A Study on Low Cost Electrification Using Solar Energy a Field Work

R. Sankar, P. K. Jery Althaf, and S. Sreevas

***Abstract*—From a path breaking innovation, electricity has grown into one of the most important factors helping us to sustain civilization today. The entire world economy is dependent on technology today. Yet, certain remote areas are deprived of this basic amenity, either due to the lack of concern from the authorities or due to the unawareness about harvesting locally available resources. In this paper, the challenges faced by one such area are identified and the issue is solved by utilizing alternate energy source. This paper describes how rural electrification can be implemented in a cost-effective manner without compromising efficiency. The area under study is located farthest from the existing power grid and the high expenditure that has to be incurred in its electrification withdrew the authority from this task. However the project team formed under the Local Integrated Network of Kerala IEEE Students identified that the solar energy can be harvested in the area. All the project parameters were analyzed in detail and thorough research was done on the land and its inhabitants. Underground cables were chosen as the means of transmission. The project implemented provided electricity for basic lighting devices. The project can be viewed from a global perspective, as the characteristics of the area selected are identical to similar non-electrified regions around the world.**

***Index Terms*—Solar energy, energy conservation, energy efficiency, renewable energy, rural areas.**

I. Introduction

The project was aimed at providing a sustainable zero energy system in a small residential rural area at Chetad Chathapu, Karukone, Kollam. The area consists of eight houses and is located at about 5 kms, from the nearest grid, inside a forest. The basic lighting system was provided to all the houses using solar power. The major issue for providing normal grid power in this area was the huge cost involved in drawing lines to this area.

II. Challenges

The major challenges in providing power to the area are described below:

A. *Presence of Thick Forests*

A huge amount of trees have to be cut down for drawing lines to the site. Also, if lines are drawn due to the presence of trees, the maintenance costs is high. The lines are to be frequently cleared from branches. The possibilities of forest fires are also high. Thus, the authorities show reluctance in spending huge amount for a small population.

B. *Lack of Sources for in Situ Generation*

The major sources that could be tapped for in situ generation are Solar power, Hydel power, Biomass, and Wind energy. Due to the presence of huge trees around each house a suitable location had to be found out for efficient tapping of sun light for atleast five hours per day. There are only minor water streams around the site but the water flow is not perennial. Wind energy could be tapped efficiently only on open lands and presence of thick forest demands deforestation. As a result only solar power could be tapped for in situ generation.

C. *Transmission Lines*

Suitable method of transmission must be chosen for transmitting power to the individual houses. Lines/cables might get damaged due to the felling of branches of the trees.

D. *Sustainability and Maintenance*

The maintenance of the PV system is inevitable. The system would be sustainable only if it is maintained well. The illiteracy of the residents further makes it difficult for them to understand the technical aspects.

III. Analysis of the in Situ Sources

Different sources of energy were examined for their feasibility.

A. *Water*

The site was surveyed for the presence of water sources/ streams. It had a minor stream located at a distance of 1 km (downhill). The head of the water is very low and the stream is not perennial. The water flows only during autumns.

B. *Power Grid*

Lines had to be drawn for about five kilometers through forests for the grid supply. This could lead to heavy deforestation and high maintenance costs.

C. *Wind Energy*

The area is covered with huge trees and in order to tap wind power tall wind mills have to be erected and this is not possible in such a small location.

D. *Bio Mass*

As the number of inhabitants is less the net bio mass available is less than 2 kilograms. And hence this cannot be accessed as a source of generation.

E. *Solar Energy*

The site receives ample sun shine at certain points. If

Manuscript received August 2, 2012; revised October 5, 2012.

The authors are with the Local Integrated Network of Kerala IEEE of (LINK) Kerala, India (e-mail: snkr1990@ieee.org, jeryalthaf@ieee.org, sreevas@ieee.org).

suitably tapped it could be used as a source of power. The comparative cost of installing a solar powered energy system compared to tapping other sources is less in this site.

IV. Demand Assessment

Number of hours of operation of the equipment in a day per house: 5hrs (7pm-11pm and 5am-6am)

Total Watt-Hour demand per day per house= 130 Wh (Watt hour)

Total watt hour demand for all the houses in a day= 550 Wh

Wattage rating for Charging Kiosk= 20 W

Expected hours it is expected to work= 5 h

Total watt hour for kiosk= 100 Wh

Maximum total demand for five houses=650 Wh

After considering loses, Demand = 675 Wh

V. System Design

The survey result indicates that the only source of energy that can be harnessed to generate electricity is the solar power. There is not enough bio mass produced in the site, and hence a biogas plant cannot be implemented. . Sunlight is available at one particular area at the plot of five houses, so solar panel assembly was made at a place where sunlight is available and then distributed. Individual panels could be provided in the remaining three houses as enough sunlight was available. For transmission underground cables were used in order to prevent damage and reduce maintenance cost.[1]

Electrical load includes each house will have 2 Compact Fluorescent lamps for lighting purpose. Charging kiosk: A small charging station will be provided in order to charge mobile phones, radios etc.

A. Solar Calculations

Power demand per house: 22W (2*11W)

Battery bank Calculation

Days backup required = 1.33

Amp storage = 36.74 Ah (Ampere hour)

Depth of discharge = 50%

Required battery backup = 73.28 Ah

Battery Ampere ratings (20 hr) = 60 Ah

Number of batteries required = 1

Solar panel calculation

Sun hours per day = 8 h

Worst weather multiplier = 1.561

Effective hours = 5.16 h

Panel size chosen = 80W, 24V

Peak Amperage of panel = 3.33 A

Number of panels = 2

B. System Components

The components involved in the distributed system were main solar panel, charge controller, Inverter, Battery ,distribution panel, UG cables and light points .The overall system voltage was fixed at 24 v considering the efficiency and cost. The solar panels consists of one or modules wired together to generate a specific voltage and current, depending upon the demand. The output of the panel will be a direct current supply depending upon the rating of the panel used. *Battery* is used for the storage of the power generated from the panel. Battery used was lead acid type. Considering the cost factor and availability factor lead acid battery is preferred. *Inverter* converts direct current produced from the panels to alternating current. The input of the inverter would be direct current at a voltage of 24 Volts and output would be at 230 Volts (ac). [2]-[6]

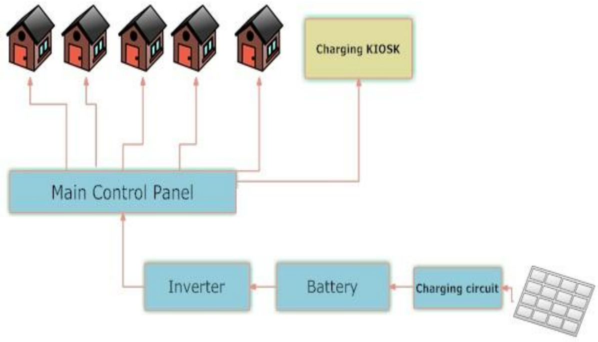

Fig. 1. Block diagram of the system.

1) *Main control panel*

It consists of an isolator and Miniature Circuit Breakers (MCB). The output from the inverter is fed into the main control panel. It is then divided into different lines through MCBs.

2) *Wiring of each house*

Each house will have two CFL bulbs of 15 Watts each. The block diagram is as shown

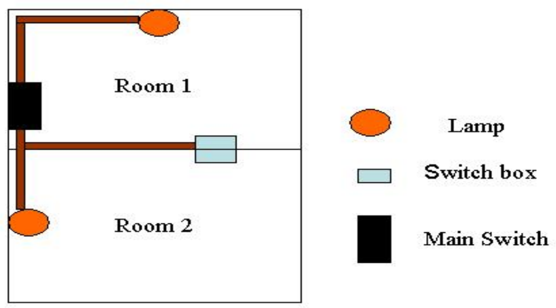

Fig. 2. Wiring diagram for each house.

3) *Wiring of charging kiosk*

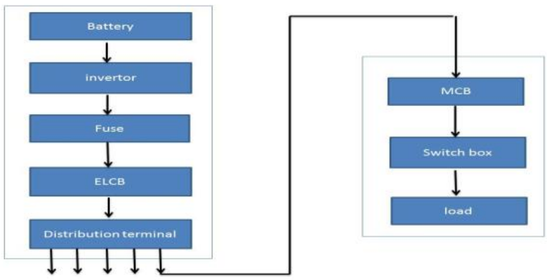

Fig. 3. Wiring of charging kiosk.

A common charging station for all the charging purpose in the site has been planned. The main advantage of providing such a station is to conserve power. There would be a control circuit which cuts the supply when the current exceeds a predefined value. This could be more accurate than the MCB. The basic block diagram is as shown in the diagram. The circuit consists of an electronic circuit that is used to control the current. The current from the supply line is sensed by a current sensor and it is compared in the comparator with a predefined value of current. When the input current exceeds this reference value, relay actuates and the supply is cut off. The station will have three plug points for the charging of mobiles, radio etc.

VI. Meeting Challenges

Solar energy was found to be the only potential source of energy .High system voltage was preferred considering the system efficiency. But the cost of the inverter was the limiting factor. Television, fans etc were avoided from the load. The usage of these gadgets cannot be controlled and this may lead to huge wastage of power. Presence of trees was a limitation in providing an overhead cable and getting proper sunlight. So in the distributed system, the panel was placed at a location and then distributed. For transmission, UG cables were used. The batteries require replacement and the local government was assigned the responsibility for it with the residents paying them monthly [7], [8].

A social challenge was the lack of knowledge, local persons was provided sufficient instructions on the basic operations of the system. The local self-government members where provided details regarding the maintenance and sustainability, which will help in keeping the panels in good state in the long run.

VII. Results

The paper provided a field study on the low cost electrification in non electrified area using solar energy. The components used to implement a solar energy system and how a system is identified based on trade off on a number of factors like efficiency, site features, cost etc. The system was successfully implemented which provided the basic demands of the residents. The expenses for them were only on the battery which may need replacement. The system proved to be much cheaper than the grid system.

VIII. Broader Perspective

A developing country like India encounters challenges like exponential increase in population and rising per capita energy consumption which demands an optimum usage of available energy resources. Currently the energy demands are mostly met by non renewable energy sources, a system that puts a tremendous pressure on the economy and causes a serious threat to the environment, flora and fauna. Hence, the government and other state nodal agencies in India are taking initiatives to promote the use of the renewable energy sources. In this regard when we consider the use of solar power we find some really startling observations [3], [9], [10].

India is a sunny country with a solar energy potential of 20 MW every square km. At present, only a tiny fraction of it is being tapped. If tropical India were to convert just 1% of the 5,000 trillion kilowatt-hour of solar radiation it receives a year into energy, the country will have enough to meet its energy needs—even in 2030—according to the national action plan on climate change.Solar heaters save up to 717,373KWh of electricity per year. These facts stress the importance that solar power will play in the future on India's growth.

TABLE I: Comparion of the Sigificant Renewable Energy Sources In India.

Attributes for Comparison	Wind energy	Solar Energy		Biomass
		PV	Solar thermal	
%Estimated distribution	7.9%	7.12%		10.49%
Installed Capacity	7093 MW	245 MW aggregate capacity (about 1,300,000 systems)	430,000 numbers.	537.47 MW
Estimated potential	net potential of about 45,000 MW and technical potential = 13,000 MW	20 MW/Sq.km.		19,500 MW
Private sector participation	Suzlon, Vestas etc	Tata BP Solar	Tata BP solar	Ankur Scientific, IISc, Grain Processing industry
Reliability factor	0.5 at 10,000 h	0.1 at 10,000 h for PV		0.9 at 10,000 h

TABLE II: Proposed System [6].

Name of Village	No: of Expected Consumers	Estimated Average Energy demand(KWh/day)	Proposed Power generating system	Estimated tariff (Rs/KWh)	Prevailing tariff for a diesel generator set (Rs/KWh)
Chetad Chetapu	23	1.25	Solar power	15	50

TABLE III: SUMMARY OF ALL THE SOLAR CALCULATIONS.

Type of Calculation	Description	Unit	Value
Estimated Watt demand			
Total Watts Per Hour (DC) Hours per day	DC Amps x 12	Watts	250
Hours Equip is expected to run (24hr)	as per application	Hrs d^{-1}	5
Watt-Hours per day			
Total daily usage	Watts x Hours	Watt-Hrs d^{-1}	1250
Amp-hour calculation			
Total watts	Daily requirements	Watt-Hrs d^{-1}	1250
Corrected for battery losses	Assumes static average loss	Watt-Hrs d^{-1}	1275
System voltage	DC voltage only	Volts	12
Amp-hours per day	Watts divided by Volts	Amp-Hrs d^{-1}	106.25
Battery bank calculation			
Days backup power required	Average 24 hour periods	Days	1.33
Amp-hour storage	Raw capacity you need	Amp-Hrs	141.31
Depth of discharge	Assumes 50%	fraction	0.5
Required amp backup	Prevents excessive discharge	Amp-Hrs	282.62
Battery Amp Rating (20 hr)	Battery Capacity in Amps	Fraction	60
Actual # batteries wired in parallel	Raw number	Number	4.71
Batteries wired in series	Relates to system voltage	Number	1.00
Rounded batteries	Always rounded up	Number	5
Solar Panel Array calculation			
Sun hours per day (Direct only)		Hrs	8
Worst-weather multiplier*	1.55 default	Fraction	1.561
Total sun hours per day	Assumes average sun	Amp-Hrs	5.161
Select panel size (Watt rating)	Watt hour rating	Watts	36
Nominal Panel Voltage	Approximate Solar output	Volts	16
Amps required from solar panels	Total daily consumption	Amps	106
Peak amperage of solar panel	Watts divided by Volts	Amps	2.25
Number of solar panels in parallel	Raw Number	Number	9.14
Charge controller rating		A	20
Rounded number of solar panels	Always rounded up	Number	10

IX. CONCLUSION

Solar energy is a potential next generation energy system for electrification of areas similar to ones where this project was implemented .The region can be considered as characteristic of areas were it was difficult to generate power by other means on the account of higher cost. In the areas that are considerably away from the grid the system can be more cost effective and practical. The high cost of establishment of the grid system may be tackled by using solar energy. When the reliable electricity is found as a challenge to the developing and under developed countries, low cost electrification using solar energy is a very effective method.

ACKNOWLEDGEMENT

We would like to thank IEEE for providing the grant for the project and the team of volunteers from LINK who put forward the best foot in successful completion of the project.

REFERENCES

[1] N. R. Karki, "Reducing the cost of rural electrification: A key to improve the quality of life in rural areas in developing countries," *Conference Proceedings, International Conference on Power System Technology, PowerCon*, vol. 1, pp. 447-452, Nov. 2004.

[2] N. M. Ijumba and C. W. Wekesah, "Application potential of solar and mini-hydro energysources in rural electrification," *Conference Proceedings, IEEE 4th AFRICON*, vol. 2, pp. 720-723, 1996.

[3] B. T. Kuhn and R. S. Balog, "Design considerations for long-term remote photovoltaic-based power supply," *Twenty-Third Annual IEEE Applied Power Electronics Conference and Exposition*, pp. 154-159, 2008

[4] G. Abla and E.-Z. Atef, "Design and economy of renewable energy sources to supply isolated loads at rural and remoate areas of Egypt," *20th International Conference and Exhibition on Electricity Distribution CIRED*, pp. 1-4, 2009.

[5] T. Q. Dung, "PV technology and success of solar electricity in Vietnam," *Conference Record of the Twenty-Sixth IEEE Photovoltaic Specialists Conference*, pp. 29-36, 1997.

[6] M. Indradip and S. P. C. Gon, "Remote village electrification plan through renewable energy in islands of indian sunderbans," *The Energy and Resources Institute*, 2005

[7] I. Schinca and I. Amigo, "Using renewable energy to include off-grid rural schools into the national equity project plan ceibal," *Conference Proceeding, International Conference on Biosciences*, pp. 130-134, 2010

[8] H. J. Corsair, "Clean energy and extreme poverty: The cost burden of donated solar home lighting systems," *Conference Proceeding, IEEE Power and Energy Society General Meeting*, pp. 1-6, 2009.

[9] C. T. Gaunt, R. Herman, and B. Bekker, "Probabilistic methods for renewable energy sources and associated electrical loads for Southern African distribution systems," *Conference Proceedings, CIGRE/IEEE PES Joint Symposium Integration of Wide-Scale Renewable Resources Into the Power Delivery System*, pp. 1-7, 2009

[10] D. B. Snyman, "Centralized PV generation and decentralized battery storage for cost effective electrification of rural areas," *AFRICON Conference AFRICON '92 Proceedings*, pp. 235, 1992.

Sankar R. received his B.Tech degree in Electrical and Electronics engineering from TKM Engineering College, Kollam. He is currently working as Assistant Systems Engineer - Trainee at Tata Consultancy Services.

Jery Althaf P. K. received his B.Tech degree in Applied Electronics and Instrumentation from College of Engineering, Trivandrum. He is currently Young India Fellowship student at Ashoka University.

Sreevas S. received his B.Tech degree in Applied Electronics and Instrumentation from College of Engineering, Trivandrum. He is currently a doctoral student in Strategic Management area in Indian Institute of Management Kozhikode.