp				Diesel Pumpset (5 HP)				
Year	Capital Cost	Running Cost	Maintenance Cost	Total Cost (A)	Capital Cost	Running Cost of equal Discahrge with 3 HP SPV pump	Maintenance Cost	Total Cost (B)	Cumulative Difference (A-B)
1	10,364			10,364	1,273	2,095		3,367	6,996
2				0		2,304	18	2,322	4,674
3			9	9		2,534	27	2,562	2,122
4			9	9		2,788	36	2,824	694
5			9	9		3,067	55	3,121	-3,806

(Jain & Jolly, 2012)
1 USD = 55 INR

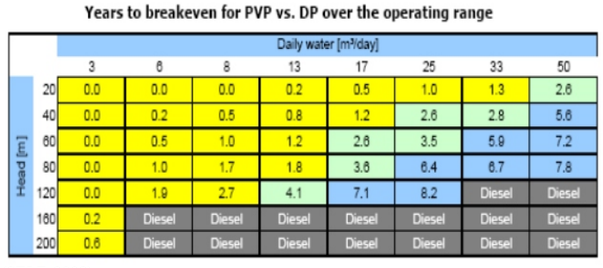
From the above table, it is clear that the SPV pump are more sustainable and financially beneficial when compared to diesel pumps in long run.

Table 6 : Comparison between SPV versus Diesel and gasoline pumps

Type	Advantages	Disadvantages
SPV	Unattended operation Low maintenance Easy installations Long life	High capital costs Water storage is required for cloudy periods Repair often require skilled technicians
DIESEL AND GASOLINE PUMPS	Quick and easy to install Low capital costs Widely used and accepted May or may not be portable	Fuel supplies erratic and expensive High maintenance costs Short life expectancy Noise and fume pollution

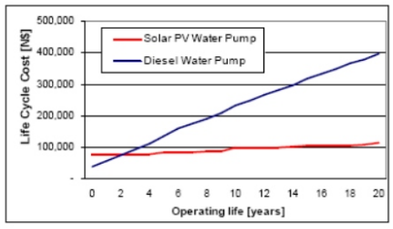
From the above table, it is clear that the SPV pumps are more sustainable and feasible in long run when compared to diesel pumps.

Figure 2: Break-even calculation over operating range



(SELF, 2008)

Figure 3: Typical years of breakeven graph for PV pump versus. Diesel pumps



(SELF, 2008)

From the above figures of comparison for three types of photovoltaic pumps (PVP) in comparison to diesel pumps, it is clear that the PVP sets break-even is for 2.5 years. After that the same results in substantial savings for rest of the life (expected life of a solar panel is around 20-25 years).

Solar power is already economical when compared to diesel powered applications market. India has about 17 mn grid powered pumps and close to 7 min diesel powered pumps* . Only 7,500 solar pumping systems have been installed for agricultural use.

Impacts on income, livelihood, education, health, and gender equality (UNDP, 2011)

- **Savings in fuel use, time and human energy**. Following electrification use of other sources of energy can be reduced significantly, and consequently time and effort spent in collecting it.
- **New enterprises and livelihoods enhancement:** With electricity, establishing a poultry farm, cable television business, water, community-owned milk processing unit and marketing facilities for dairy products, which has increased income from dairying and employment for local people. Also small agriculture product processing units, irrigation are also supported by off-grid electricity.
- **Educational benefits**: Parents and school teachers have reported that study hours had increased from one to two hours as per TERI one million lighting campaign report. Furthermore, children had previously studied by the light of candles or kerosene lamps, which adversely affected their eyes; with electricity, they enjoy a safer and more effective study environment. Children are also no longer required to assist their mothers with fuel wood collection.
- **Health benefits:** It is free from smoke and any other harmful release.
- **Gender equality and women empowerment:** Through extended educational opportunities, improved communications and information services & improved health (eliminated smoke and fumes in the kitchen), it facilitate gender equality in community.
- **Forest & Environment friendly by providing alternate and sustainable source of energy.**

Summary

- Solar PV today is a god-sent opportunity for India considering its geographical locations.
- Number of technical challenges need to be overcome: System design issues are critical Hence, Pilot deployments has to prove their viability
- Policy actions should promote solar PV instead of subsidy
- Real savior of rural poor as it creates livelihood options as well
- Protect rural poor from environmental sins
- SPV technology is more sustainable and cost effective in long run
- It helps micro-enterprises in rural settlements by fulfilling their energy demands.
- More livelihood options like processing of agricultural products, milk processing, irrigation and other allied agricultural activities can be supported through decentralized off-grid solar power.
- The cost- benefit analysis for SPV technology also proves its more viability and feasibility in rural settlement.

CONCLUSION

India is suffering from acute power shortage and even if villages are electrified, the power supply is not reliable and regular. Considering the significant potential of decentralized renewable energy technologies it is possible to generate sufficient power to create employment, stop migration and increase agricultural productivity using renewable energy. Solar energy seems to be the most promising amongst all the renewable as it can be customized to different capacities, is freely available in almost all the states of India and its cost has decreased to the level that it is competitive with diesel. Several organizations like claro energy, teri *etc.* have demonstrated financially viable models of solar water based pumping, lighting and other commercial applications. It is worrying that despite such successful dissemination of decentralized solar energy utilization, it is not being implemented at a large scale. While central government is providing subsidies to promote solar it is crucial for them to promote solar by enhancing awareness

amongst end users particularly the rural community. There is a need to implement more projects and organize exposure visits and demonstrations for other farmers so that they develop confidence in solar technologies.

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