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Renewable energy scenario and disregarded petition of rural populace of an Indian island: A critical survey and concept of an inexpensive artifact

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Abstract
This study attempts to establish the challenges associated to solar energy scenario in rural living of south-east of Indian province namely West Bengal and to suggest an inexpensive solar artifact with an aim to cater to the areas which are scarcely electrified and primarily in countryside. Stockpile of fossil fuels are depleting and there is an urgent need of promoting renewable energy products that can pertinently be supported by this clean energy. Renewable energy is alternate source of energy or non-conventional energy such as, solar energy, water energy, wind energy, biomass and bio-gas energy, tidal energy, Geo-thermal energy, hydrogen energy. Scope of this article converges on disregarded demand scenario of rural inhabitants and fostering inexpensive appropriate solar technology based product. For subsequent investigation a critical socio-technical survey has also been conducted in the rural Sundarban area of Southern part of West Bengal, with an aim to acquire the glimpse of the presently operating government project on solar technology and to identify the demand and solar product there for.

Keywords: Renewable energy, Solar energy, Sundarban, Product model, Survey.

1. Introduction
Owing to the low level of wage rate of countrified populace in contrast with urban inhabitants and periodical rise in cost of electricity [1] and scarcity of conventional energy sources, renewable energy is a moderate replacement with the involvement of substantial cost factors [2]. Scope of solar electric goods in contemporary market is competitive, though the products are expensive for people belong to countryside. The past study based on renewable energy states, the growth of use of renewable energy is high from India's perspective over past few decades, which is substantially 200% for solar PV power [3].

1.1 Renewable energy scenario in India
India is blessed with an abundance of sunlight, water and biomass [4]. Vigorous efforts throughout the past two decades are now engendering outcomes as people in all walks of life are further responsive of the aids of renewable energy, particularly decentralized energy [5] which is consequently essential in villages and in urban or quasi-urban locations. India has the world's largest curriculum for renewable energy.

Government established the Department of Non-conventional Energy Sources (DNES) in 1982. In 1992 a full-fledged Ministry of Non-conventional Energy Sources was developed under the complete custody of the Prime Minister.

1.2 The scope of its activities encompass

- Elevation of renewable energy technologies,
- Construct an environment favorable to foster renewable energy technologies,
- Construct an environment favorable to merchandize the scope,
- Renewable energy source appraisal,
- Research and development,
- Illustration,
- Augmentation,
- Invention of biogas units, solar thermal appliances, solar PV (photovoltaic), solar cooker, wind energy and trivial hydropower units.

1.3 Wind power

India now lines as a dominating country with an installed wind power capacity of closely 1167 MW (mega watt) and nearly 5 billion units of electricity have been fed to the national grid so far [6]. Undertaken curriculums which are subsequently progressive such as wind resource assessment programme, wind monitoring, wind mapping, encompassing approximately 800 stations in 24 states with nearly 193 wind monitoring stations in operations. Entirely 13 states of India have a net potential of nearly 45000 MW.

1.4 Solar energy

Solar water heaters have evidenced the most prevalent so far and solar photovoltaic for decentralized power supply are becoming widespread more rapidly in rural and remote areas [7]. More than nearly 700000 PV systems generating closely 44 MW power, have been ordained throughout this country. Under the water pumping programme more than around 3000 systems have been instated so far and the arcade for solar lighting and solar pumping is far from being overwhelmed. Solar drying is one area which offers moderately decent prospects in food, agricultural and chemical products drying applications.

1.5 SPV systems

More than closely 700000 PV systems of capacity over around 44 MW for various purposes are installed throughout this country [8]. The market subdivision and practice is primly for household lighting, street lighting, solar lanterns and water pumping for irrigation. Over 17 grid interactive solar photovoltaic spawning more than nearly 1400 KW which are in effect in around 8 states of India. As the requirement for power matures exponentially and conventional fuel based power generating capacity flourishes arithmetically, SPV based power generation could be a source to sustain the expected deficit. Exclusively in rural, far-flung locations where the prospect of traditional electric lines is scarce, SPV power generation is the ideal replacement.

1.6 Study of solar electrification program in west Bengal run by WBREDA

On an average West Bengal receives nearly 1600 kWh/m^2 of solar radiation per year. The climatic data of West Bengal [9].
Average number of Sunny days in a year: 250 days
Number of partial Sunny days in a year: 60 days
Total overcast days in a year: 55 days
Highest ambient Temperature in summer: 40^0 C
Highest ambient Temperature in winter: 27^0 C
Lowest Temperature in winter: 8^0 C
Solar energy is being exploited in West Bengal, mainly for village electrification. However, there are some usages in respect of Solar Thermal energy as well. The State of West Bengal has completed substantial advancement in respect of village electrification by means of Solar PV course. There are nearly 2,000 villages in West Bengal where conventional electric means cannot be expanded owing to

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exorbitant expenses. Closely 400 villages out of these 2000 villages have been electrified by Solar PV means by now. Few Types of PV systems are being employed for village electrification (Table 1), according to WBREDA; the total Solar PV invested competence in the State of West Bengal has exceeded closely 1 MW recently [10]. There are beyond 15 Stand Alone type Power Plants in Sundarban area of West Bengal operating for about last 5 years in revenue-oriented mode. Micro level entrepreneurs are preserving the Solar Home Lighting Systems, which has spanned beyond eighty thousand. WBREDA has also installed an enormous number of Solar Street lights in several remote areas of West Bengal.

1.7 Initial survey conducted in rural area of Sundarban

A short survey has been accomplished in the rural areas of southern part of West Bengal namely Basanti and Gosaba islands of Sundarban. The study has reported that the countryside of that part of India is extremely deprived. Price of electric commodities and forest artifacts are substantially elevated with respect to the low wage rate of the inhabitants. West Bengal State Government initiated funding in solar projects as stated in preceding subsection, to make it accessible to rural populace.

Table 1. Available products to rural consumers of west Bengal

No	Model	System configuration	Working hours	Cost	WBREDA contribution	User contribution
1.	Model – II Solar PV Home Lighting System	37 Wp Module, 40Ah Battery, 2 no 9W CF Lamp , 1 no Plug Point for DC Fan	4 – 5 hrs daily, depending upon day time solar radiation	INR 12,000/-	INR 4,800/- for selected for non-electrified	INR 7,200/-
2.	Model – V HLS	74 Wp Module, 80Ah Battery, 4 no 9W CF Lamp , 1 no Plug Point for DC Fan		INR 18,666/-	INR 4,800/-	INR 13,866/-
3.	Solar PV Street Lighting System (RA)	4 meter Steel Tubular Pole, 74 Wp Module, 75 Ah Battery, one no 11 W CF Lamp	Dusk to dawn	INR 24,700/-	INR 19,200/- for Govt. user & INR 9600/- for others	INR 5,500/- for Govt. users & INR 15,100/- for others

2. Literature review

Rural electrification in Sundarban location has been a growing research area during last decade. Many researchers have interpreted their study to enlighten the expansion of renewable energy scenario in aforementioned venue as well as the disregarded plea of the populace of this underdeveloped region.

Chakrabarti and Chakrabarti [11] initiated a survey in the Sagar Dweep island of Sundarban and reported noticeable improvement and upgradation of rural living in post-solar photovoltaic period, which incorporates to some essential services such as health care and tele-communication and consequently enlightening the night life of inhabitants. However their study indicated the moderate cost association with the implementation which may not be a suitable option for rural electrification.

Whereas in another study, Mukhopadhyay [12] demonstrated the impact of Biomass Gasification based Power Plant in Chottomollakhali islands of Sundarban and reported the improvement of household life of rural populace and profitable turn over for the commercial consumers and subsequently proposed some recommendations based on merits and demerits of the project.

Ghosh, Das and Jash [13] further extended the study in Gosaba Island and reported that the biomass power plant is sufficiently generating the electrical energy which can subsequently reduce diesel usage and per capita gross energy consumption in the island is also reduced substantially. They have reported the usage of improved Chulha promoted by Government of India and consequently stated the merits and demerits of the system by proposing of 100% gasifier gas-based IC engines.

Mitra [14] stated Islands are important to promote the renewable energy worldwide. There are many success stories of island electrification by means of renewable energy, and it would be useful to remote locations of the mainlands also. Overall increasing interest amongst the island authorities and the renewable energy industry is exploring the vast potential which is still unexploited.

However Moharil and Kulkarni [15] demonstrated Well-established technology, simple operation and maintenance, downward trend of cost, optimum resource availability in remote and island areas, environmental sustainability, good management systems, are indications of large scale installations of solar power plants in near future at Sagar Dweep Island, where conventional power cannot reach as techno-economically viable proposition, SPV system will offer a competitive option there. Consumers are benefited, viewed in the context that the electricity is at their disposal, which is the important ingredient to raise their standard of living.

While Bhandari and Jana [16] conducted their survey in rural Sundarban Island and reported that household expenditure on kerosene is the critical part for the willingness to adopt mini-grid connection. The probability of willingness increases significantly with the successive higher expenditure on kerosene. Households with higher monthly expenditure on kerosene are likely to opt for SPV mini-grid connection. They may perceive that the expenditure on kerosene could cover the cost of electricity, apart from the benefits of using solar lighting systems. The preference for solar electricity might increase if the price of kerosene distributed through PDS is higher. Rural households are more concerned about cost factor rather than superiority in services.

The basic literature survey indicates that solar technology is indispensable due to its eco-friendly nature and independency of periodic investment but due to high cost involvement this noble venture is not functioning in full fledge throughout the place.

3. Survey conducted in Kamalpur power plant in Sagar Dweep Island

The authors visited the Kamalpur Solar Plant in the vicinity of Sagar Dweep area of Sundarban to conduct a socio-economic survey. Abovementioned plant claims the capacity to generate up to 26 KW of electricity from solar energy.

3.1 Plant description

The aforesaid plant comprises 18 arrays of 27 panels i.e. 486 solar panels. The plant contains 4 inverters, 3 of which produce 15 KVA power and 4th one produces 20 KVA in the central control room and it also entails a battery cell storage area to store the power for possible power supply when required. Due to some natural disasters some blocks of the above plant are damaged and kept inside the storage as idle 'waste'. The captured images of the plant are shown in Figures 1, 2 and 3.

3.2 Purpose of the visit

- To identify the working function of an existing solar plant.
- To find out the need of solar product for scarcely electrified areas.

3.3 Findings

The authors have found the followings:

- The petition of electricity is higher in that island, as the populace receives electricity up to four hours throughout the day (6 PM to 10 PM).
- Authors conducted a meet to the Block Development Officer in-charge and to the local people concerning the prevailing renewable energy scenario and promotion of renewable energy products and subsequently recognized that inexpensive solar goods are the exact replacement which can subsequently modify the circumstances.
- Despite of the fact that the area consists of a 26 KW power plant, yet electricity is inaccessible to the inhabitant since 10 PM at evening. Therefore they are enforced to purchase other expensive artifacts to enlighten their households.
- Some alterations could be made in the plants so as to enhance the efficiency of the existing system which in turn can make better quality of living of the local people.
- Substantial collection of damaged panels is merely stored inside a locker room, which are marked as 'waste' (as articulated by the plant in-charge), which are expected to be recycled and to be made accessible to the populace for negligible cost.

- Therefore a competent maintenance team should be introduced to control the state which can eventually shrink the 'waste' of the nation.

Figure 1. Solar panels in plant

Figure 2. Storage room

Figure 3. Control room

4. Proposed model of inexpensive artifact

The concept of the product does not only concentrate on a particular attribute rather it is a complete lamp system (Figure 4). A detail description of the system can be found in the study by Nath, Ghosh, De Sarkar and Chakraborty [17].

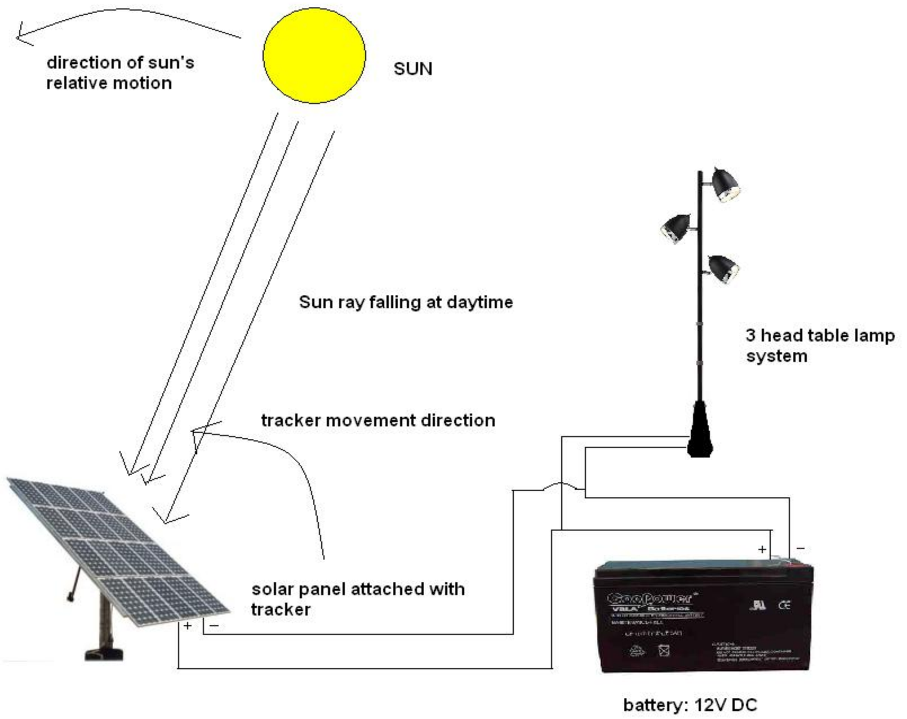

Figure 4. The system at a glance

The proposed artifact utilizes Light Emitting Diode or LED as the light source to meet the economic feasibility as stated by Wu, Huang, Huang, Tang and Cheng [18]. A comparison among accessible Incandescent, CFL, LED lamp is shown in Table 2.

The proposed model introduces an inexpensive way to design a battery with the help of recyclable metallic waste [17]. The schematic diagrams of Figure 5 and Figure 6, state that the arrangement produces 1.5V DC with 0.5-1 Amp current. The container used here is an aluminum metallic can which can be recycled once it turns out to be 'waste'.

Such ready cells are assembled inside a wooden box pack and connected serially. Therefore the 12V battery is ready to use. The top view of the battery is shown in Figure 7. The sodium chloride solution inside the individual cell would gradually decrease, therefore refilling of solution is required in a periodic interval.

Table 2. Comparison among incandescent, CFL, LED lights

Energy Efficiency	**Incandescent Light Bulbs**	**Fluorescent (CFL)**	**LED**
Life Span (average)	1,200 hours	8,000 hours	50,000 hours
Watts of Electricity Used(equivalent to 60 watt bulb).LEDs use less power (watts) per unit of light generated (lumens). LEDs help reduce greenhouse gas emissions from power plants and lower electric bills	60 watts	13-15 watt	6 - 8 watts
Annual Operating Cost. Average household has 30 bulbs in operation. Statistic represents the usage of the 30 bulbs for 5 hours per day.	$361.35/year	$84.32/year	$42.16/year
Environmental	**Incandescent Light Bulbs**	**Fluorescent (CFL)**	**LED**
Carbon Dioxide Emissions (Carbon Footprint).Lower energy consumption decreases: CO2 emissions, sulfur oxide, and high-level nuclear waste. For this example we will use the average watts used for LED lights and CFLs that compare to a 60-watt Incandescent light bulb for comparable light output. The time frame will be 5 hours/day for 365 days/year for 30 bulbs per household.	4405 pounds/year	1028 pounds/year	514 pounds/year
Contains the TOXIC Mercury. A silvery-colored poisonous elemental metal that is liquid at room temperature.	No	Yes - Toxic for your health and the environment.	No
RoHS Compliant (Reduction Of Hazardous Substances).The maximum concentration limits on hazardous materials used in electrical and electronic equipment. Enforced by the European Union.	Yes	No - contains 1mg-5mg of Mercury and is a major risk to the environment	Yes
Important Factors	**Incandescent Light Bulbs**	**Fluorescent (CFL)**	**LED**
Sensitivity to low temperatures	Some	Yes - may not work under negative 10 degrees Fahrenheit or over 120 degrees Fahrenheit	None
Sensitive to humidity	Some	Yes - can have a higher failure rate in more humid climates/weather.	No
On/off Cycling. Switching a CFL on/off quickly, in a closet for instance, may decrease the lifespan of the bulb.	Some	Yes - can reduce lifespan drastically	No Effect
Turns on instantly	Yes	No - takes time to warm up the Mercury to achieve maximum light output.	Yes
Durability	Not Very Durable - glass or filament can break easily	Not Very Durable - glass can break easily	Very Durable - LEDs can handle jarring and bumping
Heat Emitted. Incandescent bulbs emit large amounts of heat which can increase air conditioning costs and energy consumption while using air conditioning.	85 btu's/hour	30 btu's/hour	3.4 btu's/hour
Possibility of Mechanical Failure	Some	Yes - may catch on fire, smoke, or omit an odor	Not typical

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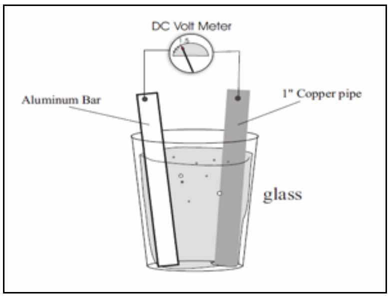

Figure 5. Arrangement of cell

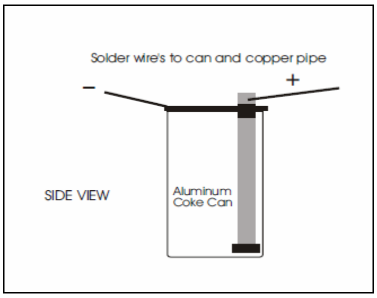

Figure 6. Sealing the cell

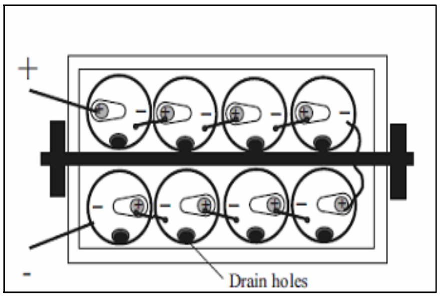

Figure 7.Arrangement of 8 such cells to form the battery

5. The design of alternative and inexpensive solar tracker

The system practices alternative solar tracking technology which enhances the power generation ability of the system. Tangible solar trackers [19] utilizes complex mechanical and electrical devices which are expensive and exorbitant to the rural inhabitants, hence the proposed tracking system is intended to serve the same purpose with moderated expenditure. The composition in Figure 8 depicts the holistic view of the system.

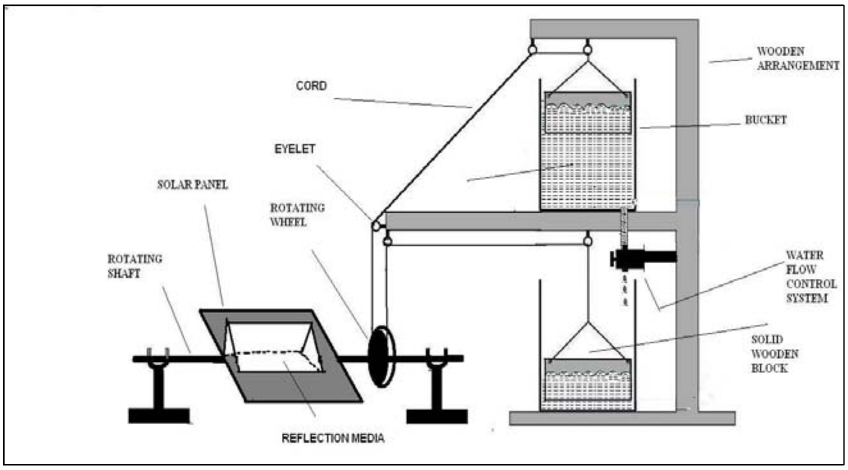

Figure 8. The working model of the alternative tracker system

5.1 Calculation of volume of the water to be stored in buckets

Adjustment with flow control system is made in such a way that one drop of water routes through it in exactly one second. So in a summer day during the time of daylight total water routes through the system is, 3600×12 = 43200 drops i.e. 43200×0.0616 ml. = 2661.12 ml.≈2.7 lt. (10 drops= 0.616 ml.), Consequently further modifications in the arrangement is suggested due to short length of day time in winter season, which is done by means of the adjustment of the stop cock of flow control system. Assumption is that, 2 drops of water passes through the system in 3 seconds i.e. total water needed for the entire day is 1.5 lt. Hence the volume of the buckets used in proposed system is up to 3000 CC (1000cc = 1 lt.) and the calculated weights of the suspended solid wooden blocks are up to 5 kg each. Figure 9 demonstrates the flowchart of working norm of the alternative tracker system.

6. Use of reflection medium to enhance the panel power

Observation has been made that the solar PV modules are not exploited completely as per the rated output due to the uneven fall of sunbeams on the surface area of the solar PV modules, which fails to excite the loosely bonded electrons up to the anticipated level. Therefore the arrangement has been made to increase the output of the panel up to a certain level by enhancing the number of incident rays falling on the surface area of the panel. With the aid of a reflecting medium [20] the purpose can be catered.

A polished metal sheet or a mirror can be used as a reflecting medium as an attachment of solar tracker. The practice of polished metal sheet would be less difficult to help the module to move with ease, owing to its negligible weight factor. Practice of mirror would be a succeeding choice due to the weight and brittleness, which further can trigger some ruptures on the surface area. The schematic diagram is given in Figure 10.

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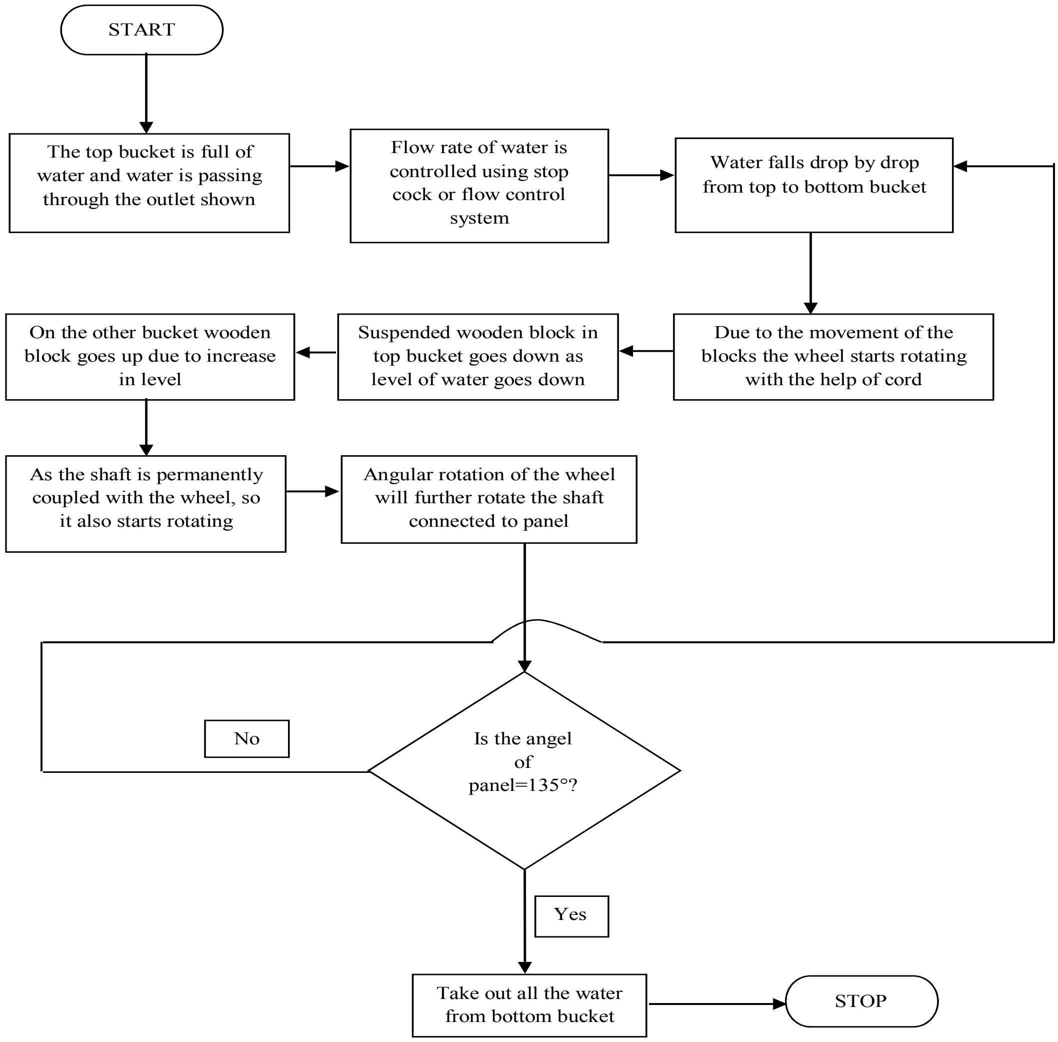

Figure 9. The flow chart of working norm of proposed solar tracker

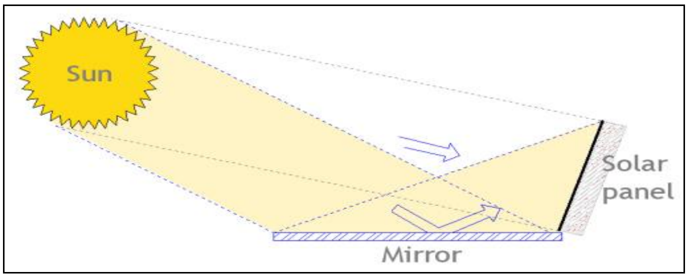

Figure 10. Use of reflecting media with solar panel

7. Cost economy is further proposed by re-using damaged solar PV module

It has been evidenced that the solar PV modules could be damaged and subsequently dumped as 'waste' in storage. Restoring these panels [21] therefore diminishes the expenditure substantially. The cost of damaged modules is closely INR 300 in e-shops such as eBay throughout the world. It has also been perceived that rated output can be obtained once the panels are repaired with considerable investment by adopting different techniques [22]. Mostly solar panels are spoiled owing to the gunshot hole in a single cell, thermal damage at the interconnection of the cell etc. Figure 11 illustrates a flowchart of step by step repairing technique of the solar PV module.

8. Conclusion

The approach here is to identify the renewable energy scenario of extreme rural area of Sundarban of eastern India and to recognize the neglected petition of the populace and to propose an inexpensive appropriate technology artifact which is to cater to the rural market. This study retrieves the progress in clean technology application throughout India and the actions taken by state government authority to electrify rural Sundarban area and consequently points out the tangible picture of the islanders. Therefore it depicts the tactic to propose an eco-friendly cost effective renewable energy artifact which is indeed competitive with other available solar products for the rural consumer segments in terms of cost and utility. The article further reports the cost effectiveness by means of alternative solar tracker design methodology with an aid of reflecting medium and subsequently the solar PV repairing procedure for the layman. Scope of improvement still remains for the product, in terms of more sophisticated design methodologies.

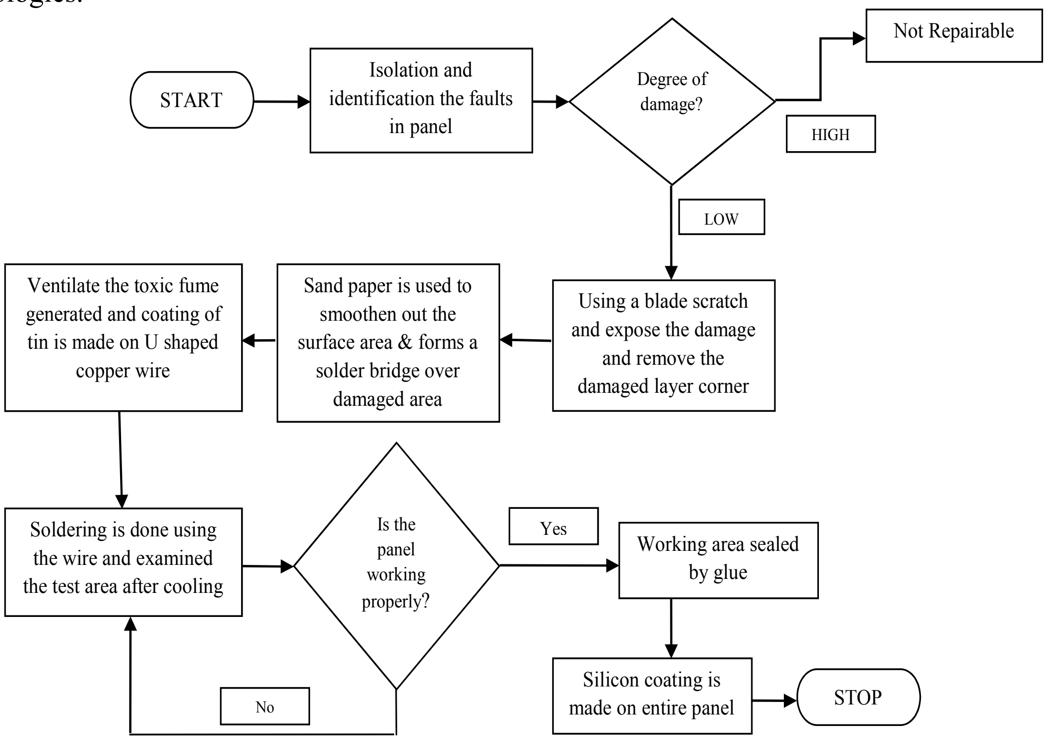

Figure 11. The flowchart of repairing damaged panel

References

[1] Audinet, P. Electricity Prices in India. Energy Prices And Taxes, 2nd Quarter, 2002.

[2] Singal, S. K., Varun. Development of Non-Conventional Energy Sources. 9th NCB International Seminar on Cement and Building Materials, New Delhi, 2005.

[3] Urban, F., Benders, R.M., Moll, H.C. Energy for rural India. Applied Energy. 2009, 86, S47-S57.

[4] Bhattacharya, S. C., Jana, C. Renewable energy in India: Historical developments and prospects. Energy. 2009, 34, 981-991.

[5] Hiremath, R. B., Kumar, B., Balachandra, P., Ravindranath, N. H., Raghunandan, B. N. Decentralised renewable energy: Scope, relevance and applications in the Indian context. Energy for Sustainable Development. 2009, 13, 4-10.

[6] Mabel, M. C., Fernandez, E. Growth and future trends of wind energy in India. Renewable and Sustainable Energy Reviews. 2008, 12, 1745–1757.

[7] Gupta, C. L. Role of renewable energy technologies in generating sustainable livelihoods. Renewable and Sustainable Energy Reviews. 2003, 7, 155-174.

[8] Urmee, T., Harries, D. A survey of solar PV program implementers in Asia and the Pacific regions. Energy for Sustainable Development. 2009, 13, 24–32.

[9] Chaudhuri, S. P. Renewable Energy in the Sundarbans. TERI Press, 2007.

[10] West Bengal Renewable Energy Development Agency. Retrieved from WBREDA: http://www.wbreda.org/, 1993.

[11] Chakrabarti, S., Chakrabarti, S. Rural Electrification programme with solar energy in remote region – a case study in an island. Energy Policy. 2002, 30, 33-42.

[12] Mukhopadhyay, K. An assessment of a Biomass Gasification based Power Plant in the Sunderbans. Biomass and Bioenergy. 2004, 27, 253 – 264.

[13] Ghosh, S., Das, T. K., Jash, T. Sustainability of decentralized wood fuel-based power plant: an experience in India. Energy. 2009, 29, 155–166.
[14] Mitra, I. A Renewable Island Life. Refocus. 2006, 7(6), 38-41.
[15] Moharil, R. M., Kulkarni, P. S. A case study of solar photovoltaic power system at Sagardeep Island, India. Renewable and Sustainable Energy Reviews. 2009, 13, 673–681.
[16] Bhandari, A. K., Jana, C. A comparative evaluation of household preferences for solar photovoltaic standalone and mini-grid system: An empirical study in a coastal village of Indian Sundarban. Renewable Energy. 2010, 35, 2835-2838.
[17] Nath, S., Ghosh, T., De Sarkar, S., Chakraborty, T. Designing of A Low Cost Solar Led Lamp for Scarcely Electrified Areas. Proceedings of FOSET Academic Meet, Kolkata, 2010.
[18] Wu, M. S., Huang, H. H., Huang, B. J., Tang, C. W., Cheng, C. W. Economic feasibility of solar-powered led roadway lighting. Renewable Energy. 2009, 34, 1934–1938.
[19] Mousazadeh, H., Keyhani, A., Javadi, A., Mobli, H., Abrinia, K., Sharifi, A. A review of principle and sun-tracking methods for maximizing solar systems output. Renewable and Sustainable Energy Reviews. 2009, 13(8), 1800-1818.
[20] Zhu, L., Fang, Z., Wang, Y., Han, L., Huang, Q. Higher Performance of Silicon Solar Cells Immersed in Dielectric Liquid. Proceedings of ISES World Congress, I-V, 2007.
[21] Yamashita, K., Umemoto, A., Okamoto, K. Research and Development on Recycling and Reuse Treatment Technologies for Crystalline Silicon Photovoltaic Modules. 3rd World Conference on Photovoltaic Energy Conversion, Osaka, 2003.
[22] Matsuoka, Y., Usami, A. Laser damage of silicon solar cells with different surface states. Optical and Quantum Electronics. 1974, 6(3), 217-223.

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