OASYS SOUTH ASIA Research Project

Papers presented at conferences/workshops/ Seminars

Cluster Approach for Effective Decentralization in Off-grid Energy Project: A Case Study from Dhenkanal District, Odisha

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Presented at the ***IV th International Conference on Advances in Energy Research, Indian Institute of Technology Bombay, Mumbai (India), 10-12 December 2013.***

Abstract

TERI is undertaking a project to set up solar powered decentralised power projects in a cluster of five villages and hamlets in Dhenkanal district of Odisha. These villages are inside the reserve forest, and therefore owing to regulations, grid extension is not possible. This study aims to conduct a techno-economic comparative analysis between the option being explored for the cluster of villages i.e. distributed power plants in each village and alternative options, where a centralised power plant installed in one village provides electricity supply to all other locations through distribution lines running between the villages/hamlets. While clustering has its own advantage of economies of scale and scope, it is imperative to assess the benefits – both from technical design and investment perspective as well as operation and maintenance costs and also ease of managing the project institutionally. This study attempted to focus on all the technical design and investment required to draw out a comparative analysis, while also focusing on the institutional aspects for trouble free operation and management of such power plants.

Keywords: rural electrification, solar, off-grid, cluster approach, techno-economics

Acknowledgement: The work reported in this paper is funded by an EPSRC/ DfID research grant (EP/G063826/2) from the RCUK Energy Programme. The Energy Programme is a RCUK cross-council initiative led by EPSRC and contributed to by ESRC, NERC, BBSRC and STFC. The author gratefully acknowledges the funding support.

Disclaimers: The views presented here are those of the authors and do not necessarily represent the views of the institutions they are affiliated with or that of the funding agencies. The authors are solely responsible for remaining errors or omissions, if any.

1. INTRODUCTION

Universal electricity access has become a key milestone for India as well for all other developing countries, especially after the launch of Sustainable Energy for All initiative [1]. This has also been recognized, both from the point of view of equitable access to resources, and the use of renewable energies to create the necessary access to modern energy services, in an environmentally benign manner. Having the largest rural population in the world, India, however, confronts a huge challenge for rural electrification, especially for electrifying remote, forested and tribal habitations. Statistics from the Census of India 2011 indicate that almost 77 million households in India were living without electricity in 2011 [2]. Despite efforts by the Central and various State Governments in India to improve electricity services during the last five decades, household electrification level and electricity availability continues to lag behind the world average. While the world average for electrification rate in 2010 was around 81.5%, the average electrification rate for India stood at about 75% with rural area having only 67% electrification rate [3]. Further, where power is available in the villages, the quality and availability is poor and in many cases electricity is available for only 6 - 8 hours per day [4].

While the centralized grid based electrification has been the most common approach in the country, literature indicate that decentralized renewable energy options have also been adopted and being increasingly considered as an cost effective mode of electrification for areas where it is techno-economically not feasible to extend the electricity grid or in areas where electricity supply from the grid is inadequate to meet the demand [4, 5]. As of June 2013, the Remote Village Electrification Program (RVEP) has covered 11,727 villages and hamlets [6]. While the program was meant to consider all forms of renewable energy technologies, it is observed that the vast majority of the villages taken up for electrification under RVEP were provided with solar home system or solar PV plants [7] The marginalized communities such as tribal communities within forested and hilly areas are most affected by non-extension of the grid supply, either due to the high costs of extending the grid to such remote locations or because of current regulations, which do not allow extension of electricity grid in the villages within reserve forests [8].

This paper focuses on the State of Odisha, where the percentage of electrified households is far below the national average at 43%, amounting to around 55 million un-electrified households in the State, out of which over 52 million households are in rural areas [2]. Only the States of Assam, Uttar Pradesh and Bihar have lower rates of electrification than Odisha. Further the state also has the highest number of remote un-electrified villages in India, not being covered under the Rajiv Gandhi Grameen Vidyutikaran Yojana (RGGVY). While the RGGVY is focusing on electrification of un-electrified villages through grid extension, the Odisha Renewable Energy Development Authority (OREDA) under the DDG scheme of the Ministry of Power (MoP), and Village Energy Security Program (VESP) and Remote Village Electrification (RVE) Program of the Ministry of New and Renewable Energy (MNRE), have been playing a central role in promoting off-grid electrification to cover the remote rural areas. Despite this progress and promotional schemes/programs, there are still many remote off-grid and forested area villages which stay out of reach of electrification. In such remote areas, the likelihood of electrification is low owing to their presence inside forests, small and scattered populations, and low paying capacities.

Electrification through renewable energy, as compared to conventional sources of energy has the advantage of modularity, i.e. small power plants can be built to provide the basic electricity needs that can be gradually scaled up to suit the growing demand of the users. This inherent quality of renewable energy gives developers the ability to design power plants in a number of ways that suit the economic and technical requirements of the area under consideration, at a particular point in time and under given funding constraints.

The paper is organised as follows: The paper first describes briefly the rural electrification situation and provides a background for the study highlighting brief details of the project site selected for the study. Section 2 covers the Methodology adopted to design the power plants and carry out the analysis. Section 3 provides the Results of the analysis followed by Discussion. Finally, the Conclusion section summarizes the study and suggests recommendations that may be considered while designing a distributed generation system for remote areas.

1.1 The OASYS Project in Dhenkanal district of Odisha

TERI is undertaking a multi-consortium action research project, titled 'Decentralised off-grid electricity generation in developing countries: Business models for off-grid electricity supply', known as 'OASYS South Asia Project. This project aims to develop innovative and participatory business models for decentralised off-grid electricity supply in South Asia to alleviate the energy access problem of the region. An important component of the project is to develop an off-grid delivery model framework and implementation of demonstration project(s), covering un-electrified villages, to test the framework. TERI have identified a cluster of un-electrified villages within Hindol block in Dhenkenal district of Odisha, which is also a backward district identified by the Planning Commission, to implement one of the demonstration projects. Dhenkenal district has about 253,118 rural households, of which only 38.5% are electrified [9].

The project area under consideration comprises of four villages and one hamlet, namely Rajanga, Kanka, Chadoi, Baguli and Rajanga Hamlet (Table 1). The village cluster is at a distance of 120 km from the state capital of Bhubaneswar. The households are mostly from the tribal communities and are completely un-electrified. These villages have also not been considered under the RGGVY scheme have also little chance of getting access to electricity through grid extension as they lie inside the Kandhara Reserve Forest which falls under an elephant corridor in the district.

Table 1: Demographic information of selected villages

Name of Village	Rajanga	Kanaka	Baguli	Chaddoi	Rajanga Hamlet(PuranaSahi)
Latitude/ Longitude	N $20^o34'07.6''$ E $85^o16'26.3''$	N $20^o32'45.6''$ E $85^o16'0.67''$	N $20^o33'19.6''$ E $85^o17'47.2''$	N $20^o32'51.9''$ E $85^o16'38.6''$	N $20^o34'26.4''$ E $85^o16'24.7''$
Total households	34	43	35	12	12
Total Population	140	189	142	46	38

Source: Authors' compilation

TERI is undertaking a project to set up solar powered decentralised power projects in the cluster of five villages and hamlets. Five solar power plants of appropriate capacity, with provision of AC and DC supply, are being installed in these villages. This study aims to conduct a techno-economic comparative analysis between the option currently being explored for the cluster of villages (i.e. distributed power plants in each village, considered as Case 1 for this analysis) and alternative options, where a centralised power plant installed in one village provides electricity supply to all the five locations through distribution lines running between the villages and hamlets. The study assumes significance as the decentralised distributed generation (DDG) scheme guidelines released by Ministry of Power clearly indicates that to the extent possible, selection of the villages/hamlets is to be carried out in a cluster to take advantage of the clustering effect and the merit of setting up a local distribution grid covering all these villages/hamlets with a central power plant as against setting up of individual village/hamlet level systems [10]. While clustering has its own advantage of economies of scale and scope, it is imperative to assess the benefits – both from technical design and investment perspective as well as operation and maintenance costs and also ease of managing the project institutionally. Further, the feasibility of adopting cluster approach may also depend on the technology selected and the results may not be same for a solar PV project design and other renewable energy technologies such as biomass gasifier based projects. This study attempted to focus on the technical design and investment required to draw out a comparative analysis, while also focusing on the institutional aspects for trouble free operation and management of such power plants.

2. METHODOLOGY

The analysis is based on the energy demand in the village cluster, identified through extensive survey of all households, for residential, community and productive applications, and actual cost of setting up and managing the power plants in the cluster. This includes capital costs of the power plants, and also cost towards civil construction, distribution line, institutional overheads, human resources and operation and maintenance costs. In order to estimate the capital and maintenance cost quotations for the different sizes of power plants were obtained from vendors of solar PV power plants. Additionally, quotations for the distribution network and civil construction costs were also obtained from local contractors in Dhenkanal district to arrive at a realistic cost for setting up the infrastructure. The cost of construction has been included because in such off-grid sites, there are often no concrete structures on which the solar panels can be installed. The construction requirement has been estimated based on the rooftop area required for the solar power plant in each case. The annualised operation and maintenance costs have been calculated at an average inflation rate of 10% for a period of 5 years. The maintenance cost is 0.5% of the capital cost of the power plant. The following sub-sections details out the assumptions made and design approach for both the Cases.

2.1 Design Approach: Case 1

The livelihoods assessment exercise was carried out to gauge the potential productive load applications that could be used in these villages, if a mini-grid is created in the villages. Using Participatory Rural Appraisal techniques, through village transits, surveys, Focus Group Discussions, and interviews with various stakeholders (village heads, forest department officials, local NGOs), information on existing and potential income and livelihood generating activities was procured, analyzed and the activities mentioned in Table 2 were shortlisted. The appropriate capacity of the productive appliances was then finalized accordingly to determine the productive load.

Table 2: Types of loads proposed at the sites

Appliances	Capacity	Purpose
Grinder	1 HP at Rajanga	For grinding turmeric and chilli powder
Electronic Weighing Scale and Sealing Machine	Weighing Scale – 10-20 W at Rajanga Sealing Machine – 150 W at Rajanga	For accurately weighing and packaging of ground turmeric and chilli powder. These have wider application since users can use the machine for other products as well and bring about standardization through accurate weighing, delinking them from the middle-men
Saal Leaf Plate Pressing Machine	0.5 HP at Rajanga	The community is currently engaged in the stitching of basic Sal leaf plates, called *Khalis*. By pressing two *Khalis* together in the machine, a firm plate can be moulded which has a much higher value in the market.
Water pumps	2 HP each at Rajanga and Kanaka	Agricultural is possible only during the monsoon and the farm lands lie unused during the rest of the year. Hence, to improve agricultural yield, especially of high value crops such as brinjal, water pumps are being

		provided to initiate activities during the non-monsoon period.
Water Purifier	50 LPH, 75 W each at Rajanga, Kanaka and Baguli	For provision of clean drinking water
In addition to the above, provision for the following services has been included in the sizing of the power plant: • TV-DVD at the community centres (for educational and training purposes) • Community centre lighting and fans (to create a resource/community centre for people to work and also for meetings, discussions, trainings, etc.) • 2 light points and a plug point at every household		

Source: Authors' compilation

Based on the above, the segregated day and night energy requirements for each village have been calculated for electricity generation through solar PV power plants as given in Table 3. Solar PV has been considered for these villages after an assessment of resource availability for biomass, wind and small hydro systems. While biomass is available in the area, however, it is not permissible to collect as per prevalent biomass extraction regulation for reserve forests and there is no sufficient agricultural residue in the villages, biomass based decentralised technology has not been considered for electricity supply. Also, wind speed and hydro power availability are insufficient to be considered for any localized power generation.

It is to be noted here that Baguli and Rajanga Hamlet only have lighting and mobile phone charging requirements, and hence the entire load is a night time requirement. However for the other three sites, the productive and community loads are operational during the day and contribute to the day time energy requirement. Using this data, the battery size has been calculated to cater to 2 night-time loads assuming that the day time loads will operate directly on the electricity being generated during the sun-shine hours. From the energy requirements data mentioned in Table 3, the solar PV power plant design for each site has been calculated (Table 4). As mentioned in the previous section, for the purpose of analysis in this paper, this design is referred to as Case 1.

The following key factors were also taken into consideration during the design of the power plants:

a) Owing to the distance between the sites and taking advantage of the modularity of solar PV technology, five individual, independent power plants were designed, one for each site, rather than a single power plant at one location with feeders for each of the 5 sites.
b) For each power plant, an independent power distribution network within the village has been planned. In the villages of Baguli, Rajanga Hamlet and Chadoi, this distribution network caters only to household and productive loads (if present). In Rajanga and Kanaka, the distribution network also connects to a water pump, located at some distance from the households.

c) Rather than adopting a stand-alone system for the water pump, it has been connected to the main power plant in the village through a distribution line. Although the distribution line contributes to additional cost, such a connection has been preferred to (i) cater to any future requirements of increase in pump size and (ii) cater to inrush current required by the pump when it is switched on.

d) Although the power plants are technically independent units, they are planned to be operated by local youths, selected from each village. A Village Energy Committee (VEC) has also been formed, with representatives from each of the villages, who will be responsible for local oversight and social engineering, leading to a clustered management approach. The VEC will be guided by TERI during the project period for atleast one year after the commissioning of the power plants. Simultaneously, an exit strategy will also be developed to either handover the plants to the electricity distribution company or any other agencies that can operate and manage the plants.

e) The three power plants catering to a larger number of households, community, productive and/or agricultural loads (in Rajanga, Kanaka and Baguli) are designed as AC power plants. Taking costs into consideration, the two smallest sites (with 12-15 households with basic 2 light points and mobile charging requirements) are being provided with DC micro grids. It is to be noted here that the number of light points and quality of the final service (lighting) for households in both AC and DC power plants has been kept similar (i.e. the type of lamp and the lumen output of the lamps have been selected as same for households). Thus, the metric chosen here residential services is energy services (final output) and not energy (kWH) to ensure equitable services.

f) The sizing of the systems has been done incorporating appropriate demand side management. For example, it is expected that the water pump will be utilised during the winter months. During this period, the other productive applications will be sparingly used to ensure that the pump can run for the maximum time. During the rest of the year when the pump is not required, adequate load will be generated from the other productive applications. Such a design ensures that the annual average Plant Load Factor (PLF) of the power plants is optimised.

g) Also, a single grid tied inverter has been considered so that the electricity can be fed to the grid in case the villages get electrified through grid extension in future. However, other inverters have not been considered grid tied to keep the cost within reasonable limits. In case the grid is extended is the villages, the non-grid tied inverters can operate on a stand-alone basis to support the productive and community load in the villages using the solar power capacity. They however, have provision to get supply from the grid to charge the batteries with preference to solar charging.

Table 3: Day and night energy requirements at each site

Site	Day Load (kWh)	Night Load (kWh)
Rajanga	11.67	6.07
Kanaka	7.66	6.88
Chadoi	0.30	5.84
Baguli	0.00	0.58
Rajanga Hamlet	0.00	0.58

Source: Authors' compilation

Table 4: System Design for Decentralised PV power plant at different sites (Case 1)

Site	AC/DC	Plant Design	Length of the distribution line along the longest feeder (meters)	Total length of the distribution line (meters)
Rajanga	AC	6 kWp SPV power plant, 6 kVA inverter (grid tied), 48 V 500 Ah battery bank	1500	2100
Kanaka	AC	5 kWp SPV power plant, 5 kVA inverter, 48 V 600 Ah battery bank	900	1400
Chadoi	AC	2.5 kWp SPV power plant, 2 kVA inverter, 48 V 500 Ah battery bank	700	1100
Baguli	DC	200 Wp, 24 V 100 Ah battery bank, 15 A charge controller	200	300
Rajanga Hamlet	DC	200 Wp, 24 V 100 Ah battery bank, 15 A charge controller	200	300

Source: Authors' compilation

2.2 Alternative Designs: Cases 2 and 3

The design of the solar power plants as given in the Table 4 has been arrived at with the objective of optimizing system design, reducing losses and minimizing projects costs, while providing the same level of service to all the households while also catering to productive and agricultural loads for the project villages in a collective manner. Using the same management structure considered for case 1, it may be useful to consider alternative technical designs within this approach of clustering of power plants, which can provide insights what technical and institutional approach should be adopted for better techno-economic results. One such alternative is the option of a single power plant at the most accessible site, with distribution lines stretching to all the other sites from the centralised power plant (Fig 1). In this paper, the techno-economics of such an alternative design has been analyzed. Such a design is expected to result in certain costs and benefits owing to changes in the capital cost, maintenance cost and ease of management, which will be further explored in Section 3.

Cases 2 and 3 discussed in the following sub-sections are based on design in which a single AC power plant is located in Rajanga village and catering to all other villages, as compared to Case 1 where five different micro solar power plants have been considered. Rajanga is chosen as the location of the central power plant owing to its better accessibility and therefore lower transport and construction costs and fewer delays due to poor road conditions.

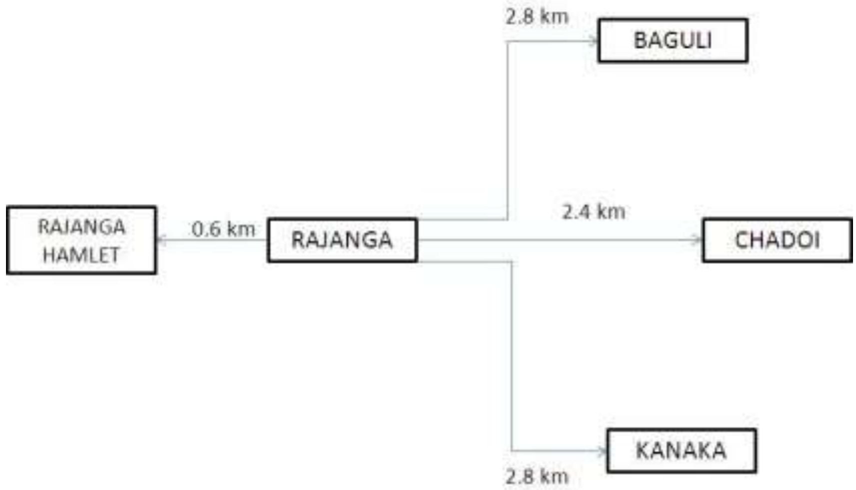

Fig. 1: Distance of the sites from Rajanga

Case 2: Increased transmission infrastructure but no change in the cumulative size of the centralised power plant

In order to cater to the demand of all 5 villages from a single power plant, the cumulative demand for day and night time is calculated and using the same design criterion as in Case 1, the power plant size is calculated. The distance of each of the villages from Rajanga is as shown in Fig. 2. Without any changes the power plant size in order to compensate for losses, if only the transmission infrastructure is to be modified, the economic transmission voltage is calculated using the formula [11] given below (Eq. 1).

$$Economic\ voltage\ \ V = 5.5\sqrt{\frac{L}{1.6}+\frac{kVA}{150}} \qquad \text{……….Eq. 1}$$

Where,

L is the length of distribution line in km and kVA is the Power per phase required to be transmitted

Case 3: No change in the transmission infrastructure, but increase in PV system size to compensate for losses accruing from extending the existing single phase transmission network.

For this case, the existing local village level distribution network is extended to supply power from Rajanga to the other villages. In such a case, the losses accruing from the transmission of power are compensated by a proportional increase in the size of the power plant. For the estimation of cable loss and voltage drop, standard electrical formulae are used and insulated copper cables have been considered for the design. The required increase in the size of the power plant to compensate for transmission losses is calculated assuming that the power will be transmitted at standard single phase voltage of 230 V, as there is no 3 phase load at the sites and supplying 3 phase power would result in higher cable and inverter costs. Two options have been considered for the cross-sectional area of the cable to be used for transmission – in first option the same cable used for local village transmission is extended to the main power plant in Rajanga and in the second option, a Cu cable of cross-sectional area of 45.6 mm2 has been considered. This analysis can be conducted for other cable types of higher cross-section area to further reduce the transmission loss however, the cost will also increase commensurately. Thus, for the purpose of this analysis two cable sizes mentioned above have been considered.

4. RESULTS AND DISCUSSION

The following section provides the results for the two alternative cases considered for the analysis.

Case 2: Using equation -1, the economic voltage at which electricity needs to be transmitted to the villages/ hamlets is provided in Table 5. Transmitting such low amount of power through 3.3 kV and 6.6 kV transmission line may be an expensive solution as the cost of transmission cables, step-up and step-down transformers and protection devices would be several times of the power plant cost. Hence such an option seems to be unfeasible from an economic point of view for the power plant design under consideration and thus is not advisable for implementation.

Table 5: Values of Economic Voltage of transmission

Village/ Hamlet	Economic Voltage (kV)	
	as per calculation	as per allowable standard voltages
Rajanga hamlet	3.4	3.3
Kanaka	7.3	6.6
Chadoi	6.7	6.6
Baguli	7.3	6.6

Source: Authors' compilation

Case 3: The voltage drop and power loss for each of the villages is as shown in Table 6. With the power loss observed in Table 6, the size of the power plant needs to be suitably increased to compensate this loss. For option -1, where same local cables are extended, the size will increase by 1,660 Wp and for option - 2, where a 45.6 mm^2 cable is used, the power plant size would need to be increased by 830 Wp. Thus, an increase of 830Wp in PV capacity with respect to cumulative PV capacity of case 1 design has been considered for designing the centralised power plant (Table 7).

In addition to the additional capacity enhancement to compensate the power loss in the transmission cables, the centralised AC power plant capacity has also increased as two DC power plants at Chadoi and Rajanga Hamlet considered in Case 1 are now being considered to get AC power. Further, in this design, two inverters of 9 kVA each have been considered, one to cater to the day load and another for the night load, so that the inverters can work at the rated capacity for higher efficiency. In addition to this, one inverter can also act as a spare to the other one in case of maintenance of either inverter ensuring that part of the load is met in case one inverter fails. Here also, one inverter is considered as grid tied and the other stand-alone (with facility for connection to solar module and also grid) for reasons explained the Section 2.1.

Table 6: Voltage drop and power loss per site

Village/ Hamlet	Total length of distribution line (m)	Peak load (kW)	Max current to be transmitted (Ampere)	Cable size (mm^2)	Voltage drop (V)	Voltage drop (%)	Power loss (Watt)	Power loss (%)
Rajanga hamlet	800	0.10	0.43	8.3	1.5	0.7	0.66	0.7
Kanaka (1)	3,700	1.98	8.62	45.6	25.3	11.0	218.34	11.0
Kanaka (2)	3,700	1.98	8.62	22.8	50.6	22.0	436.68	22.0
Chadoi	2,600	0.10	0.43	18.7	2.2	1.0	0.95	1.0
Baguli (1)	3,500	0.95	4.11	45.6	11.4	5.0	46.91	5.0
Baguli (2)	3,500	0.95	4.11	22.8	22.8	9.9	93.81	9.9
Rajanga (1)	1,500	2.00	8.70	45.6	10.4	4.5	90.04	4.5
Rajanga (2)	1,500	2.00	8.70	22.8	20.7	9.0	180.08	9.0

Source: Authors' compilation

Table 7: Design of centralised AC power plant at Rajanga

Site	AC/DC	Plant Design	Length of the distribution line along the longest feeder (meters)	Total length of the distribution line (meters)
Rajanga	AC	14.6 kWp SPV power plant, 2*9 kVA inverter (one grid tied), 96 V 800 Ah battery bank	3,700	13,800

Source: Authors' compilation

In the case with distributed power plants, 5 operators are required for the running the three AC and two DC power plants whereas for the centralised power plant, only one operator is required. A remuneration of INR 1000 per month per operator for AC plants and Rs 500 per month per month for DC operators has been considered. The operator's salary has been arrived at in discussion with the VEC keeping in mind the expected revenue from the household connection. The operator's role would be to switch on and off the power plant and minor operations such as cleaning of solar panels and battery terminals on a monthly basis. Considering the above remuneration and the capital costs for solar power plants, civil construction and distribution network, it is observed from Table 8 that the incremental solar power plant capacity of the centralised system and the resultant increase in length of the distribution line is resulting in almost 40% increase in the capital cost and O&M cost (capitalized to the first year) as compared to the distributed systems. However the civil construction cost for housing the power plants has reduced owing to a single construction at Rajanga instead of civil construction at three different sites.

Table 8: Cost comparison for both design cases

Particulars	Cost (INR)	
	Case 1	Case 3
Solar Power Plant	3,162,229	2,926,000
Distribution Line	1,748,000	5,244,000
Household connections	272,000	272,000
Construction Requirements	1,983,923	1,523,861
Annualised O&M cost over a 5 year period	241,894	100,948
TOTAL	7,166,152	9,965,861

Source: Authors' compilation

5. CONCLUSIONS

The paper attempted to conduct a techno-economic comparative analysis between implementing distributed power plants in each village to provide electricity supply in a cluster of villages and alternative options, where a centralised power plant installed in one village provides electricity supply to all the other locations through distribution lines running between the villages and hamlets. The analysis of the two Cases indicates that there is high difference in cost owing to almost 200% increase in transmission line cost for the distributing the energy from a centralised power plant. This is thus not feasible option for such small power plants and low demand and thus a decentralised approach is preferred from technical point of view vis-à-vis a clustered approach for electricity supply. However, there might be some operational benefits to having a central power plant, mainly accruing from ease of maintenance of a single system. But with a good system design that ensures infrequent maintenance, even managing multiple power plants may not be a difficult proposition. Owing to such technical and economic limitations, a strong case can be made in favour of technical design of distributed systems. However for ease of management of the system, a single institutional entity can be formed covering a group of villages.

While the analysis carried out for solar PV technology clearly demonstrates the efficacy of having decentralised power plants with a possible institutional clustering for better management, the same may not be said for biomass gasifier technology. While solar PV technology is a truly modular technology with sizing from Wp to a scaled-up capacity of MWp, there are design capacity constraints existing for other renewable energy technologies. For example, the minimum commercial capacity available for a biomass gasifier is 10kWe and so clustering of load for best utilization of rated capacity may be useful for the gasification technology [12]. Similar is the case of small-wind aero generators. Also, while this analysis was done for cluster of villages within a forested area and lower population, in case of area with higher population and density, a larger power plant may be more feasible. It would be thus pertinent to undertake future research on a techno-economic comparative analysis of various renewable energy technologies to decide for an optimized design for a particular location. Future research may also be undertaken to analyze another alternative option to have a centralised power generation and decentralised storage systems for optimal use of the energy depending on household needs and also ensuring that there is no overload on the system. These analyses can have useful implications on the design of mini/micro grids systems and can directly contribute to scale-up efforts to enhance electricity access in developing countries to ensure Sustainable Energy for All by 2030.

6. ACKNOWLEDGMENTS

This paper is based primarily on the research carried while implementing decentralised power plants in a cluster of villages in Odisha, India, conducted as part of a multi-consortium research project titled 'Decentralized off-grid electricity generation in developing countries: business models for off-grid electricity supply', supported by the Engineering and Physical Sciences Research Council (EPSRC)/Department for International Development (DFID) research grant (EP/G063826/2) from the Research Council United Kingdom (RCUK) Energy Program. We also acknowledge the support provided by Rural Electrification Corporation to partially meet the capital cost of installation of the solar mini-grids in the villages. Authors of the reference materials are also gratefully acknowledged.

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OASYS South Asia project

The Off-grid Access Systems for South Asia (or OASYS South Asia) is a research project funded by the Engineering and Physical Sciences Research Council of UK and the Department for International Development, UK. This research is investigating off-grid electrification in South Asia from a multi-dimensional perspective, considering techno-economic, governance, socio-political and environmental dimensions. A consortium of universities and research institutes led by De Montfort University (originally by University of Dundee until end of August 2012) is carrying out this research. The partner teams include Edinburgh Napier University, University of Manchester, the Energy and Resources Institute (TERI) and TERI University (India).

The project has carried out a detailed review of status of off-grid electrification in the region and around the world. It has also considered the financial challenges, participatory models and governance issues. Based on these, an edited book titled “Rural Electrification through Decentralised Off-grid Systems in Developing Countries” was published in 2013 (Springer-Verlag, UK). As opposed to individual systems for off-grid electrification, such as solar home systems, the research under this project is focusing on enabling income generating activities through electrification and accordingly, investing decentralised mini-grids as a solution. Various local level solutions for the region have been looked into, including husk-based power, micro-hydro, solar PV-based mini-grids and hybrid systems. The project is also carrying out demonstration projects using alternative business models (community-based, private led and local government led) and technologies to develop a better understanding of the challenges. It is also looking at replication and scale-up challenges and options and will provide policy recommendations based on the research.

More details about the project and its outputs can be obtained from www.oasyssouthasia.dmu.ac.uk or by contacting the principal investigator Prof. Subhes Bhattacharyya (subhesb@dmu.ac.uk).

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