Decentralised Renewable Energy (DRE) Micro-grids in India

A Review of Recent Literature

Supplementary Material:
Reviews of the individual documents

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Prayas Energy Group

Disclaimer

This supplementary material contains individual reviews of the literature referred while preparing the report **"Decentralised Renewable Energy (DRE) Micro-grids in India *A Review of Recent Literature*"**. The main report can be downloaded from the Prayas website (http://www.prayaspune.org/peg/publications/item/187).

It is important to note that the purpose of this supplementary material is to aid the interested reader to gain more insight on the information provided in the above-mentioned summary report. The individual reviews presented here were prepared only for internal research and learning purposes and hence should be treated as such. The issues as reflected in the individual reviews are not necessarily PEG's own recommendations/views on the subject.

List of documents reviewed

1. Gurtoo, A., & Lahiri, D. (2012). Empowering Bihar: Policy Pathway for Energy Access. Greenpeace (pp. 4). http://www.greenpeace.org/india/Global/india/report/Empowering-Bihar-Policy-pathway-for-energy-access.pdf

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List of abbreviations

ALCC :	Annualised life cycle costs
ASEAN :	Association of Southeast Asian Nations
BERI :	Biomass Energy for Rural India
BGPP :	biomass gasifier based power project
BoP :	Base of Pyramid
BPL :	below poverty line
CAPEX :	capital expenditure
CDM :	Clean Development Mechanism
CEA :	Central Electricity Authority
CERC :	Central Electricity Regulatory Commission
CFA :	Central Financial Assistance
CPA :	Central Procurement Agency
CPU :	Council of Power Utilities
CSR :	Corporate Social Responsibility
CUF :	capacity utilisation factor
CWF :	ClimateWorks Foundation
DDG :	Decentralised Distributed Generation
DECO :	dynamic energy, emission and cost optimization
DESI :	Decentralised Energy Systems (India) Pvt. Ltd.
DF :	duel-fuel
DG :	Distributed Generation
DG&S :	Distributed Generation and Supply
DISCOM :	Distribution Company
DPR :	Detailed Project Report
DRE :	Decentralised Renewable Energy
DSM :	Demand Side Management
EA 2003 :	Electricity Act 2003
EAF :	Energy Access Funds
ESCO :	Energy Service Company
FiT :	Feed-in-Tariff
FoR :	Forum of Regulators
GC :	grid-connected
GDP :	Gross Domestic Product
GHG :	greenhouse gas
GLS :	Generation Linked Subsidy
GoI :	Government of India
HOGA :	Hybrid Optimisation by Genetic Algorithms
HOMER :	Hybrid Optimisation Model for Electric Renewables
HPG :	hundred percent producer gas
HPS :	Husk Power Systems
IEA :	International Energy Agency
IREDA :	Indian Renewable Energy Development Agency
JNNSM :	Jawaharlal Nehru National Solar Mission
LCA :	life cycle analysis
LUCE :	levelised unit cost of electricity
M&V :	monitoring and verification
MDP :	minimum desired price
MGNREGA :	Mahatma Gandhi National Rural Employment Guarantee Act

MGP :	MeraGao Power
MNRE :	Ministry of New and Renewable Energy
MoP :	Ministry of Power
NAPCC :	National Action Plan for Climate Change
NEP :	National Electricity Policy
NPBD :	National Project on Biogas Development
NPIC :	National Programme for Improved Chulha
NSSO :	National Sample Survey Organization
O&M :	Operation and Maintenance
ODGBDF :	Off-Grid Distributed Generation Based Distribution Franchise Model
OGR :	Off-Grid Renewable
PEG :	Prayas Energy Group
PFC :	Power Finance Corporation
PIA :	project implementing agency
PLF :	Plant Load Factor
RBI :	Reserve Bank of India
RDF :	Rural Distributed Franchisee
RE :	renewable energy
REAA :	rural energy access authorities
REC :	renewable energy certificate
REP :	Rural Electricity Policy
RGGVY :	Rajiv Gandhi Grameen Vidyutikaran Yojana
RPO :	renewable purchase obligation
SA :	stand-alone
SERC :	State Electricity Regulatory Commission
SHS :	solar home system
SLDC :	State Load Dispatch Centre
SNA :	state nodal agency
SPEED :	Smart Power for Environmentally-sound Economic Development
SPV :	solar photovoltaic
T&D :	Transmission and Distribution
TERI :	The Energy Research Institute
UCE :	unit cost of electricity
USO :	Universal Services Obligation
VEC :	village energy committee
VESP :	Village Energy Security Programme
ViPOR :	Village Power Optimisation model for Rural Renewables
WBREDA :	West Bengal Renewable Energy Development Agency

1
Title: Empowering Bihar: Policy Pathway for Energy Access
Authors: Gurtoo, A[1] and Lahiri, D.[2]
Authors affiliation: 1. Indian Institute of Science, Bangalore 2. Indian Institute of Technology, Kharagpur
Year: 2012
Name of publication: Greenpeace Report
Publication/author link: http://www.greenpeace.org/india/Global/india/report/Empowering-Bihar-Policy-pathway-for-energy-access.pdf

Key words: Bihar, decentralised generation, policy, governance

Key observations:
Bihar is facing severe shortage of electricity, particularly in its rural parts. At the same time, there is significant amount of natural resources it possesses which when harnessed, can reduce the burden of electricity shortage in the state. This report suggests the changes needed in institutional and government policies to enable Bihar to meets its energy requirements. The main message of the report is to create a favourable environment for the establishment of the decentralised systems all across to provide electricity to rural population.

The report provides basic definition of the term "decentralised generation" and then provides pros and cons of the centralised grid and decentralised based power systems. According to the authors, decentralised electricity generation signifies "an electric power source connected directly to the distribution network or on the customer's side of the meter." It is energy generated at or near the point of use.

The report also provides the statistics on the current power scenario of Bihar, such as installed capacity, demand and supply gap, transmission and distribution (T&D) losses, etc. In the energy situation analysis, the report provides reasons behind low rural electrification in Bihar, such as high T&D losses with low user charges, low technical and operational efficiency, and low collection of revenue. From the case studies showcased in the report, the gap assessment can be summarized into (pp.23):

Resource gaps: limited government resources, limited infrastructure development, low financial strength of the government to support large scale investments, etc.
Access gaps: low consumption in rural areas, low commercial electricity consumption etc.
Policy gaps: limited scope for private investment, limited incentives for private sector, lack of system to promote DRE technologies, etc.
Institutional/governance gaps: limited involvement of key departments, no clear mandates/targets in rural energy sector, non-alignment between energy regulators and decentralised renewable energy (DRE) operations, etc.

The report suggests forming "a state-wide network of DRE plants (stand alone and micro-grids) developed with support from state government agencies, in collaboration with private entrepreneurs for an effective and accelerated economic development of the state."(pp.1). For making the policy framework for Bihar, the authors have followed three steps (pp.3):

Phase 1: analysis of current energy infrastructure and resources, technical and governance issues
Phase 2: assessment of gaps in energy access to rural areas

Phase 3: Short term and long term policy and governance options and their execution strategies.

To achieve this vision, the authors recommend two sets of changes. The suggested changes in the immediate terms can be called as “Composition and Institutional Changes” which include integrated planning of state-wide natural resources and technologies, incorporating electricity in the Rural Industrialization Plan (2008), state-incentivized new private business models for setting up energy services companies (ESCOs) in DRE generation, meeting renewable energy obligations, empowerment of relevant government agencies and showcase Bihar worldwide as an evolved market in DRE.The suggested changes in the long-term can be categorised in “Governance and Policy Changes” which include a policy to facilitate DRE use with better economics, institutional support for micro-grids, tariff design to encourage DRE, regulatory provisions through the Electricity Regulatory Commission (ERC) and evolvement of pricing models through regulation and competition.

2	
Title: "E[R] Cluster" for a Smart Energy Access	
Authors: Greenpeace	
Publication category: Report	**Year: May** 2012
Publication/author link: http://www.greenpeace.org/india/Global/india/report/Bihar-Smart-Energy-Access.pdf	

Key observations:

Year 2012 has been declared as the International Year of Sustainable Energy for All by the United Nations General Assembly. This initiative has been designed to mobilise action from governments, the private sector and civil society globally with the objectives of universal access to modern energy services, improved energy efficiency and expanded use of renewable energy sources. Against this background, Greenpeace initiated a project to develop a smart grid for rural electrification for basic electricity needs in rural area of Bihar state. Greenpeace's approach is "bottom-up" grid expansion where the smart grid will be expanded to a full 24x7 supply base on 100% renewables. The authors termed this concept of energy revolution for villages as "E[R] cluster". The report has been organised in three sections covering the access to energy concept, a case study on micro-grid design and various grid technologies, respectively.

This report in its introductory section elaborates on E[R] cluster and provides policy recommendations for supporting such a concept. Based on the bottom-up approach for overall energy-led development, the vision for Bihar that is evolved, according to the report is "a state-wide network of decentralised energy plants (stand alone and micro-grids), developed with support from state government agencies in collaboration with private entrepreneurs for a high impact and accelerated economic development of the state". Here the report states that to achieve this objective, the important step is to develop a resource and technology plan for rural electrification at policy level which will include identifying target population, their needs, investment required, availability of raw material, identifying and developing suitable technologies, etc. The report further elaborates specific mandates of district administrations and the Bihar Rural Electrification Corporation (REC) which will include clubbing of areas to form 'economic clusters', infrastructure support for technology development, integrated energy planning, empowerment of relevant government agencies to drive the expansion of decentralised energy, creation of supportive institutional avenues for micro-grids, etc.

The authors further recommend designing a tariff mechanism to encourage micro-grids and decentralised systems as tariffs will have a significant impact on the economic viability of distributed energy generation system. The report details out key requirements for its Energy [R]evolution scenario as:

i. **Long term security for the investment:** to offer long term profitability for investors
ii. **Maximize the leverage of scarce financial resources:** to ensure distribution of scarce public and international resources
iii. **Long term security for market conditions:** to obtain a "good" return of investment (ROI) for the investors
iv. **Transparent planning process:** for the licensing process to be clear, transparent and fast

v. **Access to the (micro) grid:** to ensure lower risk to ROI, project financing. The report suggests to start a feed-in regulation for the cluster with the help of international funding.

The report, with the help of a case study demonstrates on how the "bottom-up" approach will work in five crucial steps:

i. Assessment of renewable sources
ii. Demand projection
iii. Using optimal mix of technologies in energy generation
iv. Optimal network design for quality and adequate electricity supply
v. Control system considerations for effectively switching between grid-connected and island modes for the clustered units

While explaining the "access to energy" concept, the report first distinguishes between a top-down approach of grid-extension and a bottom-up approach of off-grid generation. The authors inform the number of bottom-up approaches available in energy development such as home energy systems, off-grid distribution systems, micro-grids and distributed generation systems. The authors of the report, however, recommend micro-grid as a preferred option for rural electrification to a fully integrated grid while promoting renewable energies because of micro-grids "ability to switch between island operation mode and grid-connected mode". Such type of operation is flexible, reliable and controls balance between local supply and demand.

The case study on micro-grids in promoting "smart" integration of renewable energy and expanding energy access as presented in this report focuses on Bihar. Methodologically, it first assesses the resources available in the area then assesses the electrical demand that need to be serviced and finally it designs a system which can serve the demand using resources available in the most economic manner. The size of the generation system is determined using software HOMER while the case of the supply of the power that is generated in the system through a physical network is simulated using software PowerFactory. The final part of the system design considers a suitable strategy for switching between grid-connected and island modes.

The report then presents the results obtained through HOMER simulations. It considers, based on peak demand, four scenarios (20, 100, 270 and 554 kW) for the situations where optimal generation capacities for micro-grids which include several combinations of technologies used are considered. These simulations have also considered the effect of rapid price reductions in solar PV to determine the costs of electricity per unit. The simulations results show that the availability of a hydro resource causes the system cost to drop and this option has significant utilisation potential in Bihar. In the cases where hydro source is not used for electricity generation because of its alternate use for irrigation, there the micro-grid must be paired other sources such as biomass or diesel for power generation. Wind resources in the state are not optimal for economic operation of wind power plants. For solar PV plants, the relatively high capital cost is the major barrier. Regarding the control strategy for switching operation between island and grid-connected modes of micro-grid, sophisticated control equipment may prove costly and may not be easily accessible financially, according to the report. Therefore a manually operated system for switching between these two modes until the economy of scale makes the automated system reduces its price has been proposed in the report

The overall conclusion of the study is that micro-grids as a bottom-up option using renewable energy could be a very useful concept in accelerating rural electrification initiatives through their integration into centralised grid. The key to the wide-spread utilisation of such systems is to come up with cost competitive system designs using standard components in modular fashion.

3	
Title: Scaling up off-grid renewables – Summary of recommendations	
Authors: Ashden India Sustainable Energy Collective	
Publication category: Report	**Year: 2012**
Name of publication: Summary of recommendations	
Publication/author link:	

Key observations:

The Ashden India Sustainable Energy Collective (AISEC), a group of sixteen India-based winners of the international Ashden Awards organised three sustainable energy policy round tables in year 2011. This document summarises the gaps in off-grid renewable energy policy and regulations in India identified during the roundtables and the major recommendations to address these barriers.

Major barriers identified for rapid development of off-grid RE in India during the AISEC round tables include:

i. Public perception that grid electricity is the only acceptable form of electricity

ii. Lack of regulations to mainstream off-grid RE

iii. Disbursed subsidies for off-grid RE failing to mainstream off-grid RE

iv. Absence of standards for RE devices

v. Lack of efficient finance at various levels for end-user and entrepreneur

vi. “Energy access” has not been recognized as “an essential right” and has not been integrated into larger development goals

This report provides the AISEC recommendations to address off-grid RE barriers, which can be summarized as below:

1. **Recommendations on regulatory framework**: the existing framework under EA 2003 can be drawn upon to establish a regulatory framework for off-grid RE, which may be under the aegis of CERC, SERCs and related ministries. This framework could specify institutional arrangements, oversee bidding procedures, monitor compliance of the procedures of the EA 2003, develop safety norms and operational standards and establish guidelines for grid connectivity of the off-grid RE projects

2. **Recognise the right to energy**: there is a need to recognize the right to “energy for all” through the enactment of an act similar to the Right to Education Act

3. **Standards and rating**: need to develop standards for off-grid RE products, suppliers and service providers which should include consumer-relevant parameters like quality and output, development of star rating systems for RE consumer products, development of accreditation procedure for suppliers, third party certification from approved laboratories, etc.

4. **Subsidy reform and rationalisation of incentives**: here the main message in the report is to "gradually move from upfront capital subsidies to performance based incentives". It has been recommended that the rationalisation and differentiation of subsidies and other incentives could be done by technology, region specific and purpose specific.

5. **Disbursement of subsidies and finances**: which can be governed by financial intermediaries with viable track record. These institutions may be chosen by the Reserve Bank of India.

6. **Cook-stove focused fiscal incentives**: here the AISEC recommendations include the provision of production tax credits to improved cook-stove producers. These incentives may be financed through Carbon Emissions Reductions (CERs) and/or partly by diverting LPG subsidy or Clean Energy Fund

7. **Securing priority finance for off-grid RE:** here AISEC supports the initiative to include "off-grid energy solutions for households" to be included as "priority sector" for lending and further requests that this initiative should be extended to RE options other than electricity based options. Thus AISEC recommendation is to accord "the priority sector status to lending for Decentralised Renewable and Efficient Energy Solutions for Agriculture, Households and MSMEs". Other recommendation from AISEC is to tap other large alternative funding sources for purposes of technology demonstration, such as Clean Energy Fund.

8. **Training and sensitisation**: here capacity building activity is not only restricted to technicians but also include institutions like banks. The need is also to strengthen existing institutions. The insurance agents in rural areas may be trained to serve as auditors and verifiers for RE systems. Inclusion of renewable energy as a priority area for existing government institutions like the National Skill Development Corporations can be very helpful, according to the AISEC.

9. **Reviewing and setting up institutional arrangement**: may play a key role in clustering small RE projects, disbursing subsidies, organising maintenance. The regulatory framework and training needs for the rural renewable energy service company must be understood and factored in, according to the AISEC.

4
Title: Report on Policy and Regulatory Interventions to Support Community Level Off-grid Projects
Authors: ABPS Infrastructure Advisory Pvt. Ltd.
Authors affiliation: ABPS Infrastructure Advisory Pvt. Ltd.
Year: November 2011
Publication/author link: http://www.shaktifoundation.in/cms/uploadedImages/final%20report_cwf_off%20grid_nov%202011.pdf

Author's Abstract: A study of the policy and regulatory interventions needed to support off-grid projects in India came up with two models for promotion of off-grid electrification in India. They are the off-grid distributed generation based distribution franchise model (ODGBDF) and the renewable energy certificate (REC). In the ODGBDF model the project developer shall provide electricity to consumer and receive tariff. DISCOMs will provide feed-in-tariff to project developer and receive financial assistance from the Government of India. In the REC model, project developer gets sufficient benefit from sale of electricity to the consumer and RECs are sold on the exchange to recover all the costs. The report however recommends the ODGBDF model. The study suggests drafting of model regulations for off-grid rural electrification. It also suggests that the Government of India should consider development of policy under which it can provide central financial assistance to DISCOMs for promoting off-grid rural electrification. This model provides the maximum certainty of revenue to the developer and proper integration of off-grid projects with grid as and when it is feasible.

Key words: off-grid, policy & regulation, business models

Key observations:
This is a comprehensive report of 160 pages and aimed at providing analytical support for Central Electricity Regulatory Commission (CERC) and Forum of Regulators (FoR) in evaluating possible options under the regulatory framework to support off-grid renewable energy (RE) programs.

Chapter 2 gives a brief about the power sector in India and ends with the status of rural electrification. The main barrier is high capital costs and hence high cost of generation and the added risk of redundancy as and when the central grid arrives.

Chapter 3 lays down the important legal (EA 2003) and policy provisions (National Electricity Policy, Tariff Policy and the Rural Electrification Policy) for rural electrification and for renewable energy. It also gives details of the various on-going Ministry of New and Renewable Energy (MNRE) schemes for rural electrification. The authors highlight clause 8 of the rural electrification policy which permits establishment of stand-alone systems for rural areas and also allows regulators to formulate appropriate guidelines to ensure that the benefits of financial subsidies are passed on to end consumers. The authors also highlight and describe in detail the following issues, clarity over which is key for off-grid promotion, namely

- Jurisdiction of appropriate commission in determining retail tariff
- Applicability of tariff for sale of surplus electricity to the grid in case of extension of grid, including the issue of state specific grid connectivity protocol
- Terms and conditions determining charges for Open Access
- Qualification of off grid RE based generation for issuance of renewable energy certificates (RECs)

Chapter 4 gives an international overview of rural electrification in Brazil, China and South Africa. The important learnings highlighted are :

- Separate Institution to promote rural electrification
- Commitment from the government
- Subsidies for grid expansion capital costs
- Tariff setting and collection mechanism
- Involvement of local community
- Participation of private sector players

Chapter 5 gives a detailed description of the existing RE technologies and their available potential in India. Chapter 6 describes the challenges in the off-grid projects. The load profile is dominated by lighting needs to begin with and one expects the commercial and small industrial loads to develop with time. Compared with the high existing expenses on kerosene, the authors infer that the willingness to pay for domestic lighting is Rs 30-120/month and that for commercial applications is Rs 10-15/kWh. (pp.88) The report points that the major barrier to rural electrification is low load and energy requirement and the coupled high cost to serve. Table 6.1 gives an overview of the load requirements in a rural setup. The chapter also outlined the various business models for off-grid projects in vogue. These include the Husk Power System model, The DESI Power – PPP service delivery model, the VESP-VEC model, the TERI Model and the Mini-grid Sunderban Model.

Chapter 7 puts forth the financial analysis of various off-grid RE technologies. It lays down the various assumptions that go in to such calculations and gives out the cost of supply (with and without government subsidy). These turn out to be Rs 6.06/kWh and Rs 8/kWh for Biomass gasifiers; Rs 3.51/kWh and Rs 5.21/kWh for micro-hydro; Rs 15.25/kWh and Rs 20.35/kWh for solar PV and finally Rs 23.47/kWh and Rs 35.35/kWh for wind-solar hybrid systems.

Chapter 8 is the crux of the report, which begins with highlighting the existing limitations of the DDG scheme and hence the need for new business models which will evince further interest from private players. The authors develop five different business models, namely (1) REC BASED MODEL, (2) CENTRAL PROCUREMENT AGENCY (CPA) BASED REC MODEL, (3) GENERATION LINKED SUBSIDY (GLS) MODEL, (4) COMBINATION OF REC AND GLS MODEL and (5) OFF-GRID DISTRIBUTED GENERATION BASED DISTRIBUTION FRANCHISEE (ODGBDF) MODEL and describe in detail the proposed mechanism under each model and their advantages and disadvantages. They conclude that the 5th model, namely the OGDGBF model would be the most suitable one going ahead. *"The reasons for the same are as given below:*

- *Maximum certainty of revenue to the project developer as the distribution company (DISCOM) shall pay Feed-in-Tariff (FiT), recoverable from ARR, and also Central Financial Assistance (CFA), if any from Government of India;*
- *Proper integration of off-grid projects with grid as and when the grid becomes available;*
- *Internalisation of costs of rural electrification as DISCOM to recover FiT through ARR;*
- *Significant experience of development of FiT model at State level;*
- *Possible to customize model according to local requirements;*
- *Optimum utilization of the government subsidy, if offered;*
- *CERC and FoR could develop FiT guidelines as in case of large scale renewable projects;*
- *Distribution franchisee framework under Rajiv Gandhi Grameen Vidyutikaran Yojana (RGGVY) could be adopted with modifications to engage private sector;*
- *Model could be used for off-grid generation as well as on-grid supply augmentation."*

Chapter 9 details out the operational, institutional and contractual structure and the implementation plan for the proposed business models. Three important aspects going ahead would be the development of model regulations for off-grid rural electrification from FoR which could be adopted by State Electricity Regulatory Commissions (SERCs) with suitable local modifications, the determination of FiTs for each technology by each SERC and the grid interconnection standards for distributed RE generation to be notified by Central Electricity Authority (CEA). The overall role and responsibilities of all the important stakeholders is also described. The chapter also details out the necessary aspects which the FoR regulations should consider to make them comprehensive and effective.

5
Title: Taking Charge**:** Case Studies of Decentralized renewable energy projects in India in 2010
Authors: Boyle, Grace and Krishnamurthy, Avinash
Authors affiliation: Greenpeace
Year: 2010
Publication/authorlink:http://www.greenpeace.org/india/Global/india/report/2011/Taking%20Charge.pdf

Author's Abstract: N.A

Key words:livelihood,leadership,maintenance

Key observations:

This Greenpeace report highlights the successful cases of renewable energy projects in rural India that could serve as an impetus for further developments in this sector.

a)**Micro-hydro power in Pathanpara village, Kerala:**

Pathanpara is a hamlet of three hundred and sixty five families in the Kannur district of Kerala. While there was no grid electricity there, the village had many perennial and seasonal streams, thus providing a potential for a micro-hydro plant there. A plant of 5KW with lean flow of 22lps,60m head and a diesel backup was setup with the help of a good community participation seen in terms of resource mobilisation ,labour ,faith in the system .A strong committee takes care of the day to day affairs and the community together sets rules so that when it comes from community it is well taken and presents a case for empowerment of group as they get to manage the system. Even when the grid later came into the village many people still stuck to the micro-hydro plant as the quality of grid supply was poor.

This case-study observes that strong leadership from community, church, wealth of social entrepreneurship exists and that can help the community come together for such village level initiatives that better their living.

b) **Micro-hydro power in Udmaroo village, Nubra Valley Ladakh: LEDeG**

A plant is of 32kVA capacity, presently generating 20-25kV and the micro-hydro system has been setup in the Udmaroo village, in the Nubra valley of Ladkah.This village is nearly cut-off from the rest with no mode of employment, dwindling interest in agriculture, low accessibility to markets, and the only other employment other than agriculture is the army with rare government jobs. So the plant has brought with it many positive changes in the lives of the people. The residents realise that even though the village has the provision to get continuous supply of electricity from the plant, they would only transmit after dark .Also only 20-25kva of the 32kva is used, so there is capacity for extra load and they have made this provision keeping in mind the future implications. The locals have been trained and operate the working of the system everyday and claim that there are 100pc bill payment rates in this village and employment opportunities now exist for women –there is an SHG, oil extraction machine has been purchased by them and they make a small income from it, the remaining oil is packed and sold to the army at a higher price.

The report notes that business has made a change to the lives of the women, wherein previously their labour at homes and agriculture was not considered and now with this business they feel motivated to work as they have small investments.

The citizens are also aware that the rivers and streams freeze in the Nubra valley for up to 4 months a year and during that time no electricity is produced .So during this time the EMC runs a small diesel genset ,which is costlier than the micro-hydro electricity in order to save up for the winter months. They also think about the pollution caused by the diesel gensets as compared to the non-polluting nature of micro-hydro, the report mentions that for the first mention of people recognising the link between Renewable energy and climate change and pollution.

The report brings out that positive effects are now being seen in the village that was once isolated and had to depend on diesel and other polluting sources for lighting and how community participation can sustain a project even in remote and unreachable locations.

c) **Solar photovoltaic power plant in Durbuk, Changthang, Ladakh**

A 100kW solar plant -1360 solar photovoltaic panels ,with some of the most cutting-edge electricity generating technology has been setup in Durbuk, in Ladakh region which is very remote that extending the main grid never really been an option. Even though they had a 250kVA diesel generator set, it led to health issues and every year 48,000 litres of diesel had to be brought at the cost of Rs1.6mn to State Government. Now due to the plant 347households receive uninterrupted electricity and has enabled heath care with the Primary Health Centre (PHC) able to store polio, measles vaccines on site due to refrigeration, and many other modern medical facilities. Renewable Energy Development Cooperative (REDCo) is a registered society and non-profit entity created by the members with 15 elected members, a board of directors headed by the councillor. Rules enforced are followed by the people and there is 100pc bill payment in this area with people being charged a flat rate of Rs50 per month The managing committee now acts also as a micro-financing institution, providing loans for business. TATA BP Solar India Ltd has taken up O&M contract, 10yr annual maintenance worth Rs3000, 000per year.

While the project initiation phase was marred by glitches, there now seems to be complete acceptance amongst the people about the technology which is seen in the way electricity is creating positive impacts in health care and community development.

6
Title: Access to Energy for the Poor: Clean Energy Option
Authors: Bast, E. and Krishnaswamy, S.
Authors affiliation: Vasudha Foundation
Year: 2011
Name of publication: Oilchange International, Actionaid and Vasudha Foundation publication
Publication/author link: http://priceofoil.org/educate/resources/access-to-energy-for-the-poor-the-clean-energy-option/

Key words: energy access, clean energy

Key observations:
This report provides voluntary recommendations to the World Bank while it revises its Energy Strategy. The authors believe that the World Bank, as an influential development bank, could play a significant role in funding the transition to a healthier energy future – by funding energy access to the world's poor through clean decentralised energy sources. The report mainly focuses on the following aspects:

1. Energy access to poor:

A dual focus on increasing access to energy for poor and promoting clean sources of energy is a win-win scenario. Initiatives to increase energy supply haven't reached poor and initiatives for energy access to poor haven't used renewable energy (RE) fully. Access to energy for poor helps in: ending poverty, universal education, gender equality, child health, maternal health, environmental sustainability, combating malaria and HIV/AIDS, etc. (pp.4). Therefore, the definition of Access to Energy, according to the authors, should not simply be a provision of connection to an electricity grid, but must be broader which includes elements of poverty reduction and development goals

2. Clean energy:

Conventional oil, gas and coal based power generation has caused serious environmental and public health impacts. Clean energy, therefore could be viewed as "the provision of energy that meets the needs of the present without compromising the ability of future generations to meet their needs (pp.7).

3. Suitability and economics of clean energy for energy access:

Decentralised renewable energy (DRE) technologies are more suitable and economical in rural areas that are far from grid. Even at a distance 5 km from the grid to a village, the cost of generation from micro or mini hydro systems is more or less the same as the costs per kWh from coal-fired grid based power plants. For a load of 100 kW which is at 12 km distance from the grid/33kVA line, the cost of generation of hybrid wind-solar are same at that of coal (when considered the cost of Rs 1 per km for transmission cost for grid and maintenance cost) (pp.10/11)

The authors add that energy efficiency measures, particularly end use efficiency measures are often very cost effective in the areas where electricity generation capacity is present. The costs of energy efficiency measures are also very low when compared to the costs of adding additional generating capacity.

4. Challenges for clean energy in increasing access

From the lessons learned from the efforts taken for increasing clean energy access to rural poor, the authors point out following challenges:

i. Addition of conventional capacity serves only rich and urban sectors: (distribution of electricity with respect to income class: top 20% = 53%, middle 40% = 34% and bottom 40% = 13% in India (pp.16)). Addition of 33,000 MW conventional capacity electrified only 18,000 villages and improved electrification by only 5% between 2002-2009 in India (pp. 16).The authors also show that the regions where new conventional plants have been set up, in fact have very low amount of electrification

ii. Average rural household pays more per unit of electricity despite unreliable quality and quantity of supply. He pays between Rs. 1.5 to 3.0 /kWh compared to Rs. 0.75-2.0 by urban household (pp.17). The authors are of opinion that the traditional belief among policymakers in India that "lack of willing ness to pay fro energy" in poor rural areas is not true. There is willingness to pay for access to energy among villagersprovided they are assured high quality and reliable energy supply.

iii. The true costs of conventional energy including public health and environmental externalities are not incorporated into pricing of energy options

At the end of the report, the authors provide following vital recommendations to the World Bank Group:

i. "The World Bank Group's energy lending should focus on increasing energy access for the poor through clean, decentralized sources
ii. The Bank should clarify its definition and criteria for 'energy access', focusing on the world's poorest and increase its level of ambition with regards to funding energy access projects with the aim of reaching poor.
iii. The World Bank Group should stop lending for fossil fuels except in extreme cases where there is clearly no other viable option for increasing energy access to the poor".

7
Title: Review of alternative methodologies for analysing off-grid electricity supply
Authors: Bhattacharyya, S.C.
Author's affiliation: CEPMLP, Dundee University
Year:2011
Name of publication: OASYS – South Asia Project
Publication/author link http://www.oasyssouthasia.info/docs/oasyssouthasia-wp7-mar2011.pdf

Key words: tools,methodology, optimisation techniques

The paper attempts to bring about an array of alternative methodologies with the help of academic literature on case studies and specific tools to help in the decision making of projects .It attempts to identify alternative methodological options and analyse the appropriateness of various options. It aims to answer the questions regarding whether there are available "cost-effective, reliable local off-grid electricity supply options that can meet the present and future needs and are socially acceptable, institutionally viable and environmentally desirable"(pp.6). Also these projects need to be verified on the basis of scalability, replication potentials for larger populations in the worlds.

The paper first provides a review of literature covering the wide variety of approaches that have been used in the past and includes techno-economic feasibility studies, various analytical approaches and project-based literature. The paper then considers the appropriateness of alternative options for the purpose of this project and makes a recommendation.

a) Literature review:

The paper notes that focus of most of the literature is on the technical design of the system and analysis of cost effectiveness using some economic indicators .It also talks of the various tools used by various authors like-HOMER(Hybrid Optimisation Model for Electric Renewables) , HYBRID Model, HOGA(Hybrid Optimisation by Genetic Algorithms). In the techno-economic feasibility studies the methodology generally follows a "common approach -assessment of technological appropriateness, evaluation of economic viability and determination of financial or other incentives required to make the project viable at a given location" (pp.11). Different studies are considered for analysing the different technologies and examples based on PV and wood fuel system for rural application are used.

b) Analytical approaches:

This approach is spelt out through indicator based analysis –levelised costs, weighted costs and sustainability indicators

- Indicator –based analysis:

A) Levelised cost of supply:

"The levelised cost of supply is a common indicator used for comparing cost of electricity supply option" (pp.16). The paper states that care needs to be taken while using this method because levelised cost calculated based on a specified capacity factor for technologies with different load profiles can lead to misleading results. The paper says that on account of ignoring the fossil fuel usage costs, the renewable energy technologies maybe at a disadvantage. It also states that the limitations of excluding external costs due to environmental effects and security supply should be kept in mind while using this tool.

The paper gives some observations on the basis of an ESMAP paper on the study of alternate generation technology.

- "The cost of off-grid options is generally higher than that of conventional energies.
- The cost of supply reduces as the size of plant increases. Electricity supplied from small – sized off-grid plants tends to cost much higher than the bigger sized plants of same technology.

•	Some renewable technologies are either cost effective or reaching cost effectiveness"(pp.18)

B) Weighted score system:
"Lhendup (2008) presented a weighted score system wherein a number of aspects (such as technical, regulatory features, environmental and social aspects) are considered. A set of indicators is then identified for each aspect and a weight is given based on the importance of the indicator. Each option is tested against a set of indicators and a score is given depending on the performance of the option against the indicator. The product of the score and the weight for a particular indicator gives the weighted score" (pp.20).
The paper notes that for this tool to become useful, it has to have a participatory approach and must also avoid subjectivity in attaching weights and rankings.

C) Sustainability indicators:
Ilskog (2008) presented a set of 39 indicators for assessing rural electrification projects. These indicators considered five sustainability dimensions – "technical sustainability, economic sustainability, social/ ethical sustainability, environmental sustainability and institutional sustainability" (pp.22).
The paper for technical sustainability took into the factors such as technical infrastructure locally available meeting the requirements of technology installed, the service provided and favourable technical performance for services and can be used if it is complaint with the participatory approach, keeping the stakeholder participation in mind.

•	**Optimisation techniques:**
Different optimisation techniques designed to minimise the total cost, subject to a number of constraints related to energy availability, energy demand, other technical constraints and their uses are given. They are namely: "Linear programming, geometric programming, Integer programming, Dynamic programming, Stochastic programming, Quadratic programming, Separable programming, and Multi-objective programming" (pp.24).
•	**Multi-criteria decision making methods:**
"The multi-criteria decision making (MCDM) is a decision support system that is used to capture multiple dimensions of a project or a policy, some of which may be conflicting with each other"(pp.27)
A) AHP method:
"It is the most commonly used MCDM approach .It is a multiple criteria decision-making technique that allows subjective as well as objective factors to be considered in decision making process (pp.28).

B) Multi-criteria Decision Making for Renewable Energy Sources (MCDM-RES):
"The planning activity is considered to be multi-dimensional activity that takes technical, economic, environmental and social aspects into consideration. The decision-making process involves the following eight steps:
•	Problem identification and initial data collection
•	Institutional analysis and stakeholder identification
•	Creation of alternatives
•	Establishing evaluation criteria
•	Criteria evaluation and preference elicitation
•	Selection of the MCDA technique
•	Model application
•	Stakeholder analysis of the results and feedback (pp33).

If the level of acceptance is low then the process is repeated till a more acceptable outcome is found and then the solution is implemented.

c) Practice-oriented literature for decentralised RE supply analysis:

The paper looks at several studies and analysis the framework used in each of them. While the Cabraal et al (1996) study focused on the best practices for household rural electrification using solar PV, the CEEP (2001) study relied on worksheet based package called RREAD (Rural Renewable Energy Analysis and Design Tool). The ESMAP (2001) study provided the best practice guidelines for implementing decentralised energy systems for project managers, while WB (2008) study looked at identifying critical factors for off-grid project

The paper finally proposes five options:

- “a worksheet-based tool that provides a sequential analysis of four dimensions retained in the project proposal;
- An optimisation-based tool to identify and design the least-cost option, supplemented by a routine to take care of social and regulatory issues;
- A multi-criteria decision-making (MCDM) tool;
- A participatory systems approach
- A suitable combination of the above options to be decided and used on a case-by-case basis.”(pp.46)

The paper finally recommends a hybrid tool that can be used in different case study situations.

8		
Title: Energy poverty: A special focus on energy poverty in India and renewable energy technologies		
Authors: Bhide, A. and Monroy, C. R.		
Authors' affiliation: Technical University of Madrid		
Name of publication: Renewable and Sustainable Energy Reviews, Elsevier		
Volume: 15	**Year:** 2011	**Pages:** 1057-1066
Publication/author link: crmonroy@etsii.upm.es (C.R. Monroy)		

Authors' Abstract: As a large percentage of the world's poor come from India, development in India is a key issue. After the establishment of how access to energy enhances development and the achievement of the millennium development goals, energy poverty has become a major issue. In India there is a great interest in addressing the subject of energy poverty, in order to reach development goals set by the Government. This will imply an increase in India's energy needs. In a climate of change and environmental consciousness, sustainable alternatives must be considered to address these issues.

Renewable energy technologies could provide a solution to this problem. The Government of India has been focusing in implementing electricity policies as well as on promoting renewable energy technologies. The focus of this article is to bring to light the problems faced in India in terms of energy consumption as well as the hindrances faced by renewable-based electrification networks. Government policies aimed at addressing these issues, as well as the current state of renewable energy technologies in India are discussed, so as to analyse the possibility of a solution to the problems of finding a sustainable method to eradicate energy poverty in India. The research reveals that the Government of India has been unable to meet some of its unrealistic development goals, and in order to achieve the remaining goals it will have to take drastic steps. The Government will have to be more aggressive in the promotion of renewable energy technologies in order to achieve sustainable development in India

Key words: India ,Energy poverty, Renewable energies, Government subsidies, Energy policy

Key observations:

While elaborating on the positive relationship among Energy, poverty and HDI, the paper looks at how affordability, availability and cultural preference impact the usage of electricity over biomass. It points out that transition from traditional to modern fuels is not linear and depends on the above factors. It also infers that lower income households prefer to use biomass for cooking and heating and as income increases, electricity is increasingly used for lighting and other purpose and not to substitute cooking and heating. Only in higher income groups biomass is completely substituted in house-hold consumption. The paper also looks at studies on household consumption patterns, current energy scenario in India to establish how rural areas need more attention.

While talking of renewable energy technologies in India, the study addresses the economic, legal and regulatory, financial and institutional issues related to it. Economic barriers can be categorised as: lack of subsidies, high initial capital costs, high transaction costs. Legal and regulatory issues are: inadequate legal and policy framework and financial and institutional barriers involve lack of access to credit for customers and investors, lack of sufficient technical, geographical and/or commercial information.

The paper then talks of different types of renewable energy systems in detail. It infers that solar thermal energy is and has several household applications relevant to rural areas and the

Photovoltaic route has been well established in India now. Wind energy has greater limitations in terms of resource distribution .Some obstacles exist such as need for isolated locations with current wind speeds but the paper says that India has not tapped its full wind energy potential. Hydro projects have excellent efficiency, low maintenance costs and low costs of generation and have the advantage of using indigenous technology. Use of biogas in households prevents indoor pollution and saves time for collection of firewood and cooking with inefficient resources. It also provides environment and social related advantages, training financial assistance is provided by MNRE.
The paper observes that the standards set by the Government in meeting the energy needs of all seem to be unrealistic and the efforts taken in this regard still insufficient and so the initiatives need to be stepped up to deliver on the eradication of energy poverty and ensuring reliable quality of power for all.

9		
Title: Operational experience on a grid connected 100 kWe biomass gasification power plant in Karnataka, India		
Authors: Dasappa, S., Subbukrishna, D.N., Suresh, K.C., Paul, P.J. and Prabhu, G.S.		
Authors' affiliation: IISc Bangalore		
Name of publication: Energy for Sustainable Development		
Volume: 15	**Year:** 2011	**Pages:** 231-239
Publication/author link: dasappa@cgpl.iisc.ernet.in (S. Dasappa)		

Authors' Abstract: The paper reports the operational experience from a 100 kWe gasification power plant connected to the grid in Karnataka. Biomass Energy for Rural India (BERI) is a program that implemented gasification based power generation with an installed capacity of 0.88 MWe distributed over three locations to meet the electrical energy needs in the district of Tumkur. The operation of one 100 kWe power plant was found unsatisfactory and not meeting the designed performance. The Indian Institute of Science, Bangalore, the technology developer, took the initiative to ensure the system operation, capacity building and prove the designed performance.

The power plant connected to the grid consists of the IISc gasification system which includes reactor, cooling, cleaning system, fuel drier and water treatment system to meet the producer gas quality for an engine. The producer gas is used as a fuel in Cummins India Limited, GTA 855 G model, turbo charged engine and the power output is connected to the grid.

The system has operated for over 1000 continuous hours, with only about 70 h of grid outages. The totalbiomass consumption for 1035 h of operation was 111t at an average of 107 kg/h. Total energy generated was 80.6 MWh reducing over 100t of CO_2 emissions. The overall specific fuel consumption was about 1.36 kg/kWh, amounting to an overall efficiency from biomass to electricity of about 18%. The present operations indicate that a maintenance schedule for the plant can be at the end of 1000 h. The results for another 1000 h of operation by the local team are also presented.

Key observations:
This paper focuses on 100 kWe gasifier operation at Kabbigere. This gasifier initially faced problems arising from operational issues which were thwarting continuous system operation which included power output decreasing in time, blockage in piping, filters, etc. and break down of the system sub elements like coolers, reactor, water treatment, etc. IISc being the technology developer found out that improper operational procedures seriously affected the hardware, such as usage of moist fuel and improper maintenance practices. The water used for gas cleaning was untreated before recirculating it. Subsequently, IISc modified the system elements. Power generated was exported to 11Kv grid with all the safety features.

The engine was operated for 1022 hrs with a grid synchronised run of 951 hrs. The total energy generated was 80.6 MWh and the net energy exported to the grid was 56.5 MWh. (pp. 236-237). The authors have estimated that for this 100 kWe operation, the conversion efficiency was around 18±1.5%. To ensure the gasifier plant works according to the specifications, the IISc technical team took several measures such as maintaining the brick lining, replacing damaged filters and enabling the water treatment plant. Besides the ash extraction system was also upgraded. The paper demonstrates the improvement of the technical performance of the various units of the plant once the corrective measures were taken. Noteworthy improved parameters, as demonstrated by authors include pressure drop across the reactor, producer gas quality, cooling water treatment, gasifier engine and generator performance and specific fuel consumption:

Pressure drop across the reactor: this is a crucial parameter since it determines the capability of the reactor to continuously produce gas without being able to build up resistance which ultimately decreases the gas output and the electrical load. The resistance of the bed to the gas flow (~ 1500 ± 500 Pa), as given in the report for the reactor seems to be within acceptable limit to obtain continuous gas mass flux.

Gas quality: the producer gas composition along with its tar and particulate contents were also checked, The gas composition: CO + H_2 = 18%, CH_4 = 1.8%, CO_2 = 9% and rest N_2, as reported in the report would result in the gas calorific value ~ 4.5 MJ/kg

Water treatment: water is recirculated in the system as a coolant; however due to the recirculation it gets contaminated by particulate and condensable matter from the producer gas. The report shows that the water was treated with activated carbon, alum and polyelctrolyste and filtered further.

Engine and generator performance: the power factor reported is 0.92, with the system able to generate nearly constant load. The authors point out that during grid failure; the system was entirely operated on the internal load.

Specific fuel consumption: The total biomass consumption for 1035 hrs of operation was 111 tonnes at an average of 107 kg/hr, while the authors remarked that the specific biomass consumption 1.36 kg/kWh for gross electricity generation which was slightly higher than the earlier recorded value (1.2 kg/kWh) on similar engines. The authors also concluded that the discrepancy between the measured average load 85 kWe and the rated capacity of the engine 120 kWe has been possibly resulted due to some inefficiencies still remaining in the system. The relatively higher ash contents (3.5%) in the fuel used and the frequent grid failures are the two main reasons behind the high specific fuel consumption in the gasifier system, according to the paper. Besides high specific fuel consumption, the system showed its engine efficiency lower when compared with natural gas operation, which was possibly due to higher exhaust temperature, and combustion properties of producer gas inside the engine.

The authors remark that the current setup having ~ 18% conversion efficiency which is significant when compared with 100 MWe coal power plant at 34 %, and at higher gasifier capacities, there is a scope to improve the efficiencies significantly. Since training and capacity building of the local operators was a part of the study, the authors also report the outcome of this activity on the plant performance after 1000 h of operation by the local team. The data suggests that all the operating parameters were under control.

The authors also compare the specific energy cost of this BERI setup along with the specific energy costs reported for duel-fuel operations reported in the literature. Here the authors conclude that the gas engine operation at BERI was the lowest cost option to generate 1 kWh of electricity when compared with duel fuel operation.

10
Title: Ministry of New and Renewable Energy – *Energy Access – Draft Sub-Group Report*
Authors: MNRE
Year:
Publication/author link: www.mnre.gov.in/pdf/plan12sg3-draft.pdf

Key observations:
The report begins by noting the importance of electricity access for human development. It also notes that the existing policy legal framework mandates Universal Service Obligation in rural areas. Also, stand alone generation and distribution is exempt from licensing requirements. Similarly, the NTP recognizes the need for distributed generation in places where grid extension is not techno-economically feasible.

Presently nearly 300 million people in India (44% of rural HHs) are without access to electricity despite the fact that 90% of villages are electrified. Supply is also very limited in electrified villages. The report states that the approach to electrification based on grid extension is un-economic due to high capital costs of infrastructure, low demand and high cost of tariff collection. The reasons listed for the present state of electrification include

1. Target-oriented and subsidy-driven national programmes with little focus on effectiveness
2. Overemphasis on grid extension
3. Lack of sustainable business models in distributed generation
4. Lack of focus on electricity for productive use
5. Non-availability of institutional finance for decentralized renewables.

Distributed renewable energy is suggested as a route to address the problem of 60 million un-electrified rural households and those which acutely suffer from frequent power cuts, and non-availability of power for long durations. The various renewable energy options possible are listed.

- Solar Lighting Systems through Bank Loans
- Central Charging Station based Solar Lighting systems
- Remote Village Electrification Scheme of MNRE
- Rice-husk based biomass power in Bihar
- Mini/Micro-Hydel based Village Electrification

The various lessons learnt from the experiences of distributed RE are as follows,
1. "All models have mixed results and successful in a limited area.
2. Grid extension for rural electrification is a very costly proposal and a not sustainable alternative.
3. Village level entrepreneurs are generally not considered creditworthy, and accordingly banks are not willing to extend loan assistance to them.
4. Village level entrepreneurs and willingness on the part of banking community to provide loan to projects on project recourse basis are prerequisites for large scale village electrification. At present both are missing. Success greatly depends on the willingness of the people to pay for the services.
6. People seem willing to pay as in turn they save a sizeable amount otherwise spent on kerosene and diesel.
7. Renewable energy increasingly offers solutions for village electrification.
8. Different programmes of the Government of India have different levels of subsidy."

Based on these learnings, a plan for Twelfth Five Year Plan Period based on the following actions is envisaged.

1. Renewable Energy based off-grid electricity systems will be mainstreamed

2. Entrepreneurship based business models will be cornerstone to the off-grid electricity access
3. An off-grid Renewable Energy Regulatory Framework will be developed.
4. A Trust Fund will be created to meet the financial requirement for electricity access projects
5. A Section 25A Company under Public-Private Partnership mode will be created to implement decentralized renewable energy projects
6. Resources from industry and businesses will be pooled under Corporate Social Responsibility (CSR)
7. A case of diversion of kerosene subsidy towards renewable based electricity access projects will be prepared
8. Ministry of Power will be approached divert a portion of funds allocated for RGGVY towards renewable energy based electricity access projects.
9. Financial assistance for electricity access projects will be rationalized
10. Financing for electricity access projects will be put in priority sector
11. Women will be involved at every step in electricity access programme

The targets suggested under 12th plan to potentially provide access to 30 million HHs is presented in the table below (numbers in Million). A financial requirement of Rs.12000 crore would be needed in the form of subsidies to achieve these targets. ("Normatively support @ Rs.4000/solar home system; @ Rs.15 lakh per gasifier system catering to 400 families; @ Rs.10 lakh per micro hydro system catering to 100 households and Rs.1 lakh per wind–hybrid catering to 20 households have been assumed".)

Source	2012-13	2013-14	2014-15	2015-16	2016-17
Solar home lighting systems	2	3	5	7	7
Biomass gasifiers (one system to cater 400 households)	0.4	0.6	0.8	1.0	1.5
Mini micro hydro (one system to cater 100 households	0.05	0.07	0.1	0.15	0.20
Wind-hybrid	neg	neg	neg	0.01	0.01
Total	2.45	3.67	5.9	8.16	8.17

11
Title: Energy For All: *Financing access for the poor*
Authors: International Energy Agency (IEA)
Year: October 2011
Name of publication: World Energy Outlook 2011
Publication/author link: http://www.iea.org/papers/2011/weo2011_energy_for_all.pdf

Key words:energy access, modern energy, World Energy Outlook

Key observations:
This report is a special early excerpt of World Energy Outlook 2011 which focuses on the critical issue of financing the delivery of modern energy access all over the world. This report first provides the statistics on the numbers of people without access to electricity (1.3 billions) and cleans cooking facilities (2.7 billions) worldwide with further remark that the most of the people without access to electricity and cooking facilities reside in sub-Saharan Africa and developing Asia's rural areas. It estimated that in 2009, $9.1 billion were invested globally in extending access to modern energy services, and further projects that in the absence of significant new policies, the investment for these purposes will average $ 14 billion per year between 2010 and 2030.

The authors recommend five actions which are essential to overcome the barriers to achieving modern energy access (pp.3):

i. National governments should "adopt a clear and consistent statement that modern energy access is a political priority and that policies and funding will be reoriented accordingly"
ii. "Mobilize additional investment in universal access, above the $ 14 billion /year" assumed in the report, of $ 34 billion, which totals $ 48 billion per year till year 2030.
iii. "Private sector investment needs to grow", but overcoming significant barriers is a prerequisite to them, while national governments must strengthen their governance and regulatory frameworks. When uses, public subsidies must be well targeted to reach the poorest
iv. "Concentrate an important part of multilateral and bilateral direct funding" where energy access does not offer "an adequate commercial return". Facilitating end-user finance is required to overcome the barrier of the initial capital cost of gaining access to modern energy.
v. A provision for "the collection of robust, regular and comprehensive data to quantify the outstanding challenge and monitor progress towards its elimination"

The report has categorised the term "access to modern energy" into two categories, namely access to electricity and access to clean cooking facilities. This report has also provided the data for India, which show that in 2009, there was a population of 289 million people (25 % share of population) which was without access to electricity and 836 million people (72 % of the total population) who solely relied on the traditional use of biomass for cooking. It further projects that in 2030, in India, 145 million rural and 9 million urban households (10 % of total population) will be without access to electricity (pp. 16). The report also estimates that in India about 719 million rural and 59 million urban people will be without access to clean cooking facilities in 2030 (pp. 19).

In the "Energy for All" case, the report recommends to consider regional costs and consumer density which result in key determining key variable of "regional cost per megawatt-hour (MWh)". The authors believe that mini-grids, providing centralised generation at a local level and using a village level network, are a competitive solution in rural areas, and can allow for future demand growth, such as that from income-generating activities (pp.21). The report estimates that a total of $ 135 billion (2010 USD) worth of investment is required in India from 2010 to 2030 to achieve universal access to electricity in the Energy for All case (pp.22).

The report then suggests few key technical and financing solutions for mini-grid projects; although it acknowledges that these solutions can vary significantly (pp. 32). According to the report, mini-grids can be run on cost-recovery basis with a "guaranteed margin", and therefore can attract private sector finance on commercial terms. In some cases, output-based subsidies may be used to support private sector activity in this sector. Financing for mini-grid electrification for low energy expenditure households can be done through government-initiated co-operatives and public-private partnerships.

In the end, the report describes different sources of financing for off-grid electrification which include multilateral and bilateral development sources, developing country government sources, carbon financing and private sector sources.

12
Title: Husk Power Systems: Generating Electricity from Waste for India's Rural Poor
Authors: India knowledge@Wharton
Year: 2011
Name of publication: N.A
Publication/author link:http://knowledge.wharton.upenn.edu/india/article.cfm?articleid=4661

Key words: rice-husk, combustible gas, prepaid energy meters

Key observations:

Husk Power Systems was established in 2008 in Bihar by Gyanesh Pandey, Ratnesh Yadav. It generates electricity from rice-husk, a waste product of rice milling. Rick-husk is used in an innovative manner by converting into combustible gas and then using this gas to produce electricity through a generator and their rates stand at Rs 2.20 per watt which the article claims is likely among the cheapest across the globe. Also they were able to introduce cost minimisation effectively through the use of bamboo poles instead of underground cables or cement poles; while electricity theft is avoided by the design of low-cost, prepaid energy meters. Also the rice husk char as a by-product can be used for making incense sticks, thus giving employment to women. HPS then sells the incense sticks to companies who add various fragrances and market the incense under their own brands. Their system has been made simple so as to impart training to locals, generating employment. At present, the company has installed more than 85 plants across different villages and provides power directly to more than 35,000 economically poor households and in order to expand to other villages they are now looking at other options like HPS will build, own and maintain the plants, but will hand over the distribution operations to local entrepreneurs against a fixed monthly charge. In the second model of partnership, HPS will only build and maintain the plants; the ownership and distribution operations will be left to the partner.

The HPS model aims at not only providing electricity but empowering the village and the people by providing energy, employment, training, women's empowerment and health care.

13
Title: India: Biomass for Sustainable Development *Lessons for Decentralized Energy Delivery Village Energy Security Programme*
Authors: The World Bank
Authors affiliation: The World Bank (South Asia Region)
Year: July 2011
Name of publication: Document of the World Bank
Publication/author link: http://www.mnre.gov.in/pdf/VESP-Final-Report-July%202011.pdf

Key words: VESP, biomass, MNRE,

Key observations:
This is World Bank's evaluation of the Village Energy Security Programme (VESP) of Ministry of New and Renewable Energy (MNRE) which started in 2005 to go beyond electrification alone, and address the total energy needs (e.g. cooking, lighting, etc.) of remote villages by using local biomass resources. The report is organised into three chapters.

Chapter 1 provides a background on rural energy scenario in India where it highlights the fact that despite comprehensive regulatory and policy environment for rural electrification, a significant gap between the demand and the supply for energy exists. Then the report sheds light on the efforts and initiatives on rural electrification and cooking energy, especially from the ministries Ministry of Power (MoP) and MNRE in India. Finally, the report states the objective of the World Bank to support the VESP Programme. Chapter 2 of the report mainly focuses on the detailed analysis of the VESP pilot phase performance in institutional, technical, financial, managerial and social aspects. In the final chapter, this report looks at the achievements and shortcomings under VESP, and it provides recommendations on improving the implementation of the Programme (pp. 9-13).

The report's data shows that out of 67 sanctioned projects under VESP, 67% were commissioned and 51% were operational. With some noteworthy achievements, the pilot phase demonstrated several institutional shortcomings in delivering VESP:

i. Due to the complex and small-scale community driven nature of VESP, "the SNAs had little interest in implementation"; thus decision-making remained centralised at the MNRE which caused delays in sanctioning the projects.
ii. Mixed results achieved in implementing the projects due to: lack of after-sale services from tech suppliers, inadequate training and salaries to villagers, inadequate fuel wood supply and lack of capacities and interest among the village communities.
iii. "The current arrangement of every household supplying a certain quantity of biomass regularly was unsuccessful in many test projects".
iv. As a result of irregular and inconsistent delivery of energy services, "willingness of communities to pay for services could not be adequately established".

The report has considered four factors to assess VESP performance: technical, financial, managerial and biomass plantation performance (pp. 27). The performance data on 11 project sites was collected.

The authors provide following recommendations to improve VESP implementing structure (pp. 13-14, 58-68):
i. Improving institutional performance:

a. In decentralising responsibilities which includes empowerment of state nodal agencies (SNAs) to sanction and implement projects through dedicated program management units, MNRE should engage with SNA in a two-three year plan
b. Phasing the management of power-plants from VECs to entrepreneurs who will be responsible for the entire operation and collection of dues
c. Change in focus from “output reporting” to “performance monitoring” by maintaining performance database by PMUs, also including third party performance audits.

ii. Improving technical performance:
   a. Building a robust aftersales services network of third party local service providers by developing contractual obligations between project developers and service providers
   b. Provision of technical training to entrepreneurs and operators

iii. Improving financial performance:
   a. Provision of viability gap funding to attract entrepreneurs, however this to be gradually phased out
   b. Secure convergence and revenue streams of VESP at a policy level

iv. Sustainable plantations and improving biomass supply
   a. Monetizing biomass supply since voluntary contributions in supplying biomass by villagers have not worked. Instead, cash incentives need to be provided to villagers who deliver biomass to the power-plant
   b. For securing biomass supply to the power-plant, dedicated plantations on private and public lands are required to be in place

v. Improving policy framework for VESP
   a. Ensuring a levelplaying field for VESP and other DDG projects of MoP
   b. Adaption of technology neutral and scale neutral approach
   c. Focus on delivering grid-quality electricity

The authors conclude the report by pointing out that the project initiatives such as VESP are important and relevant, in the absence of any government initiatives for bringing grid quality power to the poor and underserved communities in remote areas. The poor performance of the VESP programme in its pilot phase was due to reasons that are “not entirely intractable or insurmountable”.

14
Title: SPEED: Smart Power for Environmentally-sound Economic Development *An Agenda for Action*
Authors: Ckinetics
Year: August 2011
Publication/author link: http://www.rockefellerfoundation.org/news/publications/speed-smart-power-environmentally-2

Key words: anchor loads, ESCOs, mobile towers, grid extension

Key observations:
SPEED (Smart Power for Environmentally-sound Economic Development) is an initiative supported by Rockefeller Foundation, which has objectives of "mobilization of private and public investors to provide clean energy services for economic development while ensuring that social, financial and environmental benefits of electric power extend to the poorest sections of the rural population, with the active participation of villagers"(pp.5). To achieve its objectives, SPEED promotes powering rural communities using decentralised renewable energy systems, while at the same time it also promotes leveraging power of the anchor loads, such as mobile towers, to ensure business viability of the DRE projects. Through this approach, SPEED aims to mitigate poverty and create economic opportunities for the rural communities.

The report explains SPEED's strategy behind promoting anchor loads by explaining the problems that DRE projects face in rural areas due to small and variable loads. It explains that for a DRE project to be financially viable in remote area, is must possess a certain plant load factor (PLF). Creation of anchor loads, even though latent in demand should be promoted in those areas to improve the PLFs of DRE projects. Therefore, the report states that the theory of change for SPEED is "to leverage anchor loads to be leading driver for rural electrification thereby stimulating the cycle of rural economic development that in turn would support long-term rural electrification."

Methodology:
Methodologically, SPEED first targets an under-electrified region. It then ties up with cellular tower operators for anchor demand, and also identifies local loads along the distribution lines. Capacity building of Energy Service Companies (ESCOs) is done and technology selection for power generation is conducted. An appropriate business model that aligns with national electrification and rural development policies is identified. Throughout the electrification process, local economic activity is also stimulated by providing energy services to local enterprises, rural households, supporting the fuel supply chain and facilitating payment collection mechanism. The key design parameters of SPEED initiative can be summed as consistency with the overall rural electrification policies, commercially viable project design, project ownership to ESCOs, appropriate selection of technology, community participation and rural enterprise development through income generating activities.

This report also explains the importance of the initiative like SPEED on global context. For doing so, it highlights the situation of lack of electricity access in many parts, especially in developing regions of the world. The report states that by using renewable sources to provide electricity in rural areas helps in achieving gender equality and empowerment of women, increased productivity in agriculture, improvement in public services, increased public safety, meeting aspirations, improved individual productivity, higher education levels and improved health care facilities.

The report also lists the typical key barriers that DRE projects face in rural areas such as lack of consistent demand, ineffective long term operation and maintenance (O&M), high up front capital expenditure (CAPEX) requirement, lack of community empowerment and problems in tariff collection and theft. By providing electricity to anchor loads, SPPED assures base demand for DRE projects. To ensure long term sustainability, SPEED promotes an ESCO through engagement of private enterprise. To minimize the problem of high CAPEX requirement, SPEED creates investable frameworks for private third parties. The community empowerment and income generation is done by building micro-enterprises.

Rationale behind choosing mobile towers as anchor loads

The report explains the reason for preferring anchor loads in the form of mobile towers by citing the explosive growth of mobile phones in the last decade, particularly in urban regions. It points out that after expanding in urban areas, mobile phone operators, in their next phase, target rural areas for their expansion. In many of these areas, however, the tower operators face a lack of grid –electricity supply, and then uses diesel-based power backup. However, now many mobile-tower companies are working towards "greening" their towers and are looking for renewable energy options for doing so. SPEED thinks that the "green" initiative of tower companies aligns with its strategy of ensuring sufficient load to promote sustainable DRE based energy generation. Greening towers, however, will require some CAPEX from tower companies. SPEED proposes to reduce the CAPEX burden by spreading out the costs among SPEED ESCOs and other private investors.

SPEED goes beyond "greening towers" by addressing the community and small enterprises' power needs.

SPEED: Indian context

The report is of opinion that the SPEED initiative is very appropriate to the Indian context, given the high growth of mobile-tower infrastructure, government push for equitable economic growth in rural regions and enhanced affordability of small-scale DRE systems due to their falling costs. There are 800 million mobile phone subscribers in India, out of which roughly 30 percent of them are from rural areas. The rural areas still possess significant potential for expanding network for mobile companies. Besides, Government of India, under its Universal Services Obligation (USO) fund, maintained by the Department of Telecommunications, targets at promoting connectivity in remote and rural regions.

SPEED also identifies opportunities for such DRE projects due to the fact that a large number of rural households are still without access to electricity, and the areas which are connected to the grid also face problems due to poor quality. The report points out that willingness to pay for electricity exists among rural households in India, and if the electricity provided to these households is tied to income-generating activities, then the ability to pay is further enhanced. The report then lists the advantages of using DRE systems for the rural electrification purposes, such as their cost-competitiveness with conventional diesel based electricity generation, predictability in operation and low maintenance and assured output.

In this report, economics of a typical SPEED ESCO has been also provided. For a biomass power plant of 56 kWe with 10 kWe internal load, 18 kWe tower rating and 28 kWe village load, the cost price of electricity per unit has been determined. For this purpose, it has been assumed the plant supplies electricity 12 hours a day to the village load and 24 hours a day to mobile tower load. The price realization in the SPPED ESCO model has been taken at Rs 15/kWh for the mobile towers and Rs 7/kWh for village loads. Thus average price realization is of Rs. 11.8/kWh has been estimated in this report.

The report is hopeful that the initiative, such as SPEED will be implemented successfully in India given the favourable policies under the Electricity Act 2003, high prices of fossil fuels, high costs of grid extension in remote areas and the potential of linking the local DRE substations and distribution lines under Rajiv Gandhi Grameen Vidyutikaran Yojana (RGGVY)

15
Title: Review of Alternative Participatory Business Models for Off-grid Electricity Services
Authors: Krithika, P.R. and Palit, Debajit
Author's affiliation: The Energy Resources Institute (TERI)
Year:2011
Name of publication: OASYS – South Asia Project
Publication/author link http://www.oasyssouthasia.info/docs/oasyssouthasia-wp9-mar2011.pdf

Key words: business model,franchisee,affordability,

Key observations:
The paper seeks to examine the various business models in the rural electrification sector with a focus on off-grid models using clean sources of energy. It gives detailed description of the following models along with case –studies from developing countries like Bangladesh, Nepal, and India etc. Different organisations have different institutional models being followed, and for example the World Bank has defined four different institutional models (Cabraal, 1996): cash sales, consumer financing through dealers and commercial banks, leasing arrangements, and fee-for-service. Similarly the UNDP defines four basic models particularly for solar PV systems-commercially led models driven by suppliers and dealers with relatively little government control, multi-stakeholder programmatic model, utility model, grant based models. Drawing from these classification systems, five models of different types of operation that have been used in rural electrification have been identified:

1. Electric co-operatives;
2. Distribution franchises;
3. ESCO/Fee-for-service models;
4. Community-managed operations; and
5. Private sector models.

The report also looks to understand how different organisations have modelled their off-grid and rural electrification supply programmes, what do those models look like and their strengths and challenges in the system.

1) **Electric cooperatives:**
While discussing about electric cooperatives in different countries like Bangladesh, Nepal and India, the paper observes that the Indian experience with the cooperative model has not been very encouraging .Very few cooperatives have been able to survive here due to factors such as a top-down approach which is against the fundamental principal of cooperation ,immense political interference in the day to day functioning of projects and conflicting directions as the "cooperatives are registered under the Cooperative Societies Act and regulated by Registrar of Cooperative Societies but subject to interference by SERC's" (pp.9)

2) Electricity Distribution Franchisees:
"An electricity distribution franchisee is an entity empowered by the DISCOM to either develop/operate a generation and distribution system or ready to distribute electricity within an identified contiguous area for a prescribed duration and collect revenues directly from rural consumers."(pp.12).It says that the franchisee based model is being implemented in India under the RGGVY programme and also explains the revenue and input based franchisees as two modes of delivery.

3) **Fee-for-service/ESCO models**:
"The ESCO is a company that owns, installs and operates electricity systems (e.g. solar home systems, solar water heaters etc.) and provides energy services to consumers. The company is also responsible for repair and maintenance of the systems" (pp.15). This model has been found to be successful in some countries such as Zambia, Kenya as well as other nations such as Sri Lanka, Dominican Republic etc. Case studies from Zambia and India have been discussed here. The Indian model involves the Lighting a Billion Lives campaign started by TERI, and innovative renting model for providing access to clean lighting through solar lanterns.

Within this type of model the consumers do not have to raise capital to purchase technology upfront. The paper says that paying monthly fees for services works well with the lower income strata in rural areas. There is good customer interface and service in this kind of system but in terms of challenges they face availability of trained personnel with technical and business skills is difficult along with risk of threat of systems and cases where to recover costs, targets get shifted from the needy households to the high income ones.

4) Community managed off- grid systems:

The Village Energy Security Programme (VESP) introduced by GoI also propagates the VEC (Village Energy Committee) model to manage off-grid projects at the village level. "TERI's study in 2009 found out that despite a holistic approach with sound basis, VESP is finding it difficult to achieve desired goal/success due to certain weaknesses "(pp.20) like-less concentrated electricity demand in the villages where VESP projects are operational, low paying capacity of the consumers, difficulty in O&M, limited technical knowledge of VEC and weak fuel supply chain linkages, the VESP projects are encountering issues of sustainability too.

The combined effect is thus very low capacity utilisation factor and hence higher unit cost of energy production resulting in low economic viability of the energy production systems. Also there is lack of clarity in the roles and responsibilities among the different stakeholders: PIAs, state nodal agencies and VECs. The coordination committee meetings between stakeholders are seldom held and advantage of technical expertise with state nodal agencies is not fully tapped.The paper also mentions positive work done in the form of CREDA's work in this sector.

5) Private Sector Models:
Private sector models either involve public private partnerships or purely private models. The paper draws some examples for both these type of models by giving in examples like Scatec Solar from India, Qualified Third Party (QTP) model in Philippines among others.

Thepaper then moves on to suggest the ways in which rural electrification models can be strengthened and how rural electrification can become more participatory and successful. It calls for:

- **Appropriate choice of technology and effective demand estimation :**

Suitable technology depends on the availability of resources ,consumption pattern and rate of dispersion of the population .While for highly dispersed populations where main usage of electricity is lighting ,stand-alone systems based on solar is advocated while for thicker populations with a productive load village mini grids is appropriate .

- **Financing:**

"Finance for project developers on favourable terms is a necessity for off-grid projects as they typically involve large upfront costs" (pp.29). A World Bank study shows that financial subsidy is an important component at least in the initial years for ensuring project sustainability.

- **Electricity tariffs :**

"As affordability is one of the key factors from a customer's perspective, the electricity tariffs should be based on the ability/willingness to pay of rural consumers. Willingness to pay and affordability are influenced by variety of factors such as trust, flexibility and frequency of payment schedules, proximity to payment points and quality of customer service" (pp.30).As grid connection is still perceived the best option over off-grid, the paper advocates for bringing out the tangible benefits that these projects offer to ensure better participation and acceptance of these systems.

- **Service delivery :**

Any participatory service delivery model can be successful only if it has a well-defined administrative structure and effective management at the local level. There should be well-trained technical, administrative and support staff to run the business on a day-to-day basis.

- **Community participation:**

"Organisations with fewer layers and greater community interaction seem to work well and have the potential to scale up. Only those institutions which can successfully mobilise the communities by engaging with them can be sustainable in the long run. Women's groups and local farmers associations should be involved in the project development process" (pp.31).

16	
Title: Off-grid Energy Development in India: An Approach towards Sustainability	
Authors: Arabinda Mishra and Gopal Krishna Sarangi	
Authors affiliation: TERI University	
Publication category: Working Paper	**Year: December 2011**
Name of publication: OASYS – South Asia Project Working Paper	
Publication/author link: http://www.oasyssouthasia.info/docs/oasyssouthasia-wp12-dec2011.pdf	

Author's Abstract: The paper carries out a critical evaluation of existing approaches to the off-grid/decentralised energy development in India and proposes a sustainability framework based on a decision hierarchy. An exhaustive review of policies and programmes is complemented with a statistical analysis of project level information available from secondary sources. The results of the analysis have been validated through select field visits and a stakeholders' workshop. The major findings of the study suggest that successful decentralised interventions are critically contingent upon certain key determinants i.e. choice of technology, scale of the project, type of policy support, role of community, economic linkages and type of investment. While the analytical results corroborate with the findings of many other studies, some of them point to interesting and new perspectives to explore. One such finding is related to the community participation in off-grid projects. Contrary to the established wisdom on role of communities, our analysis suggests that in practice the reality of capacity constraints among communities, local level conflicts and elite capture subvert the established premise on community participation. The decision hierarchy proposed for off-grid energy services has been linked to certain enabling methods at each stage of decision-making and is expected to address the key sustainability dimensions of off-grid energy interventions.

Key words:

Key observations:

The publication is organized into eight sections which look at the off-grid energy sector in India critically and proposes way-forward solutions towards its sustainability. In the introductory chapter, the authors discuss the importance of off-grid solutions as alternatives to conventional grid extension in providing access to energy in many (especially rural) parts of the world. However, here the authors caution that there are some inherent constraints that off-grid decentralized sector may likely to face in future due to high upfront costs, 'thin' rural markets, difficulty faced by developers in obtaining institutional finance and 'ambiguous' government policies. On the policy front, the main hurdle that decentralised energy projects face is to get into mainstream of the national planning process. According to the authors, the greatest challenge for this sector is inadequate capacities at local community or village level to operate the projects and maintain the infrastructure. The authors here distinguish the motivations behind decentralized energy generation efforts conducted in developed and developing countries. For developed countries, the micro generation is an attractive area because of its potential to become future technologies. Whereas, in developing countries, micro generation is pursued in the overall context of community life and it is an integral component of rural development efforts.

While describing decentralised energy sector in Indian context, the authors first provide details of electricity requirement projections in coming years. Here the authors explain the importance of electricity access to people If India has to achieve its goals of economic development, environmental sustainability and technological leapfrogging. To explain their emphasis of electricity access, the authors demonstrate a strong correlation between the Human Development Index (HDI) and the percentage of household electrification using the data on selected States in India. Here authors also provide details on the policy derivers and decentralised energy generation backed schemes in India.

From authors' point of view the rural applications of renewable energy systems faces multiple challenges related to technology, economics, community participation and learnings focused towards 'what exactly matters for sustainability of off-grid projects'. With the help of their review of the publications in this sector, the authors identify three critical factors that contribute to the successful implementation of rural electrification models, viz. sense of ownership, affordability and post-commissioning support. They conclude that "mainstreaming renewable energy based off-grid systems in rural setting is challenging and requires nuanced understanding of a whole gamut of factors operating at different scales".

To gain further insights into operationalization aspects of decentralised energy sector in India, the authors provide their analysis on Indian policy support, rural energy markets and community participation. At policy level, there seems to ambiguity on what is meant by either a decentralised or an off-grid energy system. Besides policies are often found to be ambiguous on technology choice and promotion of such systems does not find holistic financial support to both capital cost component and O&M cost component. Moreover, "often juxtaposing a policy or programme with the existing legal and political institutions have led confusion" in this sector. The lack of co-ordination between different Ministries and Departments conducting similar electrification programmes seems to be a common feature in India. At State level, policies and regulations are mainly designed to promote grid-interactive renewable energy with very little focus on decentralised energy systems. On rural energy market front, the policy efforts do not sufficiently appreciate the role and potential of private players. Since India is a very diverse country, the community needs vary significantly from its one part to another. In this context, the authors believe that an effective engagement of local communities in decentralised projects play a key role in their sustainability.

After analyzing the key sustainability dimensions of off-grid energy sector in India at 'macro' level, the authors attempt to understand such dimensions at 'project' level. For this purpose, based on secondary data sources, 74 projects including a range of technologies, project sizes and locations, tariff structures, ownerships and management arrangements have been studied. Based on their analysis, the authors reveal some interesting observations. The success of off-grid projects at local level depends on the ability of such projects to generate income for local communities. With the current settings of mainly government funded off-grid projects, the effective community participation is constrained by their limited capacities to manage the projects, local level conflicts and 'elite capture'. The authors analyse both operational and non/partially operational proejcts based on six parameters: technology selection, size, funding source, community participation, income generating linkage from the project and policy linkage. **They found that the operational projects score high for all variables save community participation.**

In the conclusion section, the authors provide their suggestions for the off-grid renewable energy sector to be operationally viable by stating that "a) macro-economic policy instruments must be aligned with local accountability mechanisms, specifically for government owned and operated projects; b) at the project level, key choices related to technology selection and scale of intervention need to emerge from an understanding of the context; c) the context itself is a variable depending on community structure and local economy; and, d) financing of a project may be linked to the nature of energy services defined by the context".

17		
Title: Sustainable model for financial viability of decentralised biomass gasifier based power projects		
Authors: Palit, Debajit, Malhotra, Ramit and Kumar, Atul		
Authors' affiliation: TERI and Utrecht University		
Name of publication: Energy Policy		
Volume: 39	**Year:** 2011	**Pages:** 4893-4901
Publication/author link: atulk@teri.res.in (Atul Kumar)		

Authors'Abstract :

This paper made a modest attempt for designing a sustainable model for financial viability of biomass gasifier power projects for enhancing electricity access in India and other developing countries. For long term sustainability of distributed generation projects in remote rural areas, viability from both project implementing agency (PIA) and the end-users need to be ensured. The minimum required prices of electricity from both PIA and end-user perspective have been estimated. While for PIA the cost recovery is the key for viability, the affordability to pay the electricity cost is crucial for the end users. Analysis carried out in this paper on the basis of data obtained from operational projects implemented in India reveal that it is essential to operate the system at a higher capacity utilisation factor. While this can be achieved through creating convergence with locally relevant economic activity, it is also observed that micro-enterprises cannot pay beyond a certain price of electricity to keep it sustainable. This paper sets forth a case for developing a regulatory mechanism to extend the tariff fixation for the projects and providing cross-subsidies to ensure long term sustainability of off-grid project.

Key observations:

A lot of failures in off-grid systems have been observed, mainly because sufficient attention was not paid to long term sustainability, and because of financial, technical and regulatory barriers. Specifically with respect to biomass projects, the lack of success is attributed to financial non-viability despite a 90% subsidy of the total cost.

The methodological approach has been to estimate the total cost of electricity generation under different operating conditions based on field performance data. The minimum desired price (MDP) from a consumer point of view is then found and the paper then does a viability gap analysis between payments and electricity price. The paper then finds and proposes mechanisms to bridge this gap and also suggests long term sustainable electrification approaches.

Parameters and assumptions used in the analysis:

Capacity Utilisation factor – 7% with 3 to 5 hours of usage and a best case scenario of 33% with 10 hours usage; Life of the plant – 10 years; Capital expenditure – As per MNRE guidelines.

Specific fuel consumption at <50% load is 2kg/kWh, at >70% load is 1.5kg/kWh; Auxiliary consumption – 10%

Interest on loan – 11.25% ; Price of feed stock – Rs 1/kg ;

Operation and maintenance (O&M) – salary is assumed at 300 Rs per month. For maintenance of 10 kWe, Rs 400 per month and Rs 600/month for 25kWe is assumed. Ignition fuel cost is taken as 300 Rs per annum. For contingency of 10 kWe system, Rs 300/ month and Rs 500/month for a 25 kWe system is assumed. Annual cost escalation of O&M and fuel cost is taken at 5% per annum; Discount rate is assumed at 12%

Two scenarios are defined, namely with and without subsidy. In the first case, 90% is the subsidy and 10% is the contribution from the community of PIA. In the second case, 70% long term loan and 30% community contribution is assumed. In both cases no return on capital is assumed because the equity is put in by the village electrification committee.

Results

For a 10 kWe system (without subsidy) the electricity price is calculated @ Rs 16.2/kWh with a 33% CUF. While assuming a 90% subsidy the same system (10kWe) has a cost of Rs 5.60/kWh while for a 25 kWe system, the price is Rs 4.29/kWh at a 33% CUF. However as most of the field BGPP's PLF was only 7%, the price for a 10 kWe system is calculated at Rs 16.6/kWh and 25 kWe at Rs 10.32/kWh. The author finds that the price is more sensitive to connected load than to the hours of operation.

While looking at the viability from the consumer's point of view, the authors find that the current prices are in the range of Rs 30-60/month/HH for 4 hours of connectivity. For long term sustainability calculations the author uses two scenarios, one looking at domestic load the other looking at domestic and productive load.

In scenario one they find the sustainable tariff to be in the range of Rs 80-100/month/HH while in scenario two they find the domestic tariff comes down to Rs 50-60/month/HH. The commercial tariff would need to be in the range of Rs 7.5-10/kWh.

CASE Study village Dicholi

The village has a 10 kWe BGPP system, 85 households connected with an average load of 50 W per household. This results in a 35% to 40% utilisation of the rated capacity. The village has a revenue collection efficiency of 80%. This system is financially unsustainable. However there is an existing flour and rice mill in the village that runs on diesel power. If the mill were to be supplied power by the gasifier, it will render the system profitable but only for the 1st year. For long term sustainability the authors propose an annual tariff escalation of 5% (for domestic and commercial).

The authors further point out that under the current regulations stand alone off grid systems have no licensing obligations and no cross subsidies making tariffs high for rural consumers. Mechanisms for tariff fixation by regulators and claiming Renewable Purchase Obligation (RPO) or Renewable Energy Certificate (REC) benefits are needed.

In conclusion, the authors note that a large scale program for rural electrification on gasifiers "requires an alignment of financial incentives and institutional structures to implement, operate, and sustain the projects". For financial sustainability, higher capacity plants are more preferable and "the BGPP should operate at more than 30% CUF i.e. average load of 70–80% of the rated capacity for 8–10 h per day and about 350 days in a year."

18		
Title: Research needs for meeting the challenge of decentralised energy supply in developing countries		
Authors: Schäfer, Martina, Kebir, Noara and Neumann, Kirsten		
Authors' affiliation: Technical University Berlin		
Name of publication: Technology in Society		
Volume: 32	**Year:** 2010	**Pages:** 303-311
Publication/author link: schaefer@ztg.tu-berlin.de(M. Schäfer)		

Authors' Abstract :
Scenarios imply that there will still be a considerable percentage of people (16%) without reliable access to electricity, especially in developing and emerging countries, in the year 2030, if ongoing efforts are not intensified. International governance and funding institutions like UNDP and the World Bank consider access to electricity as being fundamental for economic development and poverty reduction. Since the extension of centralized grids is often expensive, different forms of decentralised electricity supply options have gained importance for rural areas and informal settlements during the last 3 decades. Until now, there has been a lack of systematic evaluation of experience with decentralised electricity systems in different cultural and geographic contexts and the transfer of this experience. One reason for this deficiency is that the 'research community' for this field is not very clearly defined regarding disciplines and institutions and that there are few institutionalized occasions and forums which enable discussion and systematization of existing knowledge. This article gives a rough overview of the challenges linked to developing and implementing systems of decentralised energy supply under difficult context conditions and the research needs resulting from these challenges. Central means towards success in this domain include embedding the introduction of technical systems in a range of services (e.g. capacity building, maintenance, repair and disposal services, financing schemes), integrating users' needs in their development and implementation, enhancing productive use of electricity by linking energy supply to regional development programs. To be able to deal with the outlined questions, the perspective of decentralised energy supply as socio-technical systems can be
helpful. Research desiring to adequately meet the challenges needs to integrate knowledge and perspectives from different disciplines as well as expertise from practitioners in the field in a reflective manner..

Key observations:
There is a large number of people without access to electricity, these are mainly the rural population in sub Saharan Africa and Asia. On way to rectify this situation is through decentralised Renewable energy however proper evaluation of existing projects need to be conducted to achieve better results in the future.

There is also a need for proper and impartial funding to ensure that present funders and project implementers can learn from past mistakes. The challenges of implementing systems of decenrtalised energy supply In remote regions are the following.

Technology is often not adopted to local conditions, the needs and skills of the local people and false and incomplete system information only exacerbates the situation.
Professional installation and long term functionality needs to be assured and sometimes the limits of the system is not properly explained to the used leading to long term unsustainability.
Technical design and quality management are not adapted to the financing models, specifically financing payback periods are not in synch with system guarantees.

R&D approaches to meet the challenges:

- Decentralised RE systems need to be robust and adaptable specifically with low level of skills and expertise available in remote regions.
- Creating regional supply and manufacturing systems will help improve the situation
- The needs of the users have to be taken into account for system design
- A service package needs to be added to technical installation.
- Decentralised energy system s if put to supply energy for productive use can lead to larger impacts. In this regards, not only individual but also community productivity needs to be taken into account.
- Energy supply must be integrated into regional development program and multi-level governance.

The research work must include an interdisciplinary team to look at various aspects of the decentralised systems and must also have a close exchange of ideas with various practitioners and policy makers.

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Title: The Solar Transitions research on solar mini-grids in India: Learning from local cases of innovative socio-technical systems		
Authors: Ulsrud, K.,Winther, T., Palit, D., Rohracher, H. and Sandgren, J.		
Name of publication: Energy for Sustainable Development		
Volume: 15	**Year:** 2011	**Pages:** 293-303
Publication/author link: kirsten.ulsrud@sosgeo.uio.no (K. Ulsrud)		

Authors' Abstract :

The article presents new empirical material from a case study on longstanding, pioneering efforts on implementation and use of solar mini-grid systems in the Sunderban Islands in India. These local, socio-technical experiments have been investigated by a trans-disciplinary team of researchers and practitioners in order to gain a deep understanding of the diversity of social and technical factors influencing the ways in which the systems work at different levels. This socio-technical research highlights the dynamics between technology and society and how they are mutually influencing and shaping each other. These dynamics create gradual changes in the socio-technical system of technical devises, people, practices, knowledge and other elements, requiring adjustments also by the implementing actors. A range of technical and non-technical factors at various levels are found to be relevant for the implementation, operation, sustenance and further development of the solar power supply systems. The research points to important factors that should be taken into account and considered when planning similar activities. In addition to the analysis of the research findings, the article includes a brief review of literature on the implementation and use of solar photovoltaic technology in developing countries, with an emphasis on solar mini-grid systems.

Key observations:

The paper notes that there are various methods of analyzing solar mini grids, some of which are:

- Seasonal fluctuation in solar radiation versus variation in power generation
- Comparison of techno-economic characteristics of mini-grids with individual solar home systems
- Problems of long term functionality and viability of technological systems for solar mini grids.
- Measurement of socio economic impact of solar mini grids.

The Solar transition case study (which is the focus of the paper) considers technological change as a social learning process recognizing social progress. It analyses decentralised solar power as a part of an emerging and not-yet-established socio-technical system which is not fully integrated in society. It looks at interaction between technologies and stakeholders.

The case study looks at the 17 solar mini grids with an aggregate capacity of 890 kW set up in Sunderbans, West Bengal and run by WBREDA. It involved a qualitative interviews with various stakeholders and was coupled with a 200 household quantitative survey where 50% had access to electricity and 50% no access. The data and results were interpreted by a multi-disciplinary team.

The project implementation cycle involves a number of steps in which WBREDA secures funding, then identifies villages, holds meeting with stake holders to discuss contributions. The tenders are then announced for technical and maintenance contracts. Local people are selected and trained during project set up.

Challenges faced and lessons learnt from the case study:

While tariff collection was very good and theft nearly non-existent, there is growing demand for electricity and a temptation to use more electricity than agreed because of a non-metered fixed charge system. One way around this seen in some places was a using a combination of mini grid and Solar Home Lighting System to meet increased demand. Installation of additional generation capacity is easy because of modularity of solar PV. Hybridization with other RE systems is also possible. Involvement of energy service providers to improve collection and system efficiency is also

under consideration. Integration of these mini solar grids with the national grid (as and when it arrives) is possible but there are technical challenges to be resolved to enable this.
The operators of the mini grids are crucial to the long term sustainability of the plant and their low wages are an important non-motivating factor in the long run. Effective O&M for plants is being addressed by developing long term (10 year) contracts with developers.
Division of responsibility is often unclear in these evolving systems, especially as was seen in the case of battery failures. From the technical side, the battery is the weakest link and the solution suggested is that the contractor responsible for the charge controller should also be responsible for battery with contractual early failure replacement guarantee.
Tariff setting is not under regulatory control and done by consultation between WBREDA and consumers. What is needed is a better balance between affordability and financial viability.

Apart from noting these challenges, the paper by making use of a socio-technical approach to the question has been able to show the dynamic interaction between the actors and the technologies which has resulted in an ongoing mutual learning process for both and highlighted the multi faceted nature of the case study. They hope that these learnings would be useful for the JNNSM.

20
Title: Dirty Talking? Case for telecom to shift from diesel to renewable
Authors: Gopal, Sanjiv and Chattaraj, Mrinmoy
Authors affiliation: Greenpeace India
Year: May 2011
Publication/author link: http://www.greenpeace.org/india/en/What-We-Do/Stop-Climate-Change/Green-Electronics/switch-off-diesel/report-switch-off-diesel/

Key words: telecom, energy use, renewable energy

Key observations:
India is the second largest telecom market and is growing further. Energy is a crucial input for running the telecom towers and is a dominant cost component. The roll out of rural towers is increasing rapidly and thereby the energy use. Electricity use is expected to increase to 26 TWh in 2012. While electricity shortages and unreliable supply, diesel backup is a must and is the norm for unelectrified areas. Diesel generators are run for 12-16 hours day in rural areas. The report estimates an annual consumption of 1.8 billion litres of diesel in the country for running telecom towers. The annual diesel energy bill for running towers, especially in off-grid locations is roughly Rs. 65 billion. The report further points to the loss for the exchequer from the use of subsidised diesel by the telecom industry.

Given these factors, the authors urge the government to mandate a rapid phase out of diesel use in tower by 2015 and further incentive use of renewables in urban and rural areas to power such towers. The Telecom Regulatory Authority of India (TRAI) has recently released recommendations for an approach to green telecommunications.

The report gives a good fact sheet like picture of the leading telecom companies with regard to their carbon emissions and renewable energy use. The report also laments the lack of transparency in the sector and urges companies to be more proactive in disclosing their carbon emissions and their use of renewables.

Chapter 4 then looks at the economics of the diesel vs. renewable story and makes the argument that while the capital costs for RE are higher, with significant savings from operating and running costs, the case for renewables is compelling. It also points to three case studies which use a combination of solar, efficiency and energy management systems and thereby have large costs reductions to their benefits.

The report ends with the following demands from Greenpeace:
The telecom industry in India should:
• Publicly disclose their carbon emissions and set progressive emission reduction targets.
• Commit to shifting the sourcing of their energy requirements significantly towards renewable sources.
• Make clear investment plans for the co-development of renewable energy based generating capacity
sources along with development of new telecom infrastructure.
• Enable a low-carbon economy by playing a significant role in advocating strong climate and energy policy changes in favour of renewable energy sources and technologies at national and international levels.

21	
Title: Assessment of the Existing Sustainable Renewable Energy based Enterprise Models Across India and Gathering Potential Evidence to Influence Policy Change	
Authors: Winrock International India.	
Authors affiliation: Winrock International India.	
Publication category: Report	**Year:** February 2011
Publication/author link: http://www.inspirenetwork.org/active_ene_existing_sustainable.htm	

Key words: sustainable energy enterprise, business models, access to energy

Key observations:
The report has been prepared by Winrock International India and the work has been supported by Shakti Sustainable Energy Foundation. The objective of the report, as it is stated is "to analyze some of the models of sustainable energy enterprises, which have been in operation and are even evolving with the changing market situation in different parts of the country." For this purpose, the report analyzes four business models of sustainable energy enterprise (SEE) presently in operation in India namely:

i. SELCO model: where the energy enterprise enters into a partnership with financial institution. The uniqueness of this model is in development of financial products based on the cash flow of the clients. Door-step servicing and door-step financing are the two key features of this model highlighted in the report.
ii. Aryavart Gramin Bank model: which is a "one-stop-shop model" where sustainable energy products and finance are provided under one roof. Here the uniqueness of this model, according to the report is that it is driven by the regional rural bank who establishes linkage between technology provider and consumers.
iii. DESI Power model: which is termed as an "umbrella model" where the rural enterprise has partnered with a range of institutions. This model has its strength in demand driven, location specific and pay and use kind activity, according to the report.
iv. Husk Power model: which is also similar to the DESI Power model. Here the report sees that this model is unique in terms of effective supply side and demand side load management.

Besides analyzing the four main models, the report also examines the experiences of SEEs in other initiatives. Moreover, it also sheds light on the policy scenario, both national (Electricity Act 2003, National Electricity Policy 2005, Rajiv Gandhi Grameen Vidyutikaran Yojana 2005) and international, which has helped in promoting such enterprises. It also details on the methodology that was adopted (literature review, telephonic conversations with the stakeholders, etc.) in gathering the information on these business models. In the annexure, a model questionnaire has been also provided for the benefit of the reader. The detailed analyses of the four business models studied are also provided in the annexure section of the report. Here the aspects such as technology selection, nature of institutional linkages, service charge collection mechanism, co-funding opportunities and key advantages as well as challenges have been studied in detail.

Based on the comprehensive analysis of the business models, the report has come up with key findings. It reveals that in all the cases studied, there was an underline desire of SSEs to bring energy to poor households and all those households have been directly benefitted by the clean energy services. In the cases studied, it was witnesses that the entrepreneurs had to rely on both market and non-market (e.g. award money) to have access to finance. However often there was not enough funding available for the research and development (R&D) activities in the SSEs. International awards often help the entrepreneurs to achieve recognition and credibility. In all the business models studied, institutional linkages played very crucial roles. All the business models studied generated employment activities for local people and helped contributing to reduction of greenhouse gas emissions.

Based on its extensive analysis of the models studied, the report also provides key recommendations on funding and end user finance and on subsidy design. Its main recommendations include making it mandatory for financial institutions to fund renewable energy enterprises in rural areas, facilitating additional funding besides government aid through carbon market and access to end user finance based on particular business model. On the subsidy front, the report recommends designing of "smart subsidy" which does not have market distorting effect.

The report identifies key areas based on its analysis which need further research. Especially, in depth analysis of government policies promoting renewable energy in rural areas, detailed study on barriers faced by renewable energy enterprises and creation of regulatory framework for off-grid energy services are some of the issues highlighted in the report. In the end, the report concludes that "access to low carbon technology has not only helped to reduce climate vulnerability but has also contributed to autonomous adaptive capacities. However, it is also important to review how access to low carbon technology has facilitated and promoted the adaptive capacity of the poor."

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Title: Access to Electricity *Technological options for community-based solutions*
Authors: Wuppertal Institute for Climate, Environment and Energy
Year: 2010
Publication/author link: http://www.wisions.net/files/downloads/Access_to_Electricity_WISIONS_2010.pdf

Key words: technology, case studies, millennium development goals

Key observations:
This report provides information on the technological options for community based sustainable energy technologies. The technologies covered are wind electric power, micro-hydro power, biomass electric power (biogas and vegetable oil based solutions) and solar photovoltaic electric power. While discussing the technological options, the report takes support of case studies to discuss their pros and cons.

While evaluating each technology, the key questions addressed are (pp.3): technologies potential contribution to global sustainable development, CO_2 reduction potential, ability to achieve the Millennium Development Goals, negative or positive environmental impact, social and regional impacts, future expected development in the technology and requirements to make the technology economically viable.

The report focuses mainly on the off-grid and mini-grid technology solutions. It points out that such solutions may result in significant improvement in the ability if individuals and communities, while on the other hand it acknowledges that a community-based approach often encounters additional challenges. The potential positive impacts of assuring electricity to communities can be better education and health conditions, improved communications, local business options and improved living conditions of women. The challenges in the community based projects mainly arrive from involving people at the project conception and implementation stage, lack of financial support for the capital and running costs of the project and ensuring technical and managerial local skills (pp.5).

Wind electric power: The report indicates that there are no significant environmental issues from wind power installations. The biggest challenge for the future is to develop strategies to integrate considerable proportion of fluctuating power from wind plants into electricity network.

The report has pointed out that the investment costs per kW of installed power have decreased up to 2004. From the case study documented in this report, the authors are of opinion that instead of small wind power systems for each house, it would be better to install centralised generation for small housing complexes within the community and connect those with micro-grids. This allows more powerful equipment to be installed (pp.9)

Micro-hydroelectric power: The report showsthat for micro-hydroelectric project, water management strategies should be developed in situations where water flows are modified in order to guarantee the minimum supply of water needed to conserve local ecosystems. In the case study (pp. 13) focused on a micro-hydro project, the importance of awareness raising amongst the users with regards to the advantages of renewable energy as well as its limitations is raised

Solar PV: The technology's main environmental impact is regarding the production and its recycling as well as disposal of PV devices**.** There are other challenges for PV technologies like: the need to increase the conversion efficiencies of commercial systems and the need to improve resource and energy efficiency in the production process and to avoid the use of rare earth metals. Economically, the PV technologies have shown relatively high learning rates, and the average cost of PV module is expected to decrease significantly in the near future.

Biomass: Biomass supply is perhaps the most crucial elementin biomass electric power project. Special care needs to be taken to harvest biomass residues that are traditionally used to condition soil. Therefore strategies to establish sustainable biomass production systems should be assessed as early as during the formulation stage that seeks to encourage the use of biomass for energy.

23
Title: Access to Clean Energy: A glimpse of off grid projects in India
Authors: MNRE,UNDP in association with SDC
Year:2010
Name of publication:
Publication/author link: http://direc2010.gov.in/pdf/ACE.pdf

Key words: gasifier, green economy, purchasing power, women power

Key observations:
The following case-studies have been presented in the MNRE report highlighting the progress of the DRE sector in India and it's scope for replication all over.

a) **Gosaba Island Gasifier: biomass gasifier :**

The geographical location with separation from the mainland by rivers, creeks was a major hindrance in getting power from the grid for Gosaba island in the Sunderban region of West Bengal and so West Bengal Renewable Energy Development Agency (WBREDA) along with Ankur Scientific Energy Technology setup a 500kW duel fuel power generation system. Biomass gasification's technology conversion efficiency being high, it can be applied over a wide range of output metrics with a small variation, since it works in locally available feedstock, it ensures uninterrupted power supply. The report observes that while there was initial resistance by people in using and accepting the renewable technology, it has now been replaced by around 1185 consumers using this technology .The plant operates for 14hours a day, has commercial stores, banks, telecommunication system with internet and computer training centre, a hospital that can conduct basic operations and has been funded 100pc by GOI and State Government but owned and operated by Gosaba Rural Energy Cooperative setup by WBREDA.

b) **Turning destructive pine to productive gas: A pine based gasifier**

Forest fires are common in the region of Kumaon and Garhwal during summer months and here the Pine chir tree that causes these fires has an advantage as the pine needles are combustible that can be used in the pine based gasifier which has been setup by AVANI –a voluntary organisation. A 9kW gasifier is already operational, out of which 1.5kW is consumed for running the system and 7.5kW available for productive use. This project hopes to ensure a "green economy" and to address issues of health, livelihoods, biodiversity of the region.

c) **Transformation of Araria: The Gasifier way**

DESI Power has setup 50kW power station based on gasification of rice husk briquettes .It takes the role of IRPP business model with a joint venture, wherein it provides affordable electricity using locally available resources ,the local partner ensures supply of raw material and promises to buy electricity generated .Another business model presented by them caters to requirements of small and medium industries .In the initial stages of the project ,DESI Power had to first start with a co-operative on it's own along with ensuring proper training and human resources for the project. Management of feedstock is assured by increasing the variety of feedstock while continuous efforts to explore all possibilities are being done in this regard. The people are encouraged to cultivate "dhencha", while the company has prepared a feedstock calendar for the entire year .The focus on productive rather than lighting load has resulted in financially viable business model with tariff payment regular. The report claims the project has led to increased purchasing power for the people, shop to sell manure and fertilizers setup, with nearly 25 shops in the area, has encouraged youngsters to find employment locally. There is a plan to spread to 100 villages in Bihar and other states as well.

d) **Bioenergy-gasifier, Bihar:**

Saran Renewable Energy (SRE) –setup biomass gasification plant at Garkha.Here biomass is purchased from local farmers to generate electricity which is sold to local businessmen erstwhile genset operators, thus saving their jobs. Dhencha is used as the raw material (70%), remaining from other sources. This cultivation now earns them an additional Rs7500-10,000 per year. Now 1000 businesses, households, school and medical clinics, grain mills, cold storage unit, saw mill get electricity for 10hours per day. Irrigation facilities have improved and cost for water supply has reduced by half, thus increasing savings and has helped instill belief in people who had given up hope of reliable, uninterrupted power supply.

e) **Jatropha: an emerging option for rural electrification:**

Winrock International India started exploring viability of oil extracted from seeds of jatropha plant for rural electrification and Ranidhera village in Chhattisgarh having a population of around 600 was selected for this project. Initial hesitation arose as people felt this would limit their chances to access conventional grid electricity; however they later were convinced about its benefits. Campaigns were undertaken to create awareness about potential of jatropha plant as viable alternative for providing electricity. Jatropha saplings were given to people to be planted in bunds and boundaries of agriculture fields. The District authorities granted the required land to construct power house-designed to accommodate oil expelling facility, power generating units, rice dehusking facility, warehouse to store jatropha oil seeds. A power plant of capacity 11kW supplies electricity for 3hours for households and 3.5hours for street lighting. Villagers were given training on each aspect of generating electricity from jatropha seed oil –from oil expelling using oil extracting and filter press, running of DG sets, electricity distribution, regular training for maintenance of diesel engines . Arun Vikas Samiti –a village energy committee was formed and entrusted with deciding tariff structure, collection of bills, and maintenance of power plant. The Report notes improvements in healthcare, education and extra entrepreneurial activity as a result of this project.

f) **Women power**:

PRADAN, an NGO instituted a project in 2009, wherein solar photovoltaic powered machines replaced diesel generated machines in production of tussar yarn. The NGO has constructed work sheds where 30-35 women can work, here solar photovoltaic were installed on rooftop and batteries and other devices in the room. This project is particularly useful in the summer when condition was not suitable for extracting yarn ,now due to lighting in the shed, they have increased time for work and has helped increase production and earnings by 15pc.Education classes are also conducted with the help of solar power

g) **Light at night: Community solar power plant:**

Development Alternatives (DA) adopted Rampura village in UP along with Scatec Solar –a Norway based organisation for community solar power plant. A project of solar panels having three strings of 20 modules each, each module consisting of 50 cells has been setup. Each module has a capacity to generate 145Wp and total panel has a capacity to generate 8kWp.The project was commissioned on a “build-own-operate-transfer” approach, wherein village community is the ultimate owner of the project. A Village Electrification Committee is created for smooth functioning of project. The tariff model has been changed to consumption based model to avoid physical policing and social conflict and the plant has been designed in such a way so as to meet energy requirements of running flour mills, water pumping and distribution, drying cash crops, running sewing machines. The project, the report notes has led to improvement in wealth and hygiene conditions of people, safety at night has increased. The project has also been able to instill confidence and project management skills among people in the village, as observed by the report.

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Title: Technical Options for Off-Grid Electricity Supply :*A Review of Literature*
Authors: Altawell, Najib
Author's affiliation: Centre for Energy, Petroleum and Mineral Law and Policy, The University of Dundee, Scotland
Year: June 2010
Name of publication:OASYS – South Asia Project
Publication/author link: http://www.oasyssouthasia.info/docs/oasyssouthasia-wp3-oct2010.pdf

Author's Abstract: As the demand for energy increase and the prices of fossil fuel continue to rise, new ideas and new technologies regularly introduced to our daily lives. This kind of approach, trying to solve the energy crisis worldwide, may have helped, in one way or another and directly or indirectly, those neglected and forgotten parts of the world of the rural areas in the developing countries.
For more than seventy years, DG tested approach for the production of electricity in the countryside is nothing but an excellent indicator of DG viability, reliability and economy.
Since the present option is to use different sources of energy, in addition to the fossil fuels, electricity production from DG portable devices using local resources is the ideal solution. Connection to the main grid, therefore, may or may not be the best economical way; at the same time, combination of the two, may provide another way in solving electricity shortages.
This report looks briefly at various types of DG technologies, their viability and their other important aspects, such as the economical and performance side.
Summary with positive and negative factors for each model have been provided whenever this is possible.
The general outlook introduced in this literature review has been aimed to be used as a quick reference for a variety of DG devices and their applications.

Key words: technical options, barriers, local resources

Key observations:
This report presents a literature review on technical options for off-grid electricity supply. Towards this, it looks into conventional (diesel, batteries and kerosene based), renewable (PV, wind, small hydro, bio-energy, etc.) and hybrid (PV-wind, wind-diesel, wind-small hydro, etc.) off-grid technologies available for rural electrification. The advantages of using decentralised generation (DG) power systems, according to the author are: self-sufficiency for local community, supplementary power for the main grid, reduction of congestion during peak demand in the main grid when supplied power from DG, etc. (pp. 11-12)

The author categorises the barriers faced by DG systems into: i) technical barriers (need for uniform standards, interconnection and power control), ii) business practice barriers (adoption of standard commercial practice, business terms for interconnection and tools to determine the value and impact of DG power at any point on the grid) and iii) regulatory barriers (tariffs, utility incentives, conditions/terms to interconnect, establishment of dispute resolution for DG projects, etc.). From the literature reviewed on DG research projects, the author suggests that the following points should be considered before and during the work related to any DG technology project in a rural area of a developing country:

i. Present and future level of energy need for the community
ii. Procurement cost and cost of maintenance
iii. Short and long term benefits

iv. Type of energy source required
v. Type of DG technology needed

The author also provides the pros and cons of the options for grid extension and off-grids while supplying electricity to the rural areas. The report concludes that although the use of renewable energy sources is a very promising option to supply electricity in rural areas of the developing countries, due to the unreliability of the local resources and immature technologies, DG hybrid solutions in proving electricity would be the best choice for speeding up the electrification(pp. 47).

The author concludes the report by suggesting to look into the following aspects while considering the electrification of the countryside using DG technologies:

i. Commercial availability of DG devices to the end users, i.e. manufacturers, suppliers, etc.
ii. Uniform standards of DG devices and their parts
iii. Fair competition between the main grid and DG electricity producers should be encouraged
iv. Consumer should be charged according to the level of their employment and average daily income
v. The development of devices using DG technologies for rural use in developing countries is still lacking
vi. Hybrid systems can be costly in the initial stage, but in long terms they help in cost saving

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Title: Biomass gasification for decentralised power generation: The Indian perspective		
Authors: Buragohain, B., Mahanta, P. and. Moholkar, V.S.		
Authors' affiliation: IIT Guwahati		
Name of publication: Renewable and Sustainable Energy Reviews		
Volume: 14	**Year:** 2010	**Pages:** 73-92
Publication/author link: vmoholkar@iitg.ac.in (V.S. Moholkar)		

Authors' Abstract :
This article attempts to highlight the technical and economic issues related to decentralised power generation in India using biomass gasification. Biomass-based energy has several distinct advantages such as wide availability and uniform distribution that puts it ahead among the renewable energy options for India. The estimated potential of power generation through renewable sources in India is 85 GW with biomass power contributing approximately 20 GW. Especially, in the remote areas and hilly terrains of India, biomass gasification-based power generation offers a highly viable solution for meeting energy demands of small villages and hamlets, which would not only make them independent but will also reduce burden on state electricity boards. This paper reviews various technical options for biomass gasification-based low-, medium- and large-scale power generation. We essentially discuss the merits and demerits (operational and other problems) of different systems. Further, we also deal with economics of these systems and discuss principal factors influencing the viability of the biomass-based power generation. Finally, we review some case studies of biomass-based power generation for meeting energy needs, both thermal and electrical.

Key observations:
The paper begins by giving a broad outline of the electricity sector in India and the latest situation with regard to renewable energy. With regard to biomass, the major source is waste and by products of agriculture and the net potential of biomass for 2006-07 has been estimated at 500 Million tonnes. 15-20% of this potential could be available for power production without compromising on existing usage. The paper further notes the various options for power generation based on biomass and explains the various merits and drawback of each option along with the capital costs and their efficiencies. The authors then explain in great detail the technical aspects of the gasification process.

The following trends have been observed in the economic feasibility of biomass gasification-based power generation:
1. "Biomass gasification-based electricity generation using duel fuel engine is found competitive with diesel generators only for capacities higher than 20 kW. However, 100% producer gas engines are not economically attractive even for 40 kW capacities.
2. The plant load factor is a crucially important parameter. Biomass gasification with duel fuel engine is economically unfeasible for even 75% load in comparison to diesel generators.
3. If electricity distribution network already exits at the installation site, it reduces the LUCE by 20%, making biomass gasification even more attractive.
4. Splitting of gasifier capacities (in view of smaller day time loads and larger night time loads) helps in reduction of capital cost but not LUCE.
5. Capacity utilization factor is also a crucially important factor influencing the economy of power generation. Higher capacity utilization factor add to economy of biomass gasification."
The paper then goes on to discuss the viability of gasifiers with comparison to diesel generation and the feasibility of large scale gasifiers (500 kW to 5 MW).

The authors conclude by noting that demand for electricity in rural areas is growing at 7% and there

are persistent shortages. Similarly conventional generation based on coal is unable to meet the needs of remote villages, where distributed generation, especially based on biomass is a viable option for the following reasons.
It has uniform and abundant availability with the technology being proven and commercially available. Flexible operation and installation as it can be put up nearly anywhere and the operation is fairly simple, with local village and community members can easily be trained for these tasks. Job creation at the local level (not limited to O&M). Biomass plantations in wastelands are effective in preventing land degradation and are an added environment benefit on top of the expected CO_2 reductions achieved.

While there exist several successful installations and projects in few states, the paper recommends the following actions to improve effectiveness, namely large scale production of gasifiers to reduce costs, promotion of productive loads, NGOs acting as energy service providers and provision of soft loans for working capital. Central regulation of the tariff structure for off grid systems would also be important.

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Title: A techno-economic comparison of rural electrification based on solar home systems and PV micro grids		
Authors: Chaurey, A.[1] and Kandpal, T.C.[2]		
Authors' affiliation: [1] TERI and [2] IIT Delhi		
Name of publication: Energy Policy		
Volume: 38	**Year:**2010	**Pages:** 3118-3129
Publication/author link: tarak@ces.iitd.ernet.in		

Authors' Abstract: Solar home systems are typically used for providing basic electricity services to rural households that are not connected to electric grid. Off-grid PV power plants with their own distribution network (micro/ minigrids) are also being considered for rural electrification. A techno-economic comparison of the two options to facilitate a choice between them is presented in this study on the basis of annualised life cycle costs (ALCC) for same type of loads and load patterns for varying number of households and varying length and costs of distribution network. The results highlight that microgrid is generally a more economic option for a village having a flat geographic terrain and more than 500 densely located households using 3–4 low power appliances (e.g. 9W CFLs) for an average of 4 h daily. The study analyses the viability of the two options from the perspectives of the user, an energy service company and the society.

Key observations:

This paper provides a techno-economic comparison of SHS and a PV microgrid for supplying electricity to a village community for domestic applications. The authors suggest, for such comparison, the perspectives of three main stakeholders: the user/community, the Energy Service Company (ESCO) and the government/society have to be analysed. For this purpose, the authors present: a review of experiences from the literature on the design, dissemination and usage of micro grids and SHS's, a comparison of their design and operational aspects and techno-economic comparison of SHS's and micro grids from different perspectives of the user, as mentioned above (pp. 3118).

Based on the literature review, the authors conclude that there could be two categories of issues that might influence the choice of using SHS's or micro grids: one could be economics of delivered electricity services on a life cycle basis and the other could be operation and maintenance (O&M) and management aspects from user's, government's and private sector's perspective (pp. 3119).

The authors considered two different cases of load requirements:
i) a village of N households having 2 x 9 W CFL to use for 4 hrs daily (i.e. 18 W per household)
ii)a village with N households having a)4 x 9 W CFL or b) 2 x 9 W CFL + 1 x 18 W fan or c) 3 x 9 W CFL + 1 DC socket for radio/cassette recorder; all to be used for 4 hrs daily.

Authors concluded that a micro-grid may be a "financially attractive option over SHSs for user, ESCO and the society if the village has a large number of households, is densely populated and lies in geographically flat terrain". For their analysis, the authors use various combinations of the assumptions, such as: renting of SHS's from ESCO rather than owning it, using and paying for the electricity services from micro-grid owned and operated ESCO rather than villagers own it. A sensitivity analysis of the results with different values of incident solar radiation using HOMER was also performed. HOMER results have also thrown some light on the capacity shortage or unmet load in case of SHS and micro-grid. Key findings are quoted below:

1. "A village of households using two appliances (totalling 18 W) for 4 h each (Case A) would find it

economical to opt for 35 Wp SHS individually rather than going for the microgrid unless the number of households are 180 or more in number and are densely located so that they can be serviced with 1 km of PDN. This number would go to a minimum of 270 households if these are scattered such that 4 km of PDN is required to service them.

2. If the households use 4 appliances for 4 h each (Case B), then a village of 100 households serviceable with 1 km of PDN would find a microgrid more economical as compared to having a 70 Wp SHS each. Similarly, if the households are scattered requiring 4 km of PDN, then the critical number is 150 households.
3. The above results (Case B) are applicable to communities residing in different climatic zones receiving insolation in the range of4.1– 5.5kWh/m2/day, according to HOMER simulations
4. There is a finite capacity shortage (0.04 up to 0.1 of the total annual load) in case of microgrid as compared to SHS, which meets all the loads all the time. However, HOMER points at the possibility of having small capacity SHS to serve the same load with same allowable capacity shortage as that of the microgrid.
5. The ratio N threshold/L (number of service connections per km of PDN) at which microgrid becomes comparable to SHS, decreases as the size of the micro grid increases. Accordingly 320 is the threshold number of household per km of distribution line for Case A type of households and 223 for Case B type of households.
6. For an ESCO renting out 70 Wp SHS to 50 households in a village and requiring 25% enterprise margin, about 26% capital subsidy on the cost of SHS is required to be given to ESCO if the user is to be kept insulated from the incremental burden of the enterprise margin. This value would be 99% if ESCO services the same village through a microgrid. However, for a village with 300 households, practically no capital subsidy is required”.

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Title: Assessment and evaluation of PV based decentralised rural electrification-An overview		
Authors: Chaurey, A.[1] and Kandpal, T.C.[2]		
Authors' affiliation:1. TERI and 2. IIT Delhi		
Name of publication: Renewable and Sustainable Energy Reviews, Elsevier		
Volume: 14	**Year:** 2010	**Pages:** 2266-2278
Publication/author link: tarak@iitd.ac.ernet.in (T.C. Kandpal)		

Authors' Abstract:
The challenges of providing electricity to rural households are manifold. Ever increasing demand–supply gap, crumbling electricity transmission and distribution infrastructure, high cost of delivered electricity are a few of these. Use of renewable energy technologies for meeting basic energy needs of rural communities has been promoted by the Governments world over for many decades. Photovoltaic (PV) technology is one of the first among several renewable energy technologies that was adopted globally as well as in India for meeting basic electricity needs of rural areas that are not connected to the grid. This paper attempts at reviewing and analysing PV literature pertaining to decentralised rural electrification into two main categories—(1) experiences from rural electrification and technology demonstration programmes covering barriers and challenges in marketing and dissemination; institutional and financing approaches; and productive and economic applications, (2) techno-economic aspects including system design methodologies and approaches; performance evaluation and monitoring; techno-economic comparison of various systems; and environmental implications and life cycle analysis. The paper discusses the emerging trends in its concluding remarks.

Key words: Decentralised rural electrification, solar photovoltaic, tech-economic comparison, performance monitoring

The paper states that Photovoltaic (PV) technology is one of the first among the several renewable energy technologies adopted globally and while literature is abound with providing insights into technological, economical, commercial and social aspects of PV, it has not been able to bring in synthesis of "all facets of development and learning into a comprehensive assessment and evaluation of PV for decentralised applications" (pp2267).

The paper then reviews the PV literature pertaining to decentralised rural applications considering the following categories:

1) *Experiences from rural electrification and technology demonstration programmes:*

   a) Barriers and challenges in marketing and dissemination:

Through the literature review, the author finds that the" challenges associated with marketing and dissemination are related with sustainability and replicability of business models, development of regulatory mechanisms for energy subsidies and incentives and integration of rural electrification policy with the dissemination of SHS".(pp2267) .The review states that "the Zimbabwean experience illustrates that a sustainable energy development programme requires a multi-pronged intervention which is well co-ordinated with a clear view of specific engagements beyond the donor commitment period"(pp2268).Another paper on the Pacific region concludes that the maintenance of PV systems by the user is not always successful and also the fee collection should be done by third party rather than the community .It also calls for technical assistance being readily available when needed. In the Dominican island, the study has raised the "negative implications subsidizing PV market and has recommended an R&D strategy as compared to market push strategy for developing PV markets for rural electrification in developing countries"(pp2268). "Policy lessons from World Bank loan in India, Indonesia and Sri Lanka highlight that India faced a challenge of aversion to rural credit, lack of market infrastructure and lack of support to entrepreneur"(pp2268). The paper also highlights unavailability of skilled technicians required for promotion and installation of the systems in developing countries as a barrier, while the high costs of selling (marketing, delivery and maintenance) of SHS in developing countries has been highlighted. It says that finding a balance between market-pull and donor-push strategies is a challenge and that the user's role in adoption of decentralised PV systems be undermined even though there are ample studies showing the positive impacts of adequately designed and delivered user awareness and training programmes, their active participation in decision making process, and targeting specific socio-economic benefits of PV systems to them.

b) Institutional and financing approaches:

The review of a study says that while emphasising the role of solar energy service companies, highlights that decentralised PV market is likely to grow on the support of commercial finance from rural and other development banks rather than on the subsidy programme. The funding organisations (governments and international donors), non-governmental sector, microfinance institutions, local energy enterprises and communities have contributed towards innovations in institutional and financing mechanisms for dissemination of PV systems.

c) Productive and economic applications:

The review takes an example of Honduras wherein small PV systems are being sued for providing power for ICT, helping them with enhanced access to business and agriculture, education and health requirements .Use of TV and radio have helped business advertisers reach a wider audience in Kenya while access to electricity enables the use of electric equipment and tools by small and micro enterprises increasing their productivity per worker. The paper says that "while the electricity services provided by small decentralised PV systems at domestic and village level may be small in quantum, their impact on socio-economic-cultural development of rural communities cannot be ignored" (pp. 2270).It calls for local government and international donors to coordinate in the delivery of developmental programmes like health, education with that of PV based electrification, thus enhancing the impacts of both.

2) Techno-economic aspects of PV:

a) System design methodologies and approaches:

"A review of different methods for sizing photovoltaic systems indicates they fall into mainly two categories: analytical methods and simulation-based schemes" (pp2270). In one paper a generalised methodology based on a time series simulation approach for generating a 'sizing curve' relating the generator rating and storage capacity is presented."Another approach of trade-off between loss-of load or capacity storage and LUCE for SHS has been presented for different locations in India using HOMER. The importance of using energy efficient appliances in system design has been explained taking the example of CFL and LED's in solar lanterns to provide clean lighting services to developing countries"(pp2271).The review states that standardised and integrated system design approaches are effective for implementing rural electrification projects.

b) Performance evaluation and monitoring:

SHS dissemination can be enhanced through projects where the people have choice in system configurations as compared to projects that support only single configuration of SHS .The study states that not enough information is available on the performance of SHS projects. "Local availability of spare batteries at the rural community level and their proper disposal were identified as critical issues for sustainability of large PV rural electrification projects" (pp2272).The paper suggests that selection of components that are reliable and easily replaceable could have a positive impact on system performance and user satisfaction.

a) Techno-economic comparison of various systems:

"PV systems are compared on the life cycle cost basis with many other types of decentralised as well as centralized systems for rural electrification to understand their economic competitiveness"(pp2272). The papers suggest that such studies maybe helpful in selecting the optimum technological solution for rural electricity supply in any given situation.

b) Environmental implications and life cycle analysis:

The paper contends that along with provision of basic electricity services, PV systems facilitate sustainable development by contributing to climate protection. The CO_2 emissions mitigation potential of SHS under CDM had been studied in India. Literature also presents several studies on energy payback time and life cycle analysis of PV technologies. With continuous advancements in the use of materials and production processes and techniques, the environmental implications of life cycle of PV systems are likely to improve.

The paper concludes by highlighting the emerging trends in the RE sector and notes that advancements in LED technology would bring down costs in terms of Rs per Watt and give more lumen output per Watt. This would lead to reducing size of storage battery and that of PV module helping in overall cost reduction. Another emerging trend is in form of distributed generation based smart grids (mini grids as their subsets) which may or may not be connected to the grid.

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Title: Rural electrification and development
Authors: Cook, Paul
Year: June 2010
Name of publication: OASYS – South Asia Project
Publication/author link http://www.oasyssouthasia.info/docs/oasyssouthasia-wp4-oct2010.pdf

Key words: rural electrification ,productive uses,cross-subsidies,Structural Adjustment Programmes, World Bank, employment

Key observations:
This paper looks into the linkage between rural electrification and productive uses of energy for development along with its relation to rural infrastructure."Rural electrification schemes and programmes have so far not been able to provide universal access and have been unaffordable to most poor people" (pp.22). It points out how services focused entirely on cost recovery rather than provision of basic access .It says that rural electrification programmes need to be implemented keeping in mind the productive uses that electricity can bring about, like improvement of rural infrastructure, job creation, entrepreneurship development ,improvement in health and education. The paper calls for innovative discount or subsidy schemes for connection and improved tariffs compatible with poor people's incomes and resources but also cautions that cross-subsidies to low income households may burden the rich leading to alteration in their consumption of electricity. It could lead to a decrease in demand of resources available for the middle and rich households if the rich households are sensitive to price and switch to alternative fuel sources.

Rural electrification programmes carry importance now due to its relevance in addressing poverty and Millennium Development Goals (MDG's). Some of the blame for poor performance of low income economies has been linked to adverse effects on infrastructure investment resulting from economic liberalisation and Structural Adjustment Programmes in the 1980's that called for smaller government and reduced public expenditure. It calls for an autonomous and effective implementation agency to ensure plans for rural electrification are delivered. It throws light on the World Bank criteria in supporting electrification projects i.e. – "cost effectiveness to connect, distance to a grid, affordability and population density" (pp.10).

The paper while focusing on the WB involvement in rural electrification, observes that even though it's investments in rural electrification was worthwhile in 1970's, it felt this would be loss making and more focus should be laid on health and water services, but in the 1990's,the approach of WB turned towards promotion of utilities in private sector ,which was a reversal in the earlier policy of WB wherein it had argued that "privatisation of utility sectors are difficult for poor countries due to lack of willing buyers and investors" (pp.9). Post 1995 the strategy shifted to poverty focus and led to significant implication for rural electrification programmes wherein link between energy and poverty were clearly laid down. The paper observes that private sector has not help develop rural electrification even though policies and infrastructures were made available for private players to come in to this sector ,but this deficit has led to growth of local entrepreneurs and small scale private providers who are now playing an increasingly important role in these areas.

The paper notes that motive power can bring in positive potential impacts in developing countries with use of proper training imparted .Sensitisation, awareness generation play an important role in establishing the link between electricity consumption and its productive uses. Along with primary roles of proving electricity ,"complementary services like extending it to cover business development services, consumer and micro-finance services ,telecommunication, transport"(pp.15) should be taken into consideration while implementing projects.

The paper points to the impact indicators that evaluate the success of rural electrification projects namely- “employment, educational achievement, changes in income and consumption patterns, safety, air pollution and benefits affecting gender differences”(pp.14). While listing the impacts of rural electrification, the paper notes that electrification enables livelihoods by stimulating employment and increase income generating activities, is helpful in reducing the drudgery of women.

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Title: Empowering Rural India: Expanding Electricity Access by Mobilizing Local Resources
Authors: The World Bank
Authors affiliation: The World Bank
Year:2010
Publication/author link: http://siteresources.worldbank.org/INDIAEXTN/Resources/empowering-rural-india-expanding-electricity-access-by-mobilizing-local-resources.pdf

Key observations:

Existing energy policies have very limited focus on the issue of access to electricity. In this paper new ways to promote investment in rural generation and distribution is explored, with the objective to develop business models to augment power supply through distributed generation and to improve rural electricity supply in the villages in grid connected mode.

There exists different ways to enhance supply in the rural areas, some of which are evaluated. Maintaining status quo will result in a very slow pace to solve the problem of energy access. There is also the issue that due to erratic power and availability at the tail end of the grid, franchises are not interested. Going the FiT route could improve access if electricity is not diverted to the urban centres. However FIT's add to the financial deficit of the utility with no obligation to improve rural supply. Rural Distributed Franchisees reduce losses and improves service while increasing efficiency in rural markets however it does not improve supply and due to lack of demand –responsive supply deters the entry of serious franchisees.

However the 'Distributed Generation and Supply' improves supply and services and reduces market losses and increases efficiency. However to succeed new financing and business models, as well as regulatory-policy interventions and FiT subsidies will have to be designed. The authors point out to the following issues that need to be looked at for the DG&S system to be successful, namely unattractiveness to investors, Detailed assessment of existing networks and systems for bidding, Project viability and need for scaled up demonstration/models.

The economic analysis for various electricity options is considered. Conventional electricity from coal power plant has a generation cost of ~ Rs 3.08/kWh and considering an AT&C loss of 15% and a transmission cost of Rs 0.20/kWh, the final cost of delivered energy Rs 4.02/kWh. Against this kerosene (back up lamp) and diesel generation cost is estimated at Rs 10.63/kWh and Rs 18/kWh respectively.

Similarly various distributed generation options based on renewables have been estimated for their levelized economic cost of delivery. These are: SHP – 4.61/kWh, Biomass – 5.73, Wind – 6.08, solar thermal – 14.32, solar PV – 20.20, Diesel – 21.38. It is important to note that there exists a lot of RE options cheaper than conventional supply.

State specific financial analysis in Haryana and Maharashtra.

In Haryana, while the FiT for Biomass generation is Rs 4.7/kWh, considering the T&D losses, distribution costs, franchisee fees, collection efficiency etc, there would remain a viability gap of Rs 3.66/kWh since the cost of supply would be Rs 6.76/kWh and the existing consumer tariffs would amount to only Rs 3.46/kWh. This gap can be reduced by bringing down T&D losses and lowering distribution costs.

For SHP plants, the average cost of supply is Rs 5.68/kWh resulting in a viability gap of Rs 2.52/kWh. Since T&D losses are high, sharing loss reduction with beneficiaries can be an option to increase efficiency.

One part of the viability gap for the operator can be met from the savings from the Utility since it would no longer be supplying this franchisee area. This is estimated to be Rs 1.27/kWh (Difference between the effective cost of supply of Rs 4.72/kWh and a realization of Rs 3.46/kWh). One option for meeting the remaining viability gap would be going in for differential tariffs for business or based on TOD for extended supply etc). Another could be availing revenue from CDM benefits.

Similarly in Maharashtra, effective tariff from biomass considering all the T&D losses, distribution costs, franchisee fees and collection efficiency is Rs 7.97/kWh while the average revenue consumer tariffs is Rs 4/kWh, leaving a viability gap of Rs 3.97/kWh. Improving T&D and distribution could bring down gap to 1.94/kWh. The lower tariff for SHP at Rs 5.04/kWh results in a gap of Rs 1.31/kWh.
In Maharashtra, the utility would save roughly Rs 1.37/kWh (Difference between the effective cost of supply of Rs 5.20/kWh and a realization of Rs 3.83/kWh) from not supplying in the franchisee area which if reimbursed to the franchisee would be make SHP viable.

The report then documents the lesson from national and international experiences. It notes that grid connected distributed generation has some advantage over off grid projects, since the large gird acts like a battery can improve the reliability and quality of power and purchase all surplus power. Predictable load factors increase profitability and reliability as maintaining a high load factor is economically important. Also small distributed generation can add significantly to the existing electricity generation. Additionally community buy-in, a strong local governance framework and local stakeholder capacity development is important for the success of the project. On the institutional front, franchisee involvement leads to more efficiency in collection and T&D loss reduction and the PPP model is important for success. Viability gap provided as an output based incentive can help reduce the supply gap in rural areas. Finally on the economic front, financial subsidy is needed at least in the initial years.

Details of the DG&S model:
In essence, "the DG&S operator will generate power and also act as a franchisee for the DISCOM and supply power to the defined area under its franchise. It will use the distribution network of the DISCOM to source electricity from its generation plant and to sell power to retail consumers. If electricity demand is more in the area, the franchisee can source power both from the DISCOM and DG&S company. If demand is less, additional generation can be supplied to the DISCOM and exported."
The report further details out various processes like selection of the operator (suggested through competitive bidding route), aggregate net metering, bulk supply tariff and the responsibilities of the utility and the operator. For effective checks and balances, "stringent service contracts must be set up to ensure not only adequate supply but also service quality and customer satisfaction metrics to monitor the DG&S operator". The paper also outlines the various risks with the DG&S model.

Bridging the viability gap is an important aspect for the success of this model. There are various ways in which this could be done, namely performance based incentives from the utility or Govts, but administered by the utility, providing lifeline tariffs for poor consumers, TOD tariffs for extended supply etc. Various enabling policy measures in the form of guaranteed grid evacuation, extending DDG policies to DG&S programs under the RGGVY DDG, enabling guidelines for differential tariffs and operating subsidies have been proposed to strengthen this model.

# 30		
Title: Rural electrification systems based on renewable energy: The social dimensions of an innovative technology		
Authors: García, Victoria Gómez and Bartolomé, Mercedes Montero		
Authors' affiliation: Universidad Carlos III de Madrid, Getafe, Madrid, Spain		
Name of publication: Technology in Society		
Volume: 32	**Year:** 2010	**Pages:** 303-311
Publication/author link: mgomez@polsoc.uc3m.es (V. Gómez)		

Authors' Abstract :
Many areas in rural non-Western regions are installing electrification systems based on renewable energy. Although these projects are usually welcome, they sometimes fail. Explanations for failures often cite technical reasons. In this research, partly based on the results of the SOPRA_RE project, we focus on the users, studying the relationships between technology and society. By analysing potential sources of failures, we identify the root of the problem as how a new technology is received by the local society. In this paper we introduce dimensions that we consider to be especially important in the process of technology integration. We defend the importance of combining the technical outlook with the sociological one, based on the idea that the latter is often indispensable as a complementary element of technical explanations of system failures, which in turn provides a better basis for solving them. We use specific examples to bolster our insistence on the need to achieve convergence between the technical and the sociological outlooks.

Key observations:
While evaluating the failures of electrification system based on renewable energy system, there has been an emphasis on the technical outlook with the important socio-cultural variables not being closely looked at. Within the technical outlook the following issues are highlighted

- Misuse of material – poor understanding of instructions, repeated failures, poor location, etc…
- Simple vs sophisticated – While decentralised RE are generally termed simple technologies they inherently have very sophisticated features, in comparison to the users in developing countries. There are also complicated issues with supply chain management of these technologies.
- Assumption of neutrality – Every technology is neutral until it falls into the hands of the users who then define its bagginess. Therefore there is a need to look into the social context of the users as well as indigenization leading to continuous assimilation and integration of the technology to ensure project sustainability.

A different way, the sociological radical approach states that

- Modern science and technology requires absorption of the mental process that go with them.
- Cultural beliefs can undergo a gradual transformation towards technological innovation.
- A reason for slow or non-diffusion of technology could be policy makers fears of the potentially disruptive impacts of technological change on social stability.
- Recipient cultures selectively borrow objects from other cultures and then adapt transform and assimilate them while attempting to guarantee the survival of their societies fundamental values.

The social construction of technology approach states that, “the importance of technology on human life may be appreciated only if it is situated within a context of social, cultural, economic and political relations”. It sometimes leads to clash between routine and new habits die to technology introduction and uncertainty amongst the users of new technology. There is also the problem of the lack of attention to unforeseen consequences of technical differences; specifically the consequences are difficult to measure including the negative costs of technology diffusion.
The trans disciplinary approach states that the appropriation of technology can only be done via

people. It is their motivation, understanding, interest, commitment, and organization that make possible a successful development. An analysis of social attitudes will generate explanatory clues that lead to the socio-technical solution of the problems leading to programmatic success.

Finally the paper sheds light on important aspects detailed below through an example of PV electrification in a non-western rural environment:

- Development of training and sensitizing material for team members on charge of launching the program.
- Assessment of the need for electric power to ensure that the needs of all the users: male, female and children are fulfilled.
- Selection of technical options must be done with community and user inputs.
- Performance must be continuously evaluated.
- Economic costs and payment structures of the households can drastically change with new technology adoption, therefore mitigating these are important.
- Participation of community leaders though leaders, first movers increases effectiveness therefore one needs to pay attention to individuals.
- Projects that work well are based on strong but fluid and adaptive channels of communication
- Often gender is neglected during project design and implementation, but gender plays a very important role in ensuring project success.

In conclusion, the authors state that, “Electrification projects based on a sustainable technology can introduce substantial changes in rural communities. The success of such projects is threatened by a lack of understanding of the life and habits of the community members, and some projects fail. Failures are sometimes blamed on poor use of what is considered an adequate technology. But in most cases, such explanations are unsatisfactory as they ignore the complex relationships established between the technology and its new users. But when these factors are taken into consideration, it is easier to understand why a system is not accepted. Exploring social habits, cultural attitudes, and the networks of social relationships and behaviours clears the path for a more precise explanation of the problems involved. This, in turn, translates into a socio-technical solution that is more likely to result in the success of the programmes”.

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Title: Life cycle assessment of village electrification based on straight jatropha oil in Chhattisgarh, India		
Authors: Gmünder, S.M., Zah, R., Bhatacharjee, S., Classen, M., Mukherjee, P. and Widmer, R.		
Name of publication: Biomass and Bioenergy		
Volume: 34	**Year:** 2010	**Pages:** 347-355
Publication/author link: simon.gmuender@empa.ch (S.M. Gmünder)		

Authors' Abstract: A decentralised power generation plant fuelled by straight jatropha oil was implemented in 2006 in Ranidhera, Chhattisgarh, India. The goal of this study was to assess the environmental sustainability of that electrification project in order to provide a scientific basis for policy decisions on electrifying remote villages.

A full Life Cycle Assessment (LCA) was conducted on jatropha-based rural electrification and then compared with other electrification approaches such as photovoltaic (PV), grid connection and a diesel-fuelled power generator. In summary, the jatropha-based electrification in Ranidhera reduces greenhouse gas emissions over the full life cycle by a factor of 7 compared to a diesel generator or grid connection. The environmental performance is only slightly improved, mainly due to the high air pollution from pre-heating the jatropha seeds. With additional measures oil extraction and overall efficiency could be further improved. However, environmental benefits can only be achieved if jatropha is cultivated on marginal land and land use competition can be excluded. Under these conditions, jatropha-based electricity generation might be a useful alternative to other renewable electrification options, as the technology is very sturdy and can be maintained even in remote and highly under-developed regions.

Key observations:
The paper presents a study which assesses the environmental sustainability of the DRE plant (7.35 kW) fuelled by straight jatropha oil in Ranidhera, Chhattisgarh, India. In its introduction, the authors mentioned the importance of decentralised renewable energy generation in electrifying remote villages in India, and added further that there are only a few studies which focus on the *Jatropha curcas* straight vegetable oil (SVO) based decentralised power generation. According to the authors, the literature that assesses the environmental impacts of jatropha value chains is even rare. Most of the studies have focuses on jatropha-based transport fuels and showed that their carbon-footprints are lower than the fossil fuels. The authors have stressed the need of having reliable information on environmental and socio-economic impacts of jatropha-based rural electrification. For this purpose and to provide a scientific insight for forming policy decisions, this study was conducted on the pilot power plant in Ranidhera.

Methodology:
For the current analysis on jatropha-based decentralised power generation, the authors compared it with other approaches, such as use of fossil diesel, a central PV system and a connection to the grid of the Chhattisgarh State. For the comparison of these options, the average village size of 100 households with a peak load of 1.9 kW with 4h of daily supply (during night) was assumed. The authors explained that using currently installed genset (7.5 kVA rate power) on load of 2 kW was not efficient; hence the optimized and downsized diesel and jatropha systems were also considered for the analysis. In the paper, a single line diagram has been provided to explain the four electricity supply systems compared.

1. Diesel-based genset analysis: for the life-cycle analysis purpose, the main processes linked to the crude-oil extraction to make diesel were considered, and the data on diesel transportation from

the refinery to the project site was uses

2. Jatropha-based power generation: in this, various steps, from cultivation of jatropha saplings to extracting oil from its dried seeds were considered. The aggregated environmental impact and the global warming potential (GWP) of jatropha-based system were compared to alternate systems.
3. For solar PV-based power generation, the life cycle analyses of PV modules, lead acid batteries and inverter were done
4. While considering the extension of the Chhattisgarh state power grid to Ranidhera, power generation from typical coal-fired and hydro-based powered plants were considered, and transmission and distribution networks along with their losses were considered

Key results:

The authors estimated that regarding jatropha-based power generation, the main impact (79.3 %) on GHG emissions come from the process chain of jatropha seeds while the remaining (20.7 %) comes from the cultivation of jatropha seeds itself. The environmental impact caused while processing jatropha seeds mainly results from inefficient combustion of the wood logs used in the steam kettle that releases particulate matter in the atmosphere.

It was concluded that for the study, "the jatropha based electrification reduces GHG over the full life-cycle by a factor of 7 compared to a diesel generator or grid connection. Nevertheless, environmental performance was only slightly improved, mainly due to the high air pollution from pre-heating the jatropha seeds". Some of the side-effects, such as increased acidification and eutrophication, originate from fertiliser application to the soil, insecticide application on the jatropha saplings, etc. The environmental benefits can only be achieved if jatropha is cultivated on marginal land and the land use competition is avoided. Thus, land suitability has to be assessed carefully before implementing Jatropha-based electricity systems.

The authors also suggested few solutions to reduce the overall environmental impact of the jatropha system, which include using expelling process without steam kettle and running the engines at full capacity, by decreasing its size or increasing the load. They also suggested optimising the jatropha cultivation procedure using best cultivation practice.

The limitations of the present study, as the authors have cited are: the lack of studies focusing on the long-term impacts of cultivating jatropha, the lack of data on the specific impacts of toxic substances and the lack of environmental impact models available for India.

32		
Title: Integrated renewable energy systems for off grid rural electrification of remote area		
Authors: Kanase-Patil, A.B., Saini, R.P. and Sharma,M.P.		
Authors' affiliation: AHEC, IIT Roorkee		
Name of publication: Renewable Energy		
Volume: 35	**Year:** 2010	**Pages:** 1342-1349
Publication/author link: amarbkanase@yahoo.co.in (A.B. Kanase-Pati)		

Authors' Abstract :
The off grid electrification by utilizing Integrated Renewable Energy System (IRES) is proposed to satisfy the electrical and cooking needs of the seven-uneletrified villages in the Almora district of Uttarakhand state, India. Four different scenarios are considered during modeling and optimisation of IRES to ensure reliability parameters such as energy index ratio (EIR) and expected energy not supplied (EENS). The optimum system reliability, total system cost and cost of energy (COE) have also been worked out by introducing the customer interruption cost (CIC). The four different renewable energy scenarios have been compared for the considered study area using the LINGO software version 10. The fourth renewable energy scenario accounting 44.99% micro hydropower (MHP), 30.07% biomass, 5.19% biogas and 4.16% solar energy along with the additional resources of wind (1.27%) and energy plantation (12.33%) has been found to be the best among the different options considered. Furthermore, the optimal reliability for the fourth IRES system has been found to be 0.95 EIR at the optimized cost of Rs 19.44 lacs with estimated COE of Rs 3.36 per kWh. The COE obtained using LINGO software and HOMER software has also been compared and briefly discussed for all the four scenarios. In order to verify feasibility and cost of system for different biomass fuel prices, a sensitivity analysis has also been carried out and it has been found that the fourth scenario is more sustainable than the other considered options

Key observations:
The paper begins by highlighting the existing literature on various techno-economic and modelling studies for decentralised renewables.

The study is limited to a cluster of 7 villages in Almora district, comprising of 267 households with a total population 1437. Agriculture is the only source of income and grid extension is rendered uneconomical. The resource assessment conducted through an extensive survey revealed the following available renewable energy options, namely micro hydro- 293040 kWh/yr; Biomass 198556 kWh/yr; Solar – 1837kWh/m2/yr; Wind 1270 kWh /m2/yr and Biogas – 224007 m2/yr, while the electricity demand is estimated at 5,61,276 kWh/yr.

Using linear programming the model tries to optimize and minimize the total cost of energy for a combination of different RE sources, keeping in mind the total reliability (represented by energy index ratio (EIR) = expected energy not supplied (EENS) / Total energy Demand (E0)) and the ability of the system to meet total demand.
The results of the various scenarios modelled are as follows.
1. MHP – biomass-biogas-SPV; Cost -19.91 lakhs; EIR-0.82 and price Rs 4.81/kWh
2. MHP-biomass-biogas-wind-SPV; Cost 19.78 lakhs, EIR-0.83 and price Rs 4.65/kWh
3. MHP-biomass-biogas-energy plantation-SPV, Cost 19.56 lakhs 0.95 EIR, price Rs 3.43/kWh
4. MHP biomass-biogas-energy plantation-wind-SPV; Cost 19.44 lakhs, EIR-0.95, price Rs3.43/kWh

Therefore scenario four is the best option for electrifying this cluster. A sensitivity analysis of the biomass prices showed that "the combined system can be more suitable to the study area, even if the biomass fuel price fluctuates with external circumstances"

33
Title: Energy poverty in rural and urban India:*Are the Energy Poor Also Income Poor?*
Authors: Khandker, S., Barnes, D. and Samad, H.A.
Authors affiliation: The World Bank Development Research Group, Agriculture and Rural Development Team
Year: November 2010
Name of publication: World bank Policy Research Working Paper (WPS5463)
Publication/author link: http://www-wds.worldbank.org/external/default/main?pagePK=64193027&piPK=64187937&theSitePK=523679&menuPK=64187510&searchMenuPK=64187511&entityID=000158349_20101101152446&cid=3001_7

Authors' Abstract: Energy poverty is a frequently used term among energy specialists, but unfortunately the concept is rather loosely defined. Several existing approaches measure energy poverty by defining an energy poverty line as the minimum quantity of physical energy needed to perform such basic tasks as cooking and lighting. This paper proposes an alternative measure that is based on energy demand. The energy poverty line is defined as the threshold point at which energy consumption begins to rise with increases in household income. This approach was applied to cross-sectional data from a comprehensive 2005 household survey representative of both urban and rural India. The findings suggest that in rural areas some 57 percent of households are energy poor, versus 22 percent that are income poor. For urban areas the energy poverty rate is 28 percent compared with 20 percent that are income poor. Policies to reduce energy poverty would include support for rural electrification, the promotion of more modern cooking fuels, and encouraging greater adoption of improved biomass stoves. A combination of these programs would play a significant role in reducing energy poverty in rural India.

Key words:energy poverty, income poor,

Key observations:
This report proposes an alternate measure to define the term "energy poverty". The authors seek to answer the question as to whether the lack of energy, especially modern energy, is a cause of poverty. The objectives stated by the authors are: i) to establish a level of energy consumption at which people can be perceived as "energy poor" and ii) to investigate the relationship between income and energy poverty to determine whether reducing income poverty can help reduce energy poverty. The report points outthat the minimum requirement of energy services may not necessarily coincide with the energy services consumed by "income poor".

This report provides a literature review for the term "energy poverty". In particular, the authors discuss the methods used to define energy poverty throughout the literature. One approach quantifies a household's direct energy needs based on his cooking and lighting. But the surveys conducted for this purposes show different levels of consumption patterns among households. The second approach defines energy poverty as the level of energy used by households below the known income poverty line. However, such approach results in different energy poverty lines per different geographical locations. The third approach focuses on energy expenditures of households as a proportion of the total income. It is considered that poor households spend as much as 10 % of their income on meeting energy needs. However, the authors think that this figure is rather arbitrary. This paper uses "a demand-based approach" to define energy poverty line as the threshold point at which energy consumption begins to rise with increases in income. The term "energy poverty line" is further explained by the authors as the threshold point at or below which households consume a minimum level of energy and should be considered as “energy poor”. This means that even if the incomes of the poorest people who are well below of the “energy poverty line” increase, their use of energy does not because “they are at the bare minimum amount necessary to sustain daily life”. The authors recognise that this type of approach of defining energy poverty is data-intensive and need an extensive analysis of household surveys that provide information on energy consumptions. Nevertheless, the authors feel that this type of approach is based on “how people actually consume energy, based on local resource conditions, energy prices, and policies.”

One could expect that energy poverty would be commensurate with income poverty; however authors suggest that this trend is for urban population and not the case for rural areas. This according to the authors is due to the fact that despite government programmes to help bring better energy services to people in rural areas, a significant gap in services still persists. The challenges in implementing government schemes are: i. how to improve the access of rural households to electricity beyond the current rate and ii. How to ensure reliable and adequate electricity supply.

Besides providing electricity, improving biomass use and its efficiency is essential for reducing energy poverty. Improving access to modern fuels such as LPG for cooking and other purposes can help reduce energy poverty. However, mostly urban households take advantage of highly subsidised LPG schemes in India and not the rural households.

In the end, based on the sample data, the authors justify their approach by providing numbers of “energy poor” and “income poor” people in rural and urban areas of India. Their analysis shows that especially in rural areas, there is a big discrepancy in the number of energy poor households (57%) and income poor households (22%).

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Title: Shifting of Goal Posts *Rural Electrification in India: A Progress Report*
Authors: Krishnaswamy, Srinivas
Authors affiliation: Vasudha Foundation
Year: March 2010
Publication/author link: http://www.christianaid.org.uk/images/shifting-goal-posts.pdf

Key words:rural electrification, DRE, subsidies, policies

Key observations:
This report is a very comprehensive document which provides the "Progress Report" of the rural electrification activity in India. In the beginning of this report, the author provides an overview of India's energy sector, where he explains the institutional framework, energy sector reforms, the installed capacity (as on 31st July 2009) as per type of fuel, the electricity supply and demand, and electricity transmission and distribution (T&D) situation in the country. The few key facts emerged from the author's analysis on India's energy sector are:

1. The electricity sector has not kept pace with the rapid growth of India's economy
2. The Government links the energy growth to GDP. In principle, they should be decoupled. Energy projections should factor in efficiency, energy conservation and demand side management (DSM) measures
3. India's power deficit is close to 86000 Million kWh with daily peak hour shortages of 13000 Million kWh
4. High T&D losses (up to 33% compared to 4-8% international standards) result due to poor governance in the sector
5. There is a big gap in the urban and rural electricity and energy infrastructure with centralised grid being the main source of electricity supply to both areas

This report makes a strong case for decentralised renewable energy systems by analysing the lack of progress in rural electrification in India since its independence. To justify his arguments in favour of decentralised solutions, the author tries to dispel some of the myths associated with decentralised renewable energy(DRE) solutions. As the name of the report indicates, the author critiques the government's policies in setting up targets for rural and rural household electrifications and frequently shifting them; with almost all of the targets has been significantly underachieved so far. For his analysis, the author has presented the history of government's various rural electrification schemes since India's independence, the cost of generation analysis for various DRE technologies and case studies of the successful as well as failed DRE projects in this report.

The report points out that only 7 out of 27 states have 100% village electrification (as per current village electrification definition) and only 3 states in the country have less than 25% households with no electricity access. The government definition of "rural electrification" or "electrified villages" is ambiguous and perhaps the reason behind the large number of population without access to electricity even though their villages/hamlets have been deemed "electrified" in government records. Despite phenomenal increase in the rural electrification budget, the results are underachieved. Government's rural electrification mainly targets primary lighting needs while other energy needs such as irrigation, sanitation, cooking, etc. are ignored. Even for lighting purposes, the rural electricity is irregular and inadequate. The two ministries, Ministry of New and Renewable Energy (MNRE) and Ministry of Power (MoP) involved in rural electrification appear to work in parallel and not in coordination. From the analysis, the author concludes that the energy and electricity have been exclusively to the urban population, particularly the rich. Besides, the fuel subsidies that meant for the benefits of the poor have also been diverted to the rich (subsidised LPG and kerosene being examples)

The report also provides a comparison of grid electricity and DRE based electricity on the basis of issues such as equity, reliability, economics, availability of technology and know-how, energy security, and further demonstrates how DRE is the appropriate option to supply electricity to poor households in India. It also cautions that although DRE is a suitable means of providing access to electricity in rural areas, there should be political will to promote such projects. Besides, renewable energy resources mapping has not been done comprehensively in India, which can hamper the growth of this sector. The past experiences have shown that a number of DRE projects have failed in rural areas, mainly because of poor planning and implementation. To justify his arguments on various issues on DRE based rural electrification, the author has provided case studies of few successful and failed projects in India.

As a way forward, the author provides his recommendations on the path that government needs to pursue. The very first step, according to the author is "Government should put in policies that will incentivize decentralised systems, followed by ensuring that the remaining 100,000 villages which are yet to be electrified are energized through renewable energy based decentralised distributed generation systems." The author recommends for a paradigm shift in government from a centralised grid production model to decentralised production model. The report also insists that the government should encourage models of decentralised projects in un-electrified villages which involve community and also encourage "a sense of entrepreneurship amongst communities to take up such projects with financial assistance from the central government under their many schemes for rural electrification." The financial sector needs to be well reformed so that their financial assistance appropriately reaches the communities in need. The electricity tariff structure should also be suitably modified according to the "polluter pays" principle, with incentives on tariffs be given to those who consume less and choose renewable energy sources. More importantly, the author suggests that all the government agencies in the power and energy sector should work in close coordination to "ensure efficient and smooth implementation plans and programmes to bolster India's electricity and energy sector".

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Title: Analysis of isolated power systems for village electrification		
Authors: Kumar,M.V.M. and Banerjee, Rangan		
Authors' affiliation: IIT Bombay		
Name of publication: Energy for Sustainable Development		
Volume: 14	**Year:** 2010	**Pages:** 213-222
Publication/author link: rangan@iitb.ac.in (R. Banerjee)		

Authors' Abstract: A large part of the world's population, particularly in India and Africa, lives in villages that often lie beyond the reach of grid power supply. Isolated power systems, which generate power at site, are considered as a viable option for the electrification of these areas. This paper discusses Indian experiences of isolated power systems. In India, there are many villages which have been electrified through renewable isolated power plants like biomass gasifier and solar photovoltaic (PV) systems. Case studies have been conducted for three such isolated power plants in the state of Maharashtra, India. It is observed from these case studies that the existing power plants are oversized and have a potential for reduction in distribution losses. This paper proposes an integrated design method for isolated power system, which combines load modeling, sizing and optimum distribution network. The levelised unit cost of energy can be reduced by 25–50% for the case studies by adopting the integrated design methodology. Generic guidelines are evolved for systems design from the case studies of sample isolated power systems.

Key observations:

The paper presents performance studies on three DRE projects in Maharashtra: 1) Solar PV power plant at Rajmachi 2) 10 kWe biomass gasifier plant at Dissoli and 3) 20 kWe biomass gasifier plant at Lonarwadi village. In the introduction section of this paper, the authors have provided a brief literature review on renewable energy based isolated systems in India. Based on the data obtained from some of these studies on solar PV isolated systems in India, the authors have pointed out that plant capacity factors derived from the data are low when compared with an optimum value of 15-18%. The authors conclude that these low plant capacity factors are due to the existing design methods which have resulted into oversized systems. In this paper, the authors analyse the performance of the selected isolated power systems, as mentioned above. For this purpose, the paper proposes a method which integrates load modeling, system sizing, generator location and loss estimation to get the efficient and cost effective design of isolated power systems. This involves estimation of the load on the system, sizing of the system components, analysing distribution network and estimating the currents and voltages and identifying the optimal source location.

In the case studies reported in the paper, the following issues have been identified:

i. Case study of the solar PV plant at Rajmachi:

In the 5 kWp isolated solar PV plant at Rajmachi village in Maharashtra, the authors found that the existing battery capacity was high, and the depth of discharge of the battery was only up to 15%; thus the output from the PV was not able to charge the battery properly. Thus a significant amount of the PV output was unutilized.

ii. Biomass gasifier plant at Dissoli, Maharashtra

In this 20 kW gasifier plant, the authors found out the use of 61 incandescent bulbs of 100 W rating. Due to which, the existing flour mill of 5 hp rating did not get sufficient power from the gasifier output. The authors propose here to replace the incandescent bulbs by CFL bulbs, and to use the saved energy to power the flour mill. The authors opine that using the mill will significantly improve the plant capacity factor of the plant. Besides, due to uneven connection of single phase customers to the distribution system, the high voltage and current unbalances in the system have been found.

iii. Gasifier plant at Lonarwadi, Maharashtra

In this plant, the authors discovered significant voltage and current unbalances (2.5% and 42%, respectively) in the output, and due to the voltage unbalance, the operations of the three-phase induction motors were affected. Besides, there was a significant loss in the distribution network was also seen.

Methodology for designing optimum isolated power systems

Based on the data from the case-studies, the authors used their integrated design procedure to provide guidelines for the optimal designs of the plants under investigation. This procedure involves estimation of the loads on the system, and then sizing of the system components was determined. Based on this data, the analysis of the distribution network using Village Power Optimisation model for Rural renewables (ViPOR) was done and finally, the optimal source locations was determined. The paper illustrates the results of this model by considering the case of the Dissoli gasifier system, which shows by just placing the source near optimal location (as shown by the model) can reduce the distribution loss from ~12 % to 3%.

The authors have demonstrated that the plants studies are oversized with poor capacity factors. The authors explain that by current sizing and reducing the distribution losses in the system, a reduction in energy cost of about 25-50% is possible. They also suggest documenting the actual field performances of isolated power systems and improving the methods for sizing and planning the distribution network. The power quality of the existing plants is also an issue, given the large unbalance and high THD in voltage and current, which leads to excess heating of motor and conductors in the network. Further the demand can be reduced by using energy efficient lighting systems.

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Title: Clusters, poverty and rural off grid electrification
Authors: Nadvi, Khalid
Author's affiliation: School of Environment and Development (SED)University of Manchester, UK
Year: 2010
Name of publication: OASYS – South Asia Project
Publication/author link http://www.oasyssouthasia.info/docs/oasyssouthasia-wp5-oct2010.pdf

Key words: clusters, poverty reduction, poverty nodes

Key observations:
This paper talks about linkages of clusters with poverty reduction, employment generation and rural electrification. The author spells out the definition of clusters as: "geographically specific agglomeration of firms and ancillary units engaged in similar activitiesand located in close proximity to each other" (pp.4). As access to electrical power is a critical constraint in many parts of the developing world, the paper says that off-grid electricity presents a feasible option here. The paper while establishing the linkages between clusters and rural poverty argues that electricity generation can have significant impact in improving employment, raising incomes and "these effects can be amplified where the focus is on agglomerations of small producers" (pp.27).

The paper has set out to show what the cluster concept implies, how prevalent it is, and the potential economic gains and social underpinnings of small firm clusters. The paper has then gone on to discuss how the concept can be of relevance to a poverty context, identifying how cluster features, cluster processes and cluster dynamics can all have poverty mitigating effects.

While talking of the connection between clusters and poverty the paper says more focus has been laid on the economics and markets of clusters like growth and competitiveness, local institutions, global value chains while leaving out the outcomes due to clusters on incomes, poverty, and employment of the people.

The paper discusses how access to electrical power can enhance the workings in a cluster .Mechanisation of tools and technologies can help raise productivity and incomes thus reducing the use of outdated labour intensive tools, and it can also enhance the ability of local producers to improve their earning potential by raising outputs, working longer hours, allowing production to take place in the evening hours due to presence of electricity. Also clusters provide for cost effectiveness in mechanisation and in acquiring new technology via collaborative methods rather than in isolation and sharing this within the cluster. Also investment in off-grid electricity implies cost can be shared within clusters thus reducing the burden on one single entrepreneur. This has been seen with evidence in Pakistan wherein small clusters "invested in the development of a "dry port" to reduce the logistical constraints that they faced in dealing with customs and shipping officials at the distant sea-port of Karachi" (pp.26).

While talking of integration between the above mentioned linkages, the paper argues that certain programmes need to be clearly focused on the need to identify "poverty nodes" within the clusters and then consider how off-grid system interventions are likely to impact upon such groups implying that the focus is to be on clearly identified pro-poor basis and also wherein the needs are clearly identified and interventions can support many members in the area. The author feels that clusters are a potential key for policy planning in terms of poverty reduction and employment generation in rural communities.

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Title: Modern Energy Access to All in Rural India: An Integrated Implementation Strategy
Authors: Patil, Balachandra
Authors affiliation: IISc Bangalore
Year: August 2010
Name of publication: Energy Technology Innovation Policy Discussion Paper Series, Discussion Paper No. 2010-08, Harvard Kennedy School Belfer Center for Science and International Affairs, Harvard University
Publication/author link: http://belfercenter.ksg.harvard.edu/files/Patil_ETIP-DP-2010-08.pdf

Author's Abstract: Expanding energy access to the rural population of India presents a critical challenge for its government. The presence of about 364 million people without access to electricity and about 726 million who rely on biomass for cooking indicate both the failure of past policies and programs, and the dire need is for a radical redesign of the current system that will address the need to expand energy access for these people. In this paper, we propose an integrated implementation framework with recommendations for adopting business principles with innovative institutional, regulatory, financing and delivery mechanisms. The framework entails the establishment of rural energy access authorities and energy access funds, both at the national and the regional levels, to be empowered with enabling regulatory policies, adequate capital resources, and the support of multi-stakeholder partnership. These institutions are expected to design, lead, manage and monitor the rural energy interventions. At the other end, the trained entrepreneurs would be expected to establish bioenergy-based micro-enterprises that will produce and distribute energy carriers to rural households at an affordable cost. The energy service companies will function as intermediaries between these enterprises and the international carbon market both in aggregating certified emission reductions and in trading them under clean development mechanism. If implemented, such a program could address the challenges of rural energy empowerment by creating access to modern energy carriers and global climate change mitigation. Additionally, it could provide economic/livelihood benefits to the rural population while simultaneously earning handsome profits for the entrepreneurs.

Key words: energy access, business model,

Key observations:
This report proposes a model for an integrated rural energy policy (IREP), which, as per author is focusing exclusively on providing access to rural energy in an integrated manner. To justify the need for such a model, the author first provides the statistics of energy (cooking and lighting) access in rural India with the reference of National Sample Survey Organisation (NSSO) 2007 (pp. 5), and concludes that the government policies and programmes for providing such access in the rural parts of India have not been successful. For example, the earlier efforts to supply kerosene (for cooking) through the Public Distribution System (PDS) and power through the Rural Electrification Corporation (REC) had limited success. (pp.6). The reason for such failures, according to the author are : lack of effective policies and programs, lack of institutional framework, inefficient and ineffective governance, misdirected targets, ineffective delivery mechanism, etc. (pp.7-8)

Author's proposed implementation framework is expected to address above-mentioned limitations. His framework is a public-private-partnership-driven business model with innovative institutional, regulatory, financing and delivery mechanism. This model includes (pp.9):

i. Creation of *rural energy access authorities* (REAA) within government systems as leadership institutions

ii. Establishing *energy access funds* (EAF) to enable transitions from the regime of investment/fuel subsidies to incentive-linked delivery of energy services
iii. *Integration of business principles* to facilitate affordable and equitable energy sales to households
iv. and carbon trade
v. Treatment of *entrepreneurs as implementation targets* and not millions of rural households

The author sees his framework as a top-down approach where appropriate government ministries are at the top of the hierarchy. He prefers this top-down approach over bottom-up model due to the scale of the problem of expanding energy access (pp. 9). This model basically entails establishment of the REAAs both at national and the regional levels and empowered with enabling regulatory policies and supported by multi-stakeholders from public and private sectors. The REAAs will establish the EAF which will be provided to micro-enterprises working in the rural areas in providing energy services. The energy service companies (ESCOs) will function as intermediaries between these micro-enterprises and international carbon trading market in aggregating the certified emission reductions and then trading them under Clean Development Mechanism (CDM) mechanism.

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Title: Scaling up Renewable Energy in India: Design of a Fund to Support Pro-poor, Off-Grid Renewables
Authors: NERA Economic Consulting
Authors affiliation: NERA Economic Consulting
Year: July 2010
Publication/author link: not available

Key words: Off-Grid Renewable (OGR), fund design, rural electrification programmes

Key observations:
This report has been submitted to UK-FCO and DFID (Government of UK) by a consortium led by NERA Economic Consulting to develop a Fund to support pro-poor off-grid renewables (OGR) in India. This report thus presents findings and proposed Fund design in OGR sector.

Experience with OGRs in India and internationally:

i. The report notes that there are various policies in place to support renewables in India. Some policies also support OGR applications. However, most of installed renewable capacity is from grid-connected renewables
ii. The Government of India is pushing towards more "market-oriented" approaches to accelerate the deployment of renewable energy.
iii. An example of a successful government intervention can be given as the Ministry of New and Renewable Energy's (MNRE's) scheme of supporting solar water heaters, which enables households to obtain credit in favourable manner. This, in turn enables households to save on their energy expenses and repay loans in a short period of time.
iv. Commercial viability of mini-grids related business models that are tried by energy providers "in the absence of subsidy has not been demonstrated among the stakeholders interviewed"
v. Internationally, "a shift to a market oriented approach to the deployment of OGR" is important which primarily focuses on sustainable business models
vi. "Sustainable models focus on establishing market infrastructure to endure for a long term"
vii. Policy interventions are needed to encourage sustainable OGR business models, which include: a) incentives to lenders to facilitate finance b) subsidise initial costs of establishing market infrastructure c) avoid ill-suited technology use in OGR solutions, instead aim to meet end-users willingness to pay and demands
viii. Foster markets to attract the market actors
ix. Alignment and integration of other policies including necessary regulatory clarifications, integration of OGR in overall energy plan to avoid competition with grid, removal of taxes and tariffs on OG services, products, long term government commitment in subsidy where required, tailor OGR policy to the specific objectives and markets

The report categorises OGR deployment in India in four routes: i. fully government funded ii. Government assisted subsidies iii. Sponsored/subsidised private deployment iv. Unsubsidised private deployment.

The lessons from past rural electrification programmes include (pp.17-18): i. conventional grid electrification suffered by rather lax definition of electrification. ii. Household level problems are more technical, institutional or operational rather than economic. There is willingness to pay in rural communities; ability to pay however does not follow iii. Poor access to credit or short repayment periods on commercial loans limit the ability of farmers, households or rural businesses to service the loans iv. Market for OGR technologies is severely underdeveloped

The report points out few gaps in the literature on OGR in India (pp. 28-29): it finds that the coverage of single household interventions via large scale market mechanisms, for solutions other than SHSs is inadequate. There is no backward looking evidence that intervention measures really delivered enduring benefits, i.e. what actually worked, at scale, in the real world. According to the report, market-oriented paradigm, known to be critical, has not yet become dominant in the literature.

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Title: Power to The People: Investing in Clean Energy for the Base of the Pyramid in India
Authors: Bairiganjan, S., Cheung, R., Delio, E.A., Fuente, D., Lall, S. and Singh, S.
Authors affiliation: World Resources Institute and Centre for Development Finance, IFMR Research
Year: September 2010
Publication/author link: http://www.wri.org/publication/power-to-the-people

Key words: Base of the Pyramid, subsidies, market development organisations

Key observations:
This report focuses on understanding the investment potential of the clean energy industry serving India's rural poor. It also analyses the market opportunities and the challenges in scaling up that are faced by the industry. The report has been divided into eight chapters. The first half of the document mainly focuses on the clean energy market potential in India's Base of the Pyramid (BoP) population for promoting clean energy electricity systems and clean energy lighting and cooking products. The remaining part of the document explains the roles of government and non-profit organizations in enabling the market potential for clean energy systems.

The authors are of opinion that the market expansion in this sector is highly possible through the development of efficient business models, additional favourable national policies and increased targeted capital. They estimate the aggregated potential market for clean energy consumer products and services to be INR 97.28 billion per year. As this report focuses on rural India, the rural Indian BoP market has been defined as the households in the bottom four expenditure quintiles (based on NSSO data) that spend less than INR 3453 on goods and services per month. This definition thus represents a market of 114 million households or 76 % of the rural population. The report focuses mainly on two areas: clean energy electricity systems and clean energy cooking and light products. This categorisation involves four subcategories namely: decentralised renewable energy (DRE) enterprises, solar home systems, solar lanterns and energy-efficient cook stoves. Within DRE enterprises, electricity providing companies that operate biomass gasifiers (DESI Power and Husk Power) and small hydro (SBA Hydro) have been studied.

The authors remark that although the lack of a reliable supply of power from the grid drives the clean energy market development for rural areas, the availability of free or inexpensive "dirty" fuels in the market is one of the obstacles in that path (pp.19). The authors note that more than 30% of subsidised kerosene intended for public distribution is diverted to the black market and sold at higher market rates (INR 35-40 per litre). This makes the subsidy considerably less effective. Other challenges being accurate assessment of users' demand, lack of qualified personnel and reliance on government policies and clearances for some DRE projects who sell their power exclusively to the government (pp.29).

DRE technologies offer competitive advantage over conventional energy generation in: 1. Use of local labour and resources and demonstrated relatively high levels of operational reliability 2. Price competitiveness over conventional, grid –based electricity considering grid extension costs in rural areas (pp.26). DRE technologies can also offer opportunities such as use of existing grid infrastructure to supply power to villages, reduction of costs through government subsidies and generation of extra income through carbon credits (pp.29).

The authors estimate the potential market of INR 94.06 billion per year for DRE services for rural BoP. For DRE enterprises, the authors conclude that there are key investment themes to be considered:

1. Increasing consumer demand (consumers want solutions “comparable to grid electricity in cost, convenience and capability”)
2. Successful forecasting of supply/demand management before setting-up mini-grids
3. Exploring available options to use existing grids to offset demand risk

Although the potential growth for providing clean energy to rural BoP is significant, the authors believe that the government’s role is critical in its development. The government provides its support to clean energy market development in terms of incentives, but some of its policies undermine the demand for clean alternatives (e.g. provision to distribute solar products for free often make users less inclined to purchase these products at cost, and the availability of highly subsidised kerosene distorts market for alternatives like solar lanterns).

The report makes three policy recommendations for government:

1. Shifting the existing kerosene subsidy to a subsidy based on lighting
2. Streamlining the application process to make the current subsidies and incentives more easily accessible to existing and potential DRE providers
3. In accordance with the lending guidelines of the RBI, promote clean energy and energy efficiency companies as priority sectors for Indian banks.

The document has also emphasized on the role that non-profit organizations can play by helping to “generate the demand for clean energy products and services among the rural BoP”. The report explains that due to high marginal costs of selling products in remote areas, the companies find it difficult to expand their reach to the rural BoP while maintaining their financial sustainability. In this scenario, according to the authors, non-profit organizations (also called as “market development organizations (MDOs)” can fill the gap in the value chain.

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Title: Empowering Villages *A Comparative Analysis of DESI Power and Husk Power Systems: Small-scale biomass power generators in India*
Authors:IFMR Reseach
Authors affiliation: Centre for Development Finance, IFMR Research
Year: 2010
Publication/author link: http://cdf.ifmr.ac.in/wp-content/uploads/2011/03/Empowering-Villages.pdf

Key words: biomass gasifier, business models, DESI Power, Husk Power, Bihar

Key observations:
This report presents insight into business strategy and technological suitability of biomass gasifier based DRE plants of DESI Power and Husk Power and highlights critical elements of relevance for replication in other locations.

The report has been organised into four chapters. Chapter 2 provides company overviews of DESI Power and Husk Power:

DESI Power:
DESI Power's gasifier plants are of capacities 30-100 kWe and run on various crop residues. DESI power has mostly used *Dhaincha* based feedstock for their plants. The primary market for DESI Power projects is micro enterprises in the remote areas and the secondary market is providing electricity to households. In their business strategy, DESI Power first sets up DRE plant and then create rural micro enterprises and energy services which provide demand for the plant. To accomplish these goals, DESI Power promotes sister organization DESI Mantra and Baharbari Odhygik Vikash Sahkari Samiti (BOVSS) that promote and support micro-enterprises. DESI Power prefers to set up their plants in rural remote areas, near highways connected to urban centres and near urban/semi-urban locations. DESI Power looks for MNRE support and is offering to supply "green energy" to telecom towers and to supply clean cooking fuels with biogas plants in the 100 Clean Development Mechanism (CDM) villages. Revenue collection is done by DESI power agents and the cost of electricity per unit is roughly : Rs. 7-8/kWh

Husk Power:
Husk power's business model targets household lighting as its priority. Based on the pre-installation audits, the demand in the area and paying capacity of community members are determined. Revenue collection is done by village collection agents. Cost of electricity is lower than DESI power

DESI Power and Husk Power: gasifier technology comparison
The report provided the comparison of the technologies being used in DESI and Husk Power gasifiers. It states, "In contrast to DESI Power, Husk Power Systems has collaboration with local manufacturers to produce the gasifiers for their plants. The gasifiers were designed to meet the company's specifications. Husk Power Systems gasifiers are primarily designed to use rice husk as raw material without any processing or conversion into briquettes. The gasifiers can be modified to use any other woody biomass for producing gases. Husk Power Systems source gasifiers and gas engines from various local suppliers.

While DESI Power and Husk Power Systems use similar technology, DESI Power uses standardized gasifiers, which are easy to maintain and have been tested in a number of plants. Husk Power Systems, on the other hand, uses gasifiers that require more detailed routine maintenance and specialised training. Unlike DESI Power, Husk Power Systems has the advantage of changing the gasifier specification/design as per their requirement. Since Husk Power Systems sources gasifiers from local manufacturers, they see significant cost reductions compared to gasifiers provided to DESI Power. Although the maintenance of DESI Power plants is easy, the lack of readily available spare parts could result in prolonged periods of down time".

Overall highlights:

i. HPS has reduced the cost of electricity by locally manufacturing plants and using locally available material
ii. HPS plants need more sophisticated maintenance
iii. DESI power plants can run on variety of feed materials, whereas HPS plants run only on rice husk
iv. DESI business strategy is based mainly on local small enterprises. However, projection of potential demand from new enterprises to determine plant size to ensure profitability is their main challenge.
v. Overall conclusion from the authors is that: in rural areas "the need for electricity solutions does not necessarily translate into ability to pay". This combined with the need for plants to maintain certain PLF for economic feasibility underscores "the needs for careful demand estimation while selecting target villages".

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Title: Report of Study on Community Micro hydro Systems in Select States
Authors: TIDE technocrats Pvt Ltd.,Bangalore
Year: 2009
Name of publication: Submitted to Swiss Agency for Development Cooperation (SDC)

Key words: micro-hydro

Key observations:
This report is the result of a study undertaken of community hydro projects in the States of Karnataka, Kerala, Orissa, Uttaranchal and the region of Ladakh. The Swiss Agency for Development and Cooperation (SDC) contracted TIDE Technocrats (P) Limited to undertake this study. The scope of the study is confined to community based off grid sites with a power generation capacity of around 50 kW installed capacity or less and is carried out as a desk study through internet and phone based questionnaires and discussions.

While documenting the experience in each of the states, it gives the data of the community hydro projects in that state along with specifying whether the plant is functioning and the reasons for its non-functioning:

i. In Orissa out of three systems, one was functioning.
ii. Ladakh has about 60 projects out of which 43 systems are functional. In Ladakh, harsh climate and local conditions have led to shut down of some projects. Also it was felt that extension of grid power, diesel or solar–based system are a threat to the micro-hydro system.
iii. Uttaranchal has one of the largest capacities for community hydro systems installed having around 30 plants covering 177 villages. But the report notes that a significant number of projects stop working after the initial demonstration /performance period is over. The survival rates are low with projects not running beyond few years. Another concern is that local agencies do not take over and run the plants on an on-going basis.
iv. In Kerala there are two areas having multiple projects running and Karnataka has around 5 community hydro systems of which 4 are functional. The report then lists the providers for micro hydro systems and its components.

- **Learnings:**

Technology:
The report states that a wide variety of technology choices are operating, with cross flow, pelton and pump gas turbine systems operating successfully. Systems without any load governing with simple operation control are also successfully running. The systems available are from within the country and from outside and both have performed well. It says that technology for project capacities less than about 20 kW need to be kept simple and that sophisticated electronics and controls can make the project uncertain. It also calls for an integrated design plan for the civil works, electro-mechanical system, power distribution and community participation to ensure successful implementation of projects.

Project management:
While the project management styles have been varied across the five study states, the report calls for appropriate community hydro project management for its successful implementation .It counts community participation as a critical element for the success of the project and calls for smaller projects for better management by the community.

While the learning’s bring about ways to better the performance of these community projects, there are some threats to sustaining these initiatives like the availability of the Grid or any alternate energy source that provides higher level of service at site. It calls for attention to be paid to integrate this aspect into the project design upfront. Ideally the power generated should be connected to the grid when available. Also large projects are difficult to sustain even though it involves local communities and so alternative process like entrepreneurship with viability gap funding ,finding alternate structures need to be evolved .It also brings in the aspect of managing funds and having contingencies for operation and maintenance work

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Title: Approach for standardisation of off-grid electrification projects:		
Authors: Kumar, A., Mohanty, P., Palit, D. and Chaurey, A.		
Authors' affiliation: TERI		
Name of publication: Renewable and Sustainable Energy Reviews, Elsevier		
Volume: 13	**Year:** 2009	**Pages:** 1946-1956
Publication/author link: atulk@teri.res.in (A. Kumar)		

Authors' Abstract: Past experiences show that a large number of off-grid electrification projects fail because focus is generally given in technical installation without paying sufficient attention to the long-term sustainability of the projects. In such projects, several important steps, which need to be followed, are not covered. Moreover, there is no standardized approach, which could be followed while formulating the off-grid electrification projects. Therefore, there is a need for developing and benchmarking the systematic approaches, which could be followed for project planning and formulation. In this paper a modest attempt has been made to develop a decision making tool which involves approaches that are to be followed for entire planning and formulation of off-grid electrification project. The standardisation of processes is expected to help in accelerating the implementation of off grid electrification projects in an effective manner while fostering to achieve the national electrification targets in a stipulated timeframe.

Key words: Rural electrification ,Off-grid electrification, Standardisation process

Key observations:

The paper while developing a procedure /tool for standardisation first gives the Project design and formulation, and then it talks of the detailed designing and commissioning of the project, Training and capacity building and Monitoring and evaluation.

1. Project design and formulation: The planning and formulation of off-grid projects is categorised into 3 stages:
   Stage-I: Project development/planning and pre-installation.
   Stage-II: Detailed designing, installation and commissioning.
   Stage-III: Post-commissioning

   I. **Project development/planning and pre-installation services**:
   "This step determines the potential sites for off-grid electrification project"(pp1947) .The geographical location is first identified and after following the seven stage process identified in the paper, it can be determined whether grid extension is feasible or cost effective .Setting up of DG based electrification is recommended if grid extension is found to be unfeasible .It also says that if grid extension is found feasible but the time frame for grid extension process takes say 5 years ,then DG based electrification is recommended.

   II. **Detailed designing, installation and commissioning**:
   It involves resource assessment, preparation of DPR, installation and commissioning of the project
      ii. Resource assessment: "Literature survey and research conducted by different agencies indicate that electricity generation and delivery through micro hydro resources is the least cost option and thus availability of hydro resources is to be checked first".(pp1949) The author has then given various sets of questions applicable to different RE technology.
      iii. Preparation of detailed project report:

- Demand assessment: It involves assessing the domestic, community, commercial and agriculture demand .An household level survey is used to understand the current energy consumption to assess the electricity demand .A village level survey is also undertaken to assess the demand with various consultations with different stakeholders .The other assessments include assessing the willingness to pay, whether road connectivity required for commutation and operation and maintenance.
- Technology selection: It is one of the crucial steps in the project planning stage .Some of the factors that need to be considered are the population pattern, topography of the area, load pattern and power delivery area, the capital cost and means of finance ,final affordable consumer tariff. Also the paper sets out a step by step process that is to be followed for the selection of appropriate technology.

iv. Financial framework for tariff determination: The paper finds that there are huge variations found in the literature on the cost of electricity generation from renewable resources primarily due to difference in input parameters .In this paper a mathematical framework has been developed for electricity tariff using "cost based method" .The cost component involves grant, loan, repayment, the return of equity, the operation and maintenance cost, fuel cost and depreciation involved. In the paper a mathematical expression has been shown that could be used for estimation of annual electricity generation from a DDG project.

v. Institutional arrangements and commissioning of the project : Clear institutional arrangements in order for the smooth functioning of power projects are necessary The paper says that projects with clear ownership along with stakes built in to ensure sustainable operation have a better chance of being successful

III. **Training and capacity building** : Capacity building measures are divided into three stages:
- Capacity building programs during pre-installation
- Capacity building programs during installation and commissioning
- Capacity building programs during post-installation

IV. **Monitoring and evaluation**: For the purpose of Monitoring and evaluation, the paper advocates for indicators that should be SMART (Specific Measurable Achievable Realistic Timely) which should be measured at the beginning of the project, during and at the end of the project and also after several years later to determine the impact of the project.

While considering the case for DG technologies the paper notes its importance not only from the economic angle but from social and livelihood angles and presenting its advantages in terms of quick start-up time for such technologies. DG also offers a cost effective alternative to conventional generation of electricity for rural electrification in the country especially in remote areas. Need for standardisation has emerged from the potential need for sustainability of such systems in the long run and in speeding up the implementation of such projects thus aiding the national goal of electrification for all.

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Title: Decentralised renewable energy: Scope, relevance and applications in the Indian context		
Authors: Hiremath, R.B., Kimar, Bimlesh, Balachandra, P., Ravindranath, N.H. and Raghunandan, B.N.		
Authors' affiliation: IISC Bangalore		
Name of publication: Energy for Sustainable Development		
Volume: 13	**Year:** 2009	**Page:** 4-10
Publication/author link: Bimlesh Kumar (bimk@civil.iisc.ernet.in)		

Authors' Abstract: Presently used centralised energy planning model ignores energy needs of rural areas and poor and has also led to environmental degradation, whereas decentralised energy planning model is in the interest of efficient utilisation of resources. Energy planning at the village level is the bottom limit of the application of decentralised planning principle. The individual villages are the smallest social units where the energy consumption occurs. Renewable energy is energy derived from sources that are being replaced by nature, such as water, wind, solar or biomass. Renewable sources are essentially non-polluting if applied correctly. The paper presents a review of the important decentralised renewable energy options, related case studies of successful deployment of renewable energy technologies in India and resulting lessons learnt. Case studies discussed in the present work show the feasibility of decentralised energy options for the residential and small scale applications in a village or a cluster of villages. The paper also details the different initiatives taken by the government of India to promote decentralised energy production in India. It is found that the small scale power generation systems based on the renewable energy sources are more efficient and cost effective. Thus the focus should be on the small scale renewable energy technologies that can be implemented locally by communities and small scale producers, but can make a significant overall contribution towards the national energy supply.

Key observations:

This paper presents a review of decentralised RE systems for rural India and their feasibility for residential and small scale applications for small villages using case studies on bioenergy, solar power, small hydro and hybrid RE systems. In case studies, it discusses the cost of installations and the electricity generated, the impacts and the lessons learned. The case studies on bioenergy include: 5x100 kW gasifier installation for rural electrification at Cosaba Island in West Bengal, 9 kW gasifier installation at Odanthurai Panchayat in Tamil Nadu and 20 kW each gasifier system installed in Hosahalli and Hanumanthanagara villages in Karnataka The case studies on solar power include: aggregate 300 kWp SPV installations in Sagar Island in Sundarban region in West Bengal, 2 kW SPV plant at Salepada, Orissa and SLS at Mundanmudy village, Kerala. Others include: 2 x 9 MW SHP system at Jaldhaka Hydroelectric Power Station in West Bengal, 4 x 12.75 MW hydroelectric project at Ramman in West Bengal, hybrid wind and gasifier-diesel system in Sagar Island and small hydro and solar hybrid system in Ladakh region in Jammu and Kashmir

In its introduction, the paper provides the drawbacks of the centralised energy planning in considering the needs of the rural poor in India. It further lists the advantages of decentralised renewable energy for providing reliable and quality power to the rural poor. The authors also provide the details on the slow progress of rural electrification activity in India, and acknowledge the efforts taken by the Govt of India in improving the access to electricity in rural parts of the country. However, it is suggested that commissioning pilot-scale models to showcase the viability of distributed generation scheme would not be sufficient to bring these technologies in the mainstream; rather a clear framework containing technical, financial, implementation and regulations is required. The paper discusses various Govt policies on RE, such as Draft Renewable Energy Policy, Rural Electricity Supply Technologies Mission, the Electricity Bill 2001, etc.; however points out that there is no national policy on distributed generation that comprehensively takes into account the nature of diverse rural situations yet.

From the case studies on biomass-based distributed generation, the paper lists a number of benefits, such as reduction in transmission and distribution (T&D) losses, better power quality supply, clean environment, opportunities for local control, etc. At the same time, it also cautions that the viability of biomass-power systems has not been yet demonstrated in India. Regarding other technologies used in decentralised renewable energy generation, the authors point out that the information on the performance, costs and impacts of these technologies (solar PV, wind and micro-hydro) is very limited. The authors are of opinion that the hybrid-systems can have a potential impact, not only in rural electrification but also in meeting water pumping and other small power requirements in rural areas.

In the end, the authors compare their estimation of the cost of delivered power in a remote village using solar PV with that of thermal station and diesel generator. For this comparison, the distance of village location from 33 kV grid point, the level of demand and the plant load factor have been considered. For the year 2010, it is estimated that solar PV is cheaper (cost of delivered power Rs. 9.67) than the cost of the electricity delivered by a centralised thermal plant having grid at 5 km from the village.

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Title: Grid–connected versus stand-alone energy systems for decentralised power-A review of literature
Authors: Kaundinya , Deepak Paramashivan, P. Balachandra andRavindranath, N.H
Authors' affiliation: IISc Bangalore
Name of publication: Renewable and Sustainable Energy Reviews
Volume: 13 **Year:** 2009 **Page:** 2041-2050
Publication/author link: Deepak@mgmt.iisc.ernet.in (D.P. Kaundinya)

Authors' Abstract: The decentralised power is characterized by generation of power nearer to the demand centers, focusing mainly on meeting local energy needs. A decentralised power system can function either in the presence of grid, where it can feed the surplus power generated to the grid, or as an independent/stand-alone isolated system exclusively meeting the local demands of remote locations. Further, decentralised power is also classified on the basis of type of energy resources used—non-renewable and renewable. These classifications along with a plethora of technological alternatives have made the whole prioritization process of decentralised power quite complicated for decision making. There is abundant literature, which has discussed various approaches that have been used to support decision making under such complex situations. We envisage that summarizing such literature and coming out with a review paper would greatly help the policy/decision makers and researchers in arriving at effective solutions. With such a felt need 102 articles were reviewed and features of several technological alternatives available for decentralised power, the studies on modeling and analysis of economic, environmental and technological feasibilities of both grid-connected (GC) and stand-alone (SA) systems as decentralised power options are presented.

Key words: decentralised planning; grid-connected; Stand-alone; renewable energy; energy systems

Key observations:

While presenting a literature review of decentralised power systems ,the authors have reviewed articles and have firstly presented the differentiation between grid-connected(GC) and stand-alone (SA) systems .While giving the important features of each ,it says that GC systems are ideal for locations close to the grid and GC systems can be of two types: wherein GC system's main priority is to cater to local needs for electricity and surplus is fed to grid, while on the other hand decentralised stations are managed by the utilities in the same way as large electric power plants. The connectivity to grid enables setting up relatively large-scale systems and hence can operate at high PLF's improving economic viability of the operation. While for SA systems, they provide power independently of the utility grid wherein the needs of the local region assume maximum priority and are ideal for remote locations.

While reviewing the literature for GC and SA systems it looks at techno-economic and environmental feasibility of both systems. Within this the review says that the authors have felt one of the main reasons for not extending the grid to rural locations is due to high domestic applications which leads to energy systems operating on low loads making the system reliability crippled. Another study done in Spain evaluated the system for its economic and environmental benefits and the results showed that system was profitable enough to invest in .The MNRE annual report discusses how attractive GC systems are in the context of CDM .Life Cycle Analysis (LCA) was performed to assess environmental benefits of solar PV systems. For SA systems the study feels that the potential solution to the problems in these systems like low capacity factors, excess battery costs is to use SA systems as a hybrid with other sources of energy carriers. There are case studies to compare the generation costs of SPV and conventional power systems to illustrate how conventional power systems are not economical for extremely remote locations. The authors also observe that there are not many studies to assess the environmental feasibility of SA systems.

The paper then looks at engineering and institutional design for these systems and then speaks of the policy measures and barriers for implementation of these systems. The review states that the status of grid-connected power supply market is still at the demonstration and validation stage in contrary to developed countries .The review also states that a need has been asserted for increasing cooperation between ASEAN countries to duplicate the grid-connected biomass power generation systems throughout ASEAN.

Mathematical modeling of performance of GC and SA systems has brought out various approaches: computer-based decision support system, HOMER, controller system to improve the system stability of fuel cell GC systems in power distribution network, DECO (dynamic energy, emission and cost optimisation) model, and computer –based dynamic economic evaluation model with five economic efficiency indicators to assess PV, diesel generators.

While climate change mitigation and role of GC and SA energy systems are discussed, the review shows how growing biomass on degraded land for power at a sustainable rate and help in carbon sequestration. In addition to packaging decentralised energy projects under CDM, several authors have studied the operational difficulties in getting CDM sanctions for these projects. The studies unequivocally suggest that CDM support can play a major role in reducing the cost burden on the RE projects in developing countries enabling them to successfully implement these projects in rural areas .

The paper says that most of the articles are context dependent and were applied to isolated cases. A generalised approach to assess suitability of SA and GC systems at a given location, based on techno-economic-financial-environmental feasibility does not find adequate coverage. It also says that the review found that techno-economic assessment of grid-connected and stand-alone systems is restricted to annualized life cycle costing methods. The review also states that SA systems still do not enjoy CDM support and calls for policy efforts in this direction.

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Title: Micro Grid & Smart Grid
Authors: Council of Power Utilities
Year: 2009
Publication/author link: http://www.indiapower.org/contentmicrogridandsmartgrid.pdf

Key words: micro-grid, smart grid, smart meters

Key observations:
This is a report of the summary records of the discussions held during the Expert Group Meetings of the Council of Power Utilities (CPU) in year 2008. These Expert Groups, as the preface of the report informs, deliberate on the "contemporary issues/problems relating to power supply industry. Emerging new technologies in the course on on-going power development are also deliberated…" This report focuses on the two power system aspects, viz. micro grid and smart grid. In addition to the meeting summary records, additional information from the internet on these issues has also been published in the document.

Micro grid
The report is mainly organised into two parts, focusing on micro grids and smart grids, respectively. In the beginning of the document, the term micro grid has been defined as "low voltage distribution system with distributed energy resources viz. PV Power system which can be interconnected to medium voltage distribution system or it can be operated isolated from the main grid." From a utility point of view, such micro grids offer advantages, such as reduction in system demand for transmission and distribution (T&D) facilities, reduction in the losses in T&D circuits, improvement of electricity service quality for the end users and support to the main grid by relieving congestion. From a consumer point of view, micro-grids enhance local reliability by providing electricity and thermal services, improve power quality and reduce emissions.

The report informs that in the Expert Group Meeting, the key points of discussion on micro grid are mainly related to the interconnectivity aspects of micro grid to the main grid, to identify key areas (e.g. commercial complex, a multi-storey building, etc.) where micro grid is required, to explore provisions for lowering tariff in micro grid by receiving power from different sources and to ensure stability of the micro grid in isolated mode. The summary records of the discussion conclude that

i. "Distributed generators offer good opportunity for Demand Side Integration of Innovative Distribution System
ii. It would be proper to aim at setting aside appropriate percentage of electricity generation to renewable sources to reduce the peak load burden of the grid
iii. Technical challenges associated with the operation and control of micro grids are immense"

The additional material published in this report covers different aspects of micro grids. For example, a research paper published here says "instead of relying solely on large power plants, a portion of the nation's electricity needs could be met by small generators such as ordinary reciprocating engines, micro-turbines, fuel cells and photovoltaic systems." (pp. 11). However, here the authors predict that some micro grids will be able to use only clean and quiet generators due to air quality regulatory restrictions, building code constraints and site limitations. Another paper published here simulates micro grid operation during grid-connected and islanded modes of operation. In one research paper, the authors are of opinion that "small networks of power generators in "micro grids" could transform the electricity network in the same way that the net changed distributed communication."

Smart grid
Smart grid is the one who can "precisely manage electrical power demand down to the residential level, network small scale distributed generation and storage devices, communicate information on operating status and needs, collect information on prices and grid conditions and move the grid beyond central control to a collaborative network" (pp. 58)

The report provides information on the key functions of smart grid. "Self-healing" is one important characteristic of micro grid which allows it to avoid power outages and power quality problems. It also empowers consumer by incorporating consumer equipment and behaviour in grid design. Micro grid technologies also allow identifying and responding to manmade and natural disruptions. Smart grids can also accommodate different generation options.

According to the report, smart grid technology can be grouped into five main areas:

i. Integrated communications: where new communication technologies have the potential to enhance grid communications, such as advanced meter reading, data acquisition, substation automation, demand response, etc. These advanced communication technologies "will allow for real –time information and data exchange to optimize system reliability, asset utilization and security".
ii. Sensing and measurement: will help in diagnosing equipment performance, grid integrity, energy theft, congestion relief, etc.
iii. Advanced components: latest R&D innovation will improve the electrical behaviour of the grid
iv. Advanced control: it includes devices and algorithms which will help in "rapid diagnosis of and precise solutions to specific grid disruptions or outages"
v. Improved interfaces and decision support: provide operators and managers with the "tools and training to operate a smart grid".

The summary records of the discussion show that the participants were of opinion that the today's grid cannot meet challenges of keeping paces with growing economy. The progress in micro-electronics will significantly improve power grid control. The current efforts by the utilities to install smart meters can be considered as the first step towards "evolution towards smart grid". Demand Side Management (DSM) can be considered as the next step along that path of smart grid progress.

There is a separate section in this report which focuses on the topic of "smart meters for smart grid". A smart meter, according to the report is "a type of advanced meter (usually an electric meter) that identifies consumption in more detail than a conventional meter and optionally but generally communicates that information via some network back to the local utility for monitoring and billing purposes (remote metering)". The smart meter offers many advantages, such as reduction in energy usage, integration of all utilities and analysis of historical data of the utility meters such as water, gas, electricity and oil in order to help optimization of use of such utilities.

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Title: Providing electricity access to remote areas in India: Niche areas for decentralised electricity supply		
Authors: Nouni, M.R., Mullick, S.C. and Kandpal, T.C.		
Authors' affiliation: MNRE and IIT, Delhi		
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Volume: 34	**Year:** 2009	**Pages:** 430-434
Publication/author link: tarak@ces.iitd.ernet.in (T.C. Kandpal)		

Authors' Abstract: This paper presents the results of a study undertaken for identifying niche areas in India where renewable energy based decentralised generation options can be financially more attractive as compared to grid extension for providing electricity. The cost of delivering electricity in remote areas considering cost of generation of electricity and also cost of its transmission and distribution in the country have been estimated. Considering electricity generated from coal thermal power plants, the delivered cost of electricity in remote areas, located in the distance range of 5–25 km is found to vary from Rs. 3.18/kWh to Rs. 231.14/kWh depending on peak electrical load up to 100 kW and load factor. The paper concludes that micro-hydro; dual fuel biomass gasifier systems, small wind electric generators and photovoltaic systems could be financially attractive as compared to grid extension for providing access to electricity in small remote villages.

Key words: Rural electrification; decentralised electricity generation options; delivered cost of electricity; critical distance for grid extension

Key observations:

As per the National Electricity Policy (NEP) of India, the commitment of GoI to ensure that the task of rural electrification for securing electricity access to all households by 2010 and for achieving this objective wherever providing grid connectivity would not be cost effective, decentralised electricity with distribution network would be provided. This paper compares indicators of financial performance such as unit capital cost, LUCE for both grid extension option and decentralised generation based options to identify niche areas of India eligible for decentralised electricity supply.

While outlining the status and growth of the power sector in India, the paper gives a snapshot of the challenges involved in providing electricity access in rural areas .It says that "nearly 24,500 villages out of 112,401 un-electrified villages come under the category of "remote villages" where grid extension is not likely to be the case in future. For such areas, renewable energy based decentralised generation options form the way "(pp.431) .Thus the paper attempts to identify such areas wherein decentralised generation options can be used instead of extending the grid. The delivered cost of electricity is estimated based on a) cost of generation at bus bar, b) cost of transmission, c) cost of distribution in case of centralised plants working on nuclear, and hydro and thermal power generation principles. For decentralised supply options, variants of biomass gasifier, small hydro power, photovoltaic system and small wind generator have been taken into consideration for analysis. When comparing there arrives a critical distance of grid extension beyond which decentralized generation options becomes financially viable. Different scenario for locality (hilly and plain terrain), load requirement, load factors are considered to check the financial viability.

While identifying the problems plaguing the rural electrification programme in India ,the paper makes an attempt towards identifying areas where electricity can be generated and supplied through DRE by comparing financial performance of indicators such as unit capital cost of different options and the levelised unit cost of electricity (LUCE) of both the decentralised generation and grid extension .Based on which it shows that for a given distance as the plant load factor (PLF) increases the per unit cost of delivered electricity increases and as the PLF decreases ,the per unit cost of delivered electricity decreases. Also as the load requirement increases for villages, the distance beyond which DRE becomes feasible over grid connectivity increases. One of the key assumption in paper is about average household peak electricity load (estimated to be 0.675 kW) which is not presented with underlying assumptions. The study shows that the projects have greater financial feasibility in the plain areas over hilly regions as the villages in hilly terrain have relatively low number of households which are dispersed. These areas also do not have high peak loads and the delivered cost of electricity in plain areas for example in case of plain areas for a 5km distance with Load Factor of 0.8 works out to be Rs 3.59 per kWh while in the hilly areas say for the same factors but at a distance of 10 kms, cost comes up to Rs 14.53per kWh which reflects its unfeasibility. Also with addition of households (every 80 newly added), cost of electricity comes down rapidly for long distance (20 -25kms) connectivity requirement as compared to shorter distance such as 5to 10 kms in case of both plain areas and hill areas (in case of hilly areas, cost of generation can be very high if load is in range of 5kW, which according to author is a highly likely scenario in such locations since electricity is mainly required for lighting only for few hours).

Based on the calculations undertaken in the study, the paper comes to the conclusion that all renewable energy based decentralised electricity supply options considered could be financially attractive as compared to grid extension for providing electricity in small remote villages with Micro Hydro as the best option for hilly areas and dual fuel biomass gasifier as the second best with number of households up to 75 (with power generation capacity of around 20 kW) along with PV and small wind electricity generators.

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Title: Rural Electrification in India: Economic and Institutional aspects of Renewables
Authors: Cust, James [1], Singh, Anoop [2] and Neuhoff, Karsten [3]
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Year:2007
Name of publication: OASYS – South Asia Project
Publication/author link http://www.eprg.group.cam.ac.uk/wp-content/uploads/2008/11/eprg0730.pdf

Authors' Abstract: The paper assesses the demand for rural electricity services and contrasts it with the technology options available for rural electrification. Decentralised Distributed Generation can be economically viable as reflected by case studies reported in literature and analysed in our field study. Project success is driven by economically viable technology choice; however it is largely contingent on organisational leadership and appropriate institutional structures. While individual leadership can compensate for deployment barriers, we argue that a large scale roll out of rural electrification requires an alignment of economic incentives and institutional structures to implement operate and maintain the scheme. This is demonstrated with the help of seven case studies of projects across north India

Key words: Rural Electrification, Distributed Generation, Renewable Energy, India.

Key observations:
The paper explores the demand for electricity in rural areas along with different relevant technology options available with the help of case studies .It draws conclusion about DDG being economically viable whilst putting a case forward for economically viable technology base along with organisational ,policy and structural implementations .Although there is willingness to pay, the paper notes that electrification needs of rural populace are not adequately met .It puts forth a point in case for DDG saying these type of projects are far reaching and can help ease the burden on both electricity supply shortfalls (by serving rural areas and subsequently feeding back into the grid), and reduce the urgency of costly grid extension. Through the case studies it shows the economics of cost for a particular type of technology and its viability .The paper enumerates the barriers that prevent smooth execution of these decentralised projects in India and calls for leadership, local participation and better institutional mechanisms for its success.

The paper also talks of the different rural electricity supply options available like-centralised conventional thermal generation combine with rural grid extension, the small-scale DDG specific to rural areas and household level technology like Solar PV .The first option is highly favoured by the MoP while the second and third proves to be economical and can have wide applications as found out through different case-studies. While talking about RE technologies as DDG, it assesses the different technology options available, the raw material and resource availability .In terms of case studies conducted, the paper arrives at different per unit cost for technologies like biomass gasification between Rs 6-8, for small hydro per kWh between Rs3-7, wind at around Rs8/kWh and between Rs 14-25 for solar PV.

While it states that renewables still struggle to compete in generation cost terms at subsidised tariff rates for grid electrification, if full cost of energy delivery is considered, renewables are often cost competitive. In terms of economics of delivery, biomass gasification are found to be least-cost electrification option .According to the study conducted by the authors ,high PLF is critical to viability of RE –DDG while arguing that ownership structures and management can ensure maximisation of PLF.

In terms of institutional structures, the paper identifies three types of barriers, namely -Intial, Organisational and Structural. While initial barriers account for appropriate technology choice, unproven technology, unpredictable local conditions contribute to risk of failure. Financing also presents a barrier while leaving out smaller players to setup such projects. Organisational barriers include the PLF which is largely dependent on organisational approaches to distribution and supply ensuring adequate load and relevant bio-fuel supply for the system. It calls for collaboration with local NGO, Panchayats, SHG's to help establish sufficient demand for power thus ensuring PLF, taking the example of the Orcha case study. Also technical support and resource availability are very critical for success of DDG projects along with local knowledge and participation. Structural barriers mainly arise from state actors as monopolies on subsides while others find it hard to secure funding, also bureaucratic and lengthy processes slow down the effective functioning.

The case studies that have been conducted have been divided into 4 categories: hierarchical, local franchisee, independent, private vendor based. In the hierarchical model, the project is government initiated, with local body and panchayat members employed on behalf of state government agency. In the second model the operation, maintenance and distribution responsibilities are given to the local VEC with support from state government. The independent model is wherein an implementing agency with partnerships with local community build and operate a decentralised electricity system and the fourth one is private or NGO based wherein solar lanterns, solar water pumps are provided to individual households, wherein there is no generation and distribution system.

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Title: Biomass Gasifier based Electrification Project at Orissa ,Village-Siunni,Block-Umerkote,Dist-Nabarangpur
Authors: Gramodaya
Year:
Name of publication: N.A
Publication/author link: N.A

Key words: VESP project, biomass gasifier
Key observations:

In the villages of Siunni, in Orissa, traditionally fuel wood was collected for cooking and kerosene was predominantly used for lighting purposes. So the biomass gasifier project was setup to address the needs of cooking, lighting and irrigation purposes. The VESP project in this village employs Biomass Gasifier (2 X10 kW), of this only one gasifier operates while the other is standby. Home illumination, street lighting, school and anganwadi lighting and power to SHGs for micro enterprises like maize threshing work and commercial establishments like shops and irrigation is now possible here. Average unit consumed per month per household is 6.8 and an amount of Rs. 55/ is charged per LUCE^ /month/household. The gasifier considering 20 years as plant life saves Kerosene as high as 1,01, 520 to 1,35,360 liters, leads to 332 tons of CO_2 mitigation of carbon offset. It is also saving 86,400 kWh of conventional grid electricity at user end which translates into 1, 20,960 kWh at the generation end, taking into account high technical commercial losses. A village local with the help of training is running the operations of the plant. Instead of paying the monthly fare they divide it by selling biomass and remaining is paid in cash (that which is saved from kerosene use).The case-study points out that the business model adopted by the project has a great scale-up potential and can help address the energy requirements of rural un-electrified areas of Orissa.

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Title: Biomass gasifier projects for decentralised power supply in India: A financial evaluation		
Authors: Nouni, M.R., Mullick, S.C. and Kandpal, T.C.		
Authors' affiliation: MNRE and IIT Delhi		
Name of publication: Energy Policy		
Volume: 35	**Year:** 2007	**Pages:** 1373-1385
Publication/author link: tarak@ces.iitd.ernet.in (T.C. Kandpal)		

Authors' Abstract: Results of a techno-economic evaluation of biomass gasifier based projects for decentralised power supply for remote locations in India are presented. Contributions of different components of diesel engine generator (DG) sets, dual fuel (DF) engine generator sets and 100% producer gas (HPG) engine generator sets to their capital costs as well as to the levelised unit cost of electricity (LUCE) delivered by the same have been analyzed. LUCE delivered to the consumers has been estimated to be varying in the range of Rs. 13.14–24.49/kWh (US$1 0.30–0.55/kWh) for DF BGPP. LUCE increases significantly if BGPP is operated at part loads. Presently available 40kW capacity HPG systems in India are expected to be financially competitive with a DG set of equivalent capacity beyond a break-even diesel price of Rs. 34.70/l. It is expected to be financially more attractive than an equivalent capacity DF BGPP for diesel prices of more than Rs. 44.29/l. In certain specific conditions operating two smaller capacity systems has been found to be attractive as against a single larger capacity system.

Key observations (from authors' conclusions):

The report, for its financial evaluation of biomass gasifier projects in India, first compares the capital costs of both dual fuel engine based biomass gasifier power projects (DF BGPP) and 100% producer gas engine based biomass gasifier power projects (HPG BGPP) are costlier to equivalent capacity diesel generator set based power generating options. It concludes that "capital cost of the HPG BGPP is almost twice that of DF BGPP based on the present prices of these options. The current market prices of the HPG based engines are high either due to very low demand for such engines and/or due to a pricing strategy of the suppliers of these engines. Among various DF BGPP options up to 40kW capacity examined in this study, the LUCE for 20kW configuration is the minimum.

Whereas on the current prices, DF BGPP of capacity greater than 10kW are competitive in terms of the LUCE with DG based power projects for decentralised power supply, the HPG BGPPs are not yet competitive with either DF BGPP or DG set based power projects. DG set based power projects are found to be financially more attractive as compared to DF BGPP for projects of 5 and 10 kW capacities."

The authors recommend that "a DF based BGPP needs to be operated at its rated capacity as the LUCE increases significantly if BGPP is operated at part loads (75% or 50% of rated capacity). The results of the study indicate that instead of installing a single large capacity BGPP often operating at part loads for long durations, it may be financially more attractive to install two smaller BGPPs with each having a capacity equal to one half of the larger capacity BGPP. However, such an option usually necessitates higher capital investment."

The report further recommends that "a 40 kW HPG BGPP can become financially attractive to DG set based power project of equivalent capacity based on the current market prices, at a diesel price of Rs. 34.70/l. Efforts should also be made by the manufacturers to bring down the prices of HPG BGPP and especially the HPG engine. In case bio-diesel is used as pilot fuel in DF engine and it can be established through research and development efforts that the life and performance of engine are not affected adversely by use of bio-diesel in comparison to diesel as a pilot fuel, switching over to bio-diesel as a pilot fuel would be financially an attractive option if its cost is brought down to about Rs. 22.16/l for a 20 kW BGPP."

The authors suggest that to encourage deployment of DF BGPP in place of DG set power projects for decentralised power supply, provision of low interest loan could be considered. Besides, a capital subsidy of more than 10% of the total cost of BGPP would make DF BGPP option more attractive than DG set option even for 5 and 10kW power projects. "With existing local electricity distribution network, the LUCE is estimated to be in the range of Rs. 20.34–11.89/ kWh for DF BGPP in the capacity range of 5–40 kW. The feasibility of modifying existing DG set power projects for decentralised power supply to operate in DF mode should also be explored. As expected, the capacity utilisation of BGPP and price of diesel have a significant effect on the levelised unit cost of electricity. Therefore, efforts should be made to improve the capacity utilisation of BGPP."

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Title: Techno-economics of small wind electric generator projects for decentralised power supply in India		
Authors: Nouni, M.R., Mullick, S.C. and Kandpal, T.C.		
Authors' affiliation: MNRE and IIT Delhi		
Name of publication: Energy Policy		
Volume: 35	**Year:** 2007	**Pages:** 2491-2506
Publication/author link: tarak@ces.iitd.ernet.in (T.C. Kandpal)		

Authors' Abstract :
A techno-economic evaluation of small wind electric generator (SWEG) projects for providing decentralised power supply in remote locations in India is presented. SWEG projects that have either been implemented or are under implementation have been considered. The capital costs of the SWEG projects and sub-systems have been analysed. Levelised unit cost of electricity (LUCE) has been estimated for 19 select places located in different geographical regions of the country. The LUCE is found to vary in the range of Rs. 4.67–83.02/kWh (US$1 0.10–1.86/kWh) for wind electric generator projects in the capacity range 3.2–50kW with annual mean wind speed variation in the range 5–10 m/s. Issues relating to their environmental impact(s), barriers to diffusion and institutional mechanism(s) to implement such projects have also been discussed.

Key observations:
Small wind energy generators (SWEGs) can be used to meet the power requirements of remote locations but in depth studies on the financial viability of SWEGs have yet to be undertaken. For this paper, wind data from 19 sites and cost data from 16 sites are used.
While the annual mean wind speed at a height of 20 m varied from 3.35 m/s to 7.08m/s, the annual output of a 1kW system varied from 292 to 1769 kWh. A 1 kW system with 5 m/s wind speed can deliver about 800 kWh or enough electricity to power 8 houses with 3x18Watt CFL for 5 hours daily.
If the wind speed increases to 7 m/s or higher the number of houses that could be served would be 15 or more. A 1 kW SWEG with an annual average wind speed of 6 m/s is expected to be more than the annual electrical power delivered by a conventional 1kWp PV plant.

With regard to costs, wind energy generators account for 74% of the total capital costs while battery accounts for 9% within the 16 projects which were scrutinized. It is also important to note that there is substantial cost variation in unit capital cost depending on the SWEGs rated capacity. Installing high number of SWEGs together has an impact in lowering specific capital costs.
The unit cost of SWEGs between 1-7.5 kW capacity is in the range of Rs 1,08,694 to 2,10,000/kW making the unit costs higher by about 16% to the capital costs of those in the USA. Similarly for SWEGs of 3.2 and 7.5 kW capacity range the capital cost in India is greater by about 63% to those compared in the USA. However one needs to keep in mind that while the costs in the USA are without battery banks because of grid interconnections, it is not the same for India.
Electricity Cost: The levelised unit cost of electricity is found to be in the range of Rs 28.57 – Rs 170.37/kWh for a 1 kW system. The cost of electricity of a 3.2 kW SWEG running at 10m/s wind speed is Rs 12.72/kWh. Larger sizes and higher wind speeds can reduce costs significantly, for example with a 50 kW system at 10m/s wind speeds, electricity costs roughly Rs 4.67/kWh.
Since these costs are much higher than the prevailing electricity prices, using a capital subsidy route can bring down wind electricity prices significantly. It was found that a capital subsidy support of 50% reduced prices by up to 45%. In remote locations where DG sets are being used, a capital subsidy of 60% on SWEGs will lead to these become competitive assuming that DG's are producing electricity at a cost of 9.22/kWh.

There remain various barriers to diffusion of SWEGs, namely:

a) High capital cost
b) Lack of wind resource mapping
c) Intermittency of wind power
d) Very slow pace of indigenization
e) Lack of repair and maintenance expertise and facilities
f) Lack of testing facilities
g) Lack of standardisation
h) Lack of resource accessibility to project implementers
i) Inaccessibility of maintenance in remote locations
j) Lack of stake holder awareness

MNES is responsible for RE policy formulation including for SWEGs and is also doing the necessary wind resource mapping. Projects are being implemented and sometimes are even owned by the state nodal agencies. The model at this point is highly centralised. What is very important to note however is that SWEGS with the right wind regimes are more viable than solar PV projects and could be therefore exploited before going in for PV.

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Title: Rural electrification of a remote island by renewable energy sources		
Authors: Singal, S.K.,Varun and Singh, R.P.		
Authors' affiliation: AHEC, Roorkee and MIT Mooradabad		
Name of publication: Renewable Energy		
Volume: 32	**Year:** 2007	**Pages:** 2491-2501
Publication/author link: sunilfah@iitr.ernet.in , sunilksingal@gmail.com (S.K. Singal)		

Authors' Abstract

India has a large number of remote small villages and islands that lack in the electricity, and probability of connecting them with the high voltage gridlines in the near future is very poor due to financial and technical constraints. The main electrical load in these villages is domestic. In this paper a study has been presented for sustainable development of renewable energy sources to fulfil the energy demands of a remote island having a cluster of five villages. The total potential of electricity from these resources is estimated to be equivalent to 3530 kWh/day whereas demand is only 2310 kWh/day with an installed capacity of 450 kW, which is sufficient to replace the existing power generation system dominated by diesel operated system.

Key observations:

A techno-economic study is being done in a remote rural island using biogas and biomass gasification and solar PV. The study was conducted in Neil Islands of Andaman and Nicobar. Surveys including door to door provided the following results.

A 400 kW diesel generating plant and a 50 kW solar plant is presently supplying electricity in the Islands, with 472 (81%) of the households being electrified with a connected load of 550 kW. The load consists of 18.4% lighting, 25.3% irrigation pumps, 20.8% industries and other loads, 12.3% load from TV and fans make 9.3% of the total load.

Renewable Energy potential and costs have been calculated from these survey results.

For a biogas system, a net electrical energy generation per day will be 986 kWh. This will mean that a 100 kW DG set will run for 8 hours with 70% diesel substitution. The total capital cost is calculated at 3025000 INR, fuel cost is calculated at INR 4.25/kWh, O&M of 2% of capital cost and a plant recovery factor of 15%. The cost of energy results in Rs 6.39/kWh.

For biomass Gasification net electrical energy generation per day is calculated 2057 kWh. This means that a 150 kW DG set will be operational for 16 hours a day. The plant cost is given by the equation 4.73x10^4(kW)^0.85. Assuming 70% diesel substitution and cost of feed stock is 1.25/kWh the total cost of fuel is calculated at INR 4.25 / kWh. Therefore assuming a plant recovery factor of 15% and O&M of 2% of capital cost, cost of energy comes to Rs 5.04/kWh.

With regard to solar photovoltaic, assuming a 4.2 hours of peak insolation per day the total unit generation for a 100 kWp plant would be 315kWh @ 13% cell efficiency. Taking a mismatch factor of 0.85, battery efficiency of 0.8 and a charge regulator efficiency of 0.9, array load comes to 700 kWh/day and array size of 200 kWp/day. The total number of modules needed is 3600.

Battery sizing has been calculated to need 1152 batteries with 200 Ah capacity each. PV capital cost has been calculated Rs 4,65,63,300. MNES has given a subsidy of Rs 3,10,42,200 INR, the subsidized capital cost is therefore 1,55,21,100. Assuming a plant recovery factor of 15% and a O&M cost of 2% of capital cost, the cost of energy is calculated to be Rs 17.60/kWh

The cost of energy generation from diesel has been calculated at 11.96/kWh.

The authors conclude that not only are the biomass and biogas options cheaper than diesel but the average cost of generation of biomass-biogas-SPV comes to 10.96 Rs/kWh which is cheaper than diesel. Therefore it is suggested that the present 400 kW diesel is substituted by a 100 kW biogas

150 kW biomass and a 200 kW solar PV system.

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Title: Techno-economics of micro-hydro projects for decentralized power supply in India		
Authors: Nouni, M.R., Mullick, S.C. and Kandpal, T.C.		
Authors' affiliation: MNRE and IIT Delhi		
Name of publication: Energy Policy		
Volume: 34	**Year:** 2006	**Pages:** 1161-1174
Publication/author link: tarak@ces.iitd.ernet.in (T.C. Kandpal)		

Authors' Abstract: Results of a techno-economic feasibility evaluation of few micro-hydropower (MHP) projects being planned and implemented for decentralised power supply for remote locations in India are presented. The capital cost of such projects (including cost of power evacuation and distribution system), cost per unit of rated capacity, and relative cost of different sub-systems of MHP projects in the capacity range of 10–100kW have been analysed. Unit cost of delivered electricity for these MHP projects has been estimated. Measures of financial performance for one of the MHP projects have also been determined. Breakeven values for useful life, plant load factor, and unit cost of electricity to the user have also been estimated for the same project.

Key observations:

The authors in the beginning of the article provide background on the electricity generation capacities of different sources in India (year 2003 estimate). They then estimate the share of hydropower generating capacities in the total energy mix of the country and point out that only 17.8 % of the total hydropower potential has been used. The authors are of opinion that small hydropower (SHP) has a great potential in India as most of unelectrified villages are located in remote forest hiily regions where power of hydro sources can be harnessed. The authors point out that in the past SHP and MHP (micro-hydro power) projects faced several technical and managerial issues while operating in decentralised mode. These projects could not supply reliable power due to the problems of maintaining stable generator frequency wherever there was variation in electricity demand from the system. In addition, there were problems of O&M of MHP projcts at remote locations. Most importantly, financial viability of decentralised MHP projects located in remote areas with limited electric load has not been evaluated yet. To find answers to some of the issues relating to techno-economics of some MHP projects (being implemented or planned) in decentralised mode has been presented in this study.

The authors have calculated the costs of MHP projects in India for decentralised power supply. For villages situated in remote and inaccessible areas, the project costs are found to be in the range of Rs.124,310–Rs. 233,335 per kW ($2715–5095 per kW, 1 US$=45.80 Indian Rupees) including the cost of power evacuation and distribution system. These values are comparable to prevailing international costs. The capital costs of MHP projects show some economy of scale in capacity range of 10–100kW. However, it mainly depends on the country of origin of the equipment and some site-specific features (for civil works and T&D network). The unit cost of electricity (UCE) delivered by the MHP projects is a function of the PLF of the plant. For a project up to 40kW capacity in Arunachal Pradesh, the UCE is estimated to be the range of Rs. 4.56/kWh to Rs. 4.92/kWh for a PLF of 40%. For a plant load factor (PLF) value of 30% the UCE delivered is estimated to be in the range of Rs. 6.08/kWh to Rs. 6.56/kWh. On the other hand for MHP projects of 20–100kW capacity implemented/being implemented in Uttaranchal the estimated UCE delivered is in the range of Rs.5.72/kWh to Rs. 8.31/kWh for a PLF of 40%. This may be attributed to higher cost of T&D network for the projects being implemented in Uttaranchal. It may be noted that even with a PLF of 30% the micro hydro- based power option appears to be financially more attractive than the PV based option in terms of the unit cost of delivered electricity. It would also be a financially better option than diesel engine/biomass-diesel dual fuel engine based alternatives.

The report concludes that "a breakeven analysis of a MHP project indicates that the project was found to be financially unviable below a PLF of 34.69%. Integration of small scale industrial and commercial activities requiring electricity with the MHP project's development initiative would therefore go a long way in improving the financial attractiveness of these projects in remote and inaccessible areas. In principle the UCE provided by the MHP projects analysed in this study can be competitive with the average price (Rs. 1.73/kWh) of electricity paid by the domestic sector consumers in 2000–2001, if the cost of grid extension to such remote and inaccessible areas is internalized in the unit cost of grid supplied electricity. However, it would necessitate the provision of a capital subsidy to the tune of 90% of their capital cost. Other suitable incentives and strategies may be considered for providing the requisite motivation to all the stakeholders for harnessing micro-hydro potential in remote locations."

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Title: Comparison of options for distributed generation in India		
Authors: Banerjee, Rangan		
Author's affiliation: IIT Mumbai		
Name of publication: Energy Policy		
Volume: 34	**Year:** 2006	**Pages:** 101-111
Publication/author link: rangan@me.iitb.ac.in (R. Banerjee).		

Author's Abstract :

There is renewed interest in distributed generation (DG). This paper reviews the different technological options available for DG, their current status and evaluates them based on the cost of generation and future potential in India. The non-renewable options considered are internal combustion engines fuelled by diesel, natural gas and micro-turbines and fuel cells fired by natural gas. The renewable technologies considered are wind, solar photovoltaic, biomass gasification and bagasse cogeneration. The cost of generation is dependent on the load factor and the discount rate. Gas engines and Bagasse based cogeneration are found to be the most cost effective DG options while wind and biomass gasifier fired engines are viable under certain conditions. PEM Fuel cells and micro turbines based on natural gas need a few demonstrations projects and cost reductions before becoming viable. A strategy involving pilot projects, tracking of costs and dissemination of information is likely to result in DG meeting 10% of India's power needs by 2012.

Key observations:

While distributed power systems were used in the early times, present systems have moved to large scale centralised planning. In this review comparison is done between the following n**on renewable options, namely** internal combustion engine (diesel), Internal combustion engine (natural gas), Micro turbine (natural gas) and proton exchange membrane fuel cell with reformer fuelled by natural gas with the renewable options, namely wind turbines, solar photovoltaics, biomass gasifier connected to a spark ignition engine and bagasse cogeneration in sugar factories.

Methodology: The annualized life cycle cost is used for comparison. The size of the system considered in a 100 kW peak except for wind and biomass cogeneration which are taken to be in the range of a few MW. When Indian costs are not available, existing international prices have been considered.

Non Renewable Cost of Generation: The author finds that except for cases of very low load factors, the gas engine and micro-turbine options are cheaper than diesel engine. This is mainly because of the difference in diesel and natural gas prices. Comparisons are also done with different discount factors to account for the different consumers. At a 10% discount rate the author finds that the cost of power from the grid is cheaper for load factors greater than 15%. Similarly for discount rates of 30% (private sector companies) diesel engines are preferred at load factors of 20% or less.

For PEM fuel cells estimating a cost of $3000/kW at a 10% discount rate these cells compete with diesel engines at load factors of 70% and higher. At a 30% discount rate PEM fuel cells are not able to compete with diesel engines at any load factors.

Renewables Cost of Generation:

With wind power the average cost of generation at an average load factor of 13.3% was found to be Rs 5.14/kWh. The author concludes that several unviable wind turbines have been installed, which is mainly because of the existing capital subsidy and accelerated depreciation regime. Furthermore wind turbines because of their hourly, daily and monthly fluctuations need to be coupled with the grid back up to meet the requirements of DG. It is also anticipated that for new wind installations better siting and technology will results at load factors as high as 38%.

For Solar Photovoltaics, the average life cycle cost with a load factor of 20% and a capital cost of Rs 200000/kW was found to be Rs 13.66/kWh, while a load factor of 25% gives a cost of Rs 10.98/kWh. For systems that are isolated an additional battery cost needs to be added. The author concludes that if capital subsidies are available then there will be great potential of PV generation plant being set up in remote locations.

Biomass Gasifiers appear to be economically viable compared to diesel engines at load factors of 20% or higher. If biomass is available, it could also work as a dispatchable power plant. Wide spread diffusion might be possible if dedicated land and plantations are available.

For bagasse based cogeneration the author concludes that with a capital cost of Rs 30,000/kW and a load factor of 40%, cost of generation is Rs 2.60/kWh and with a load factor of 60% the cost of generation is Rs 2.27/kWh.

The author concludes that amongst non-renewable generation options diesel engines are prevalent because of low load factors. However in areas where natural gas is available gas turbines will be cost competitive. For PEM and micro turbines demonstration projects will be needed. Among renewable energy technologies wind energy is promising because of the supportive policies. With sites that have 30% capacity factors wind is competitive. Similarly biomass gasifiers have great potential but appropriate engine technologies seem to be a major issue. Solar PV is not a good option for grid connected systems because of high costs, however for remote systems this appears to be the way to go.

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Title: Electricity access for geographically disadvantaged rural communities—technology and policy insights		
Authors: Chaurey, Akanksha, Ranganathanan, Malini and Mohanty, Parimita		
Authors' affiliation: TERI and Jadavpur University		
Name of publication: Energy Policy		
Volume: 32	**Year:** 2004	**Pages:** 1693-1705
Publication/author link: akanksha@teri.res.in (A. Chaurey)		

Authors' abstract: The purpose of this paper is to weigh the issues and options for increasing electricity access in remote and geographically challenged villages in interior Rajasthan, the desert state in Western India where power sector reforms are currently underway. By first providing an overview of reforms and various electrification policy initiatives in India, the paper then analyzes the specific problems as studied at the grass-roots level with respect to rural electricity access and the use of off-grid renewables. Finally, it discusses interventions that could facilitate access to electricity by suggesting a sequential distributed generation (DG)-based approach, wherein consecutive DG schemes—incorporating the requisite technological, financial, and institutional arrangements— are designed depending on the developmental requirements of the community. In essence, this approach fits under the broader need to understand how the three ''Rs''— rural electrification (the process), power sector reforms (the catalyst), and the use of renewable energy technologies (the means)—could potentially converge to meet the needs of India's rural poor.

Key words: Rural electrification; Power sector reforms; Distributed generation

Key points drawn:

The paper presents a case for rural electrification and different types of electrification by giving a case-study of electrifying areas in Rajasthan .It then gives the status of electricity sector in Rajasthan and outlines the key stakeholders in this process of electrification .It has identified five categories of deprivation in the rural areas based on the study namely:

1) "The first category of a deprived population is one that cannot afford the electricity services that come to it at a higher price than its neighbours due to its nonexistence as per national census records(pp.1697)"- in the district studied ,all the villages were reported to be electrified but very few neighbouring hamlets were found electrified which upon scrutiny was found that electrification plans were made only for census villages and a hamlet is neglected until it is recognised as a census village

2)" A second type of deprivation is a situation where the consumers pay for what they do not get" (pp.1697): While the users of electricity pay for the initial electricity connection and also a fixed tariff rate which takes up the bill per month to Rs110-150, the services obtained was not found satisfactory, frequented by blackouts and brownouts.

3) "Yet another type of deprivation exists in certain villages whereby the virtue of their physical location, provision of grid electricity is techno-commercially unviable, and in some cases, prohibited by forest law" (pp.1697). Specific to the case studied, it was found that because of the villages in this region falling within and on the periphery of the national park and wild life sanctuary, the rules and regulations that govern forest affects electrification in these areas. The people living in the sanctuary were encouraged to move out as MoEF prevents transmission lines through the forests and are thus affected due to inability to avail the electricity services.

4)"SHS, whose distribution is managed by the government, is limited in its reach due to paucity of funds and lack of infrastructure. The forth category of deprivation is thus precipitated by the above wherein the population is eager to procure SHS, but supply is inadequate" (pp.1697).

5) "Households that have already invested in SHS now face a problem with respect to repair and maintenance" (pp.1698): There has been unreliability with regards to O&M services due to the terrain and low density of systems and the servicing infrastructure is very poor in these areas as people have to wait for days on end to get a simple problem rectified.

The paper brings in three scenarios:
(a) Wherein there were two villages which were electrified with some users of SHS.
(b) Unelectrified villages (grid electrification technically feasible, but not electrified as yet) with many users of SHS
(c) Unelectrified villages (electrification technically unfeasible) with no users of SHS.

Thus these scenarios bring in groups of people without access to electricity, and they also highlight the practical limitations for grid-based electrification in this region as perceived by the utility and by community. It brings the need to examine alternative technologies for such situations. The paper then goes to outline possible solutions for these areas for electricity provision in inaccessible areas.

While advocating for distributed generation programmes, the paper states that this would be of use for tackling the problems of T&D losses, address peak load shortage and help in rural electrification. The paper also states that although the Govt has accorded an important status for DG systems, there is still no clarity with regards to the types of DG technologies needed for enhancing the process of development in rural areas. DG scheme based on small-scale RET's like SHS is another option which pertains to small isolated communities but are riddled with barriers that include "lack of information about the technology, purported grid extension plans, lack of capital for SHS businesses and consumer financing programs, and lack of trained technicians, managers, and other human infrastructure needed for system delivery and maintenance" (pp.1700). It says that a DG scheme on off-grid mini power plants with localized distribution works well for remote and distant rural areas, forest areas and islands with the socio-economic significance of this scheme carrying higher significance here. DG scheme based on integration with the main grid network is deemed desirable due to the economics of rural electrification and that it becomes viable scenario for market driven business approaches.

While providing a case for the above types of technologies, the paper calls for looking at developing not just technologies but also effective delivery mechanisms of its services. Also it says that technology policies must be aimed at establishing linkages between off-grid electrification and providing value added services and those subsidies can be administered through the "processes of competitive bidding, connections to local bodies, low household connection fee which would encourage electricity service provision and use" (pp.1703).

The paper concludes by advocating for a sequence where the DG scheme is categorized such that it starts from a elementary scheme, namely small-scale household level RET's, and graduates to higher capacity DG (possibly through the establishment of mini power plants, each with their own distribution network) and finally integration of such mini power plants into a localized grid or into the main grid itself.

The paper thus through a case-study method has presented the energy vulnerability in the rural areas and the ways in which this vulnerability can be reduced through effective service and delivery mechanisms using DG technologies in varying capacities according to the geography, population socio-economic profile of the areas.

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Title: Gokak Committee Report on Distributed Generation
Year: 2003
Publication/author link: http://www.powermin.nic.in/reports/pdf/gokak_report.pdf

Key words: rural electrification, distributed power, renewable energy sources, finance, regulations

Key observations:
The report has been published in 2003 and available on Ministry of Power's (MoP's) website. Taking cognizance of the new trends then (economic liberalization, gaps in the supply and demand for electricity in India and restructuring of power sector in India), the Government of India appointed this committee to examine the possible steps towards distributed generation in India with special focus on rural electrification.

The report is divided into 9 chapters. In Chapter 2, the report explains the concept of "*distributed generation (DG)*" by stating thatit *"refers to a variety of small modular power generating technologies that can be combined with energy management and storage systems and used to improve operations of the electricity delivery systems, whether or not these technologies are connected to an electric grid*"(pp. .5). It further adds that DG power technologies are installed for the purposes of reducing overall load through supplemental power generation, obtaining independence from the grid, allowing homeowners/entrepreneurs to generate more electricity than they need and selling their surplus to the grid, and achieving grid support in terms of meeting high peak loads by power companies (pp. 6).

The report also lists the benefits of DG to consumers, the grid and other stakeholders. For consumers, DG will be useful in obtaining reliable and quality power at low cost, while the grid will be benefitted by way of reduced transmission and distribution (T&D) losses, reduction in upstream congestion on transmission lines and better demand side management. The report suggests that DG will help India in reducing peak load shortages, T&D losses, serving remote and inaccessible areas and helping in achieving an overall rural electrification objective (pp.8-9)

Different government definitions of "rural electrification" and the history of setting up the Rural Electrification Corporation (REC) are provided in Chapter 3 of this report. For DG, the authors explain the challenges of technology (immature technologies), resource availability, land availability, climate, policy (frequent changes) and market. The report suggests that people's participation in DG projects is crucial and it can be obtained through local bodies and communities, cooperatives, user associations, NGOs and the Energy Service Companies (ESCOs) working with local communities (pp.28).

The report explains the institutional framework for financing schemes in the power sector from REC, the Power Finance Corporation (PFC), the Indian Renewable Energy Development Agency (IREDA) and the State Finance Corporations, and suggests that an understanding of the role played by each of these financing agencies is essential to understand the gaps in the present framework

The report provides suggestions regarding regulatory framework in dealing DG schemes while pointing out that (pp. 58-60):

1. There is no uniform policy or approach of the regulators with regard to DG schemes
2. DG schemes being extremely location specific cannot be subjected to rigid and uniform rules at least before they establish

3. While determining tariffs for the DG systems, considerations on reduced T&D losses and their typical low load factors should be considered
4. Assured price for buy back power generated by biomass and wind projects by State Electricity Boards
5. Uncertainty of demand for the DG power is the main risk. To reduce this risk, the power from DG units should be wheeled into the grid for sales to third parties
6. The wheeling charges for DG units should be related to reasonable levels of T&D losses of the State Electricity Boards
7. The question of interconnectivity between the state grids and the grids of the DG systems should be resolved on a most urgent basis
8. The report states *"As the entrepreneurs operating DG schemes are extremely venerable to discriminatory behaviour by the incumbent operators in connecting to the T&D grid, the CERC would have to have to establish technical interconnection rules so that DG schemes can be implemented before resolving the broader competition issues that arise on account of their implementation. Considering the overall benefits that accrue to the economy on account of DG schemes, it is imperative that the terms and conditions for the interconnectivity are finalized with the utmost expedition without a final resolution of all competition issues*."

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Title: Sustainability of decentralized wood fuel-based power plant: an experience in India
Authors: Sonaton Ghosh, Tuhin K. Das,TusharJash
Year: 29 (2004) 155–166
Name of publication: Energy
Publication/author link:
Authors'Abstract: In accordance with the long-term policy objectives ofthe government of India for rural electrification, an off-grid woodfuel-based power plant for generation of grid quality electricity has been installed in a remote island of West Bengal. The present study focuses on technical performance of the largest biomass gasifier based power plant in India. Sustainability ofsuch a power plant has been reviewed with respect to diesel replacement, fuelwood supply, cost of electricity generation and pollution load.

Key points drawn:
while distributed power systems were used in the early times present systems have moved to large scale centralized planning. In this review comparison is done between:

Non renewable
internal combustion engine (diesel)
Internal combustion engine (natural gas)
micro turbine (natural gas)
Proton exchange membrane fuel cell with reformer fuelled by natural gas.

Renewable
Wind turbine
solar photovoltaic
Biomass gassifier connected to a spark ignition engine
bagass cogeneration in sugar factories

Methodology

The anualised life cycle cost is used for comparison. The size of the system considered in a 100 kW peak except for wind biomass and cogeneration which are taken to be in the range of a few MW. When Indian costs are not available existing international prices have been considered.

Non Renewable Cost of Generation

The author finds that except for cases of very low load factors the gas engine and microturbine options are cheaper than diesel engine. This is mainly because of the difference in diesel and natural gas prices.

Comparisons are also done with different discount factors to account for the different consumers.at a 10% discount rate the author finds that the cost of power from the grid is cheaper for load factors greater than 15%. Similarly for discount rates of 30% (pvt sector companies) diesel engines are preferred at load factors of 20% or less.

For PEM fuel cells estimating a cost of $3000/kW at a 10% discount rate these cells competes with diesel engines at load factors of 70% and higher. At a 30% discount rate PEM fuel cells are not able to compete with diesel engines at any load factors.

Renewable Cost of Generation

Wind

The average cost of generation at an average load factor of 13.3% was found to be Rs 5.14/kWh. the author concludes that the implication that can be drawn from this is that several unviable wind turbines have been installed, which is mainly because of the existing capital subsidy regime. Furthermore wind turbines because of their hourly daily and monthly fluctuations need to be coupled with the grid back up to ensure that Distributed generation requirements are met. It is also anticipated that for new wind installations better siting and technology will results at load factors as high as 38%.

Solar Photovoltaic

The average life cycle cost with a load factor of 20% and a capital cost of 200000 rs / kW was found to be 13.66. while a load factor of 25% gives a cost of 10.98 Rs/kWh. For systems that are isolated an additional battery cost needs to be added. The author concludes that if capital subsidies are available then there will be great potential of PV generation plant set up in remote locations.

Biomass Gassifiers

Biomass Gassifiers appear to be economically viable compared to diesel engines at load factors of 20% or higher if biomass is available, it could also work as a dispatch able power plant. Wide spread diffusion might be possible if dedicated land and plantations are available.

For bagass based cogeneration the author concludes with a capital cost of 300000 / kWh and a load factor of 40% cost of generation is 2.60 Rs/ kWh and with a load factor of 60% the cost of generation is 2.27 Rs /kWh.

The author concludes that amongst non-renewable generation options Diesel engines are prevalent because of low load factors. However is areas where natural gas is available gas turbines will be cost competitive. For PEM and micro turbines demonstration projects will be needed.

Among renewable energy technologies wind energy is promising because of the supportive policies. With sites that have 30% capacity factors wind is competitive. Similarly biomass gassifiers have great potential but appropriate engine technologies seem to be a major issue. Solar PV is not a good option for grid connected systems because of high costs however for remote systems this appears to be the way to go.

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Title: Rural electrification programme with solar energy in remote region–a case study in an island		
Authors: Chakrabarti, Snigdha and Chakrabarti, Subhendu		
Authors' affiliation: Economic Research Unit, Indian Statistical Institute		
Name of publication: Energy Policy		
Volume: 30	**Year:** 2002	**Pages:** 33-42
Publication/author link: snigdha@isical.ac.in (S. Chakrabarti).		

Authors'Abstract

In the programme of total electrification, centralized supply of power generated by conventional methods using exhaustible resources is proving to be uneconomic and, more importantly, unmanageable so far as supply to rural areas, particularly remote places, are concerned. On the other hand, the decentralised approach based on supply of power produced with renewable energy resources available locally is, for various reasons, gradually being recognised as a viable alternative for such remote places. The present paper attempts to examine, from a broad-based socio-economic and environmental point of view, the feasibility of decentralised solar photovoltaic (SPV) system as a source of power compared to that from conventional sources in a remotely located island. The study, based on a sample survey, conducted in an island called 'Sagar Dweep' in West Bengal, India, shows that within a short spell of time of four years, there have been noticeable improvements and significant impact on education, trade and Commerce, entertainment, health etc. as a result of supply of power from SPV power plants. Productivity levels of some agricultural activities as well as women's participation in different economic activities (at night) other than household work have shown definite signs of betterment. The SPV system is also superior to other conventional systems on consideration of its environmental effects. Thus, on the whole, there seems to be a strong case for the locally installed SPV system in spite of its current unfavourable position in respect of the direct cost of production

Key observations:

The technical feasibility of SPV systems are clear however there is a need to find out about its socio economic feasibility as compared to conventional systems. A cost comparison between SPV, Diesel, and Thermal has shown generation costs to be 26.10, 6.97, and 2.37 respectively. However it is noted that generation systems have a cost of setting up distribution systems when compared we find that diesel systems are unviable when distributing at more than 5km and 10Km for coal. Furthermore the cost of diesel and coal are expected to increase while that of SPV is expected to fall. The use of SPV has environmental benefits that are not added to the economic costs reducing its viability.

The biggest social benefit of SPV systems is the ability to provide power in remote villages where because of high transmission and transportation costs provision of electricity is very difficult.

Case Study Saga Dweep:

- Small SPV plants have been installed at different locations since 1995 serving around 475 consumers in 2000 and meeting about 32% of households of the plant area.
- Primary surveys have indicated that 46% of the households work in agriculture, while the remaining 54% non-agricultural activities.
- 59% of the population is engaged in more than 1 activity.
- These consumers are incurring more that kerosene costs (53 Rs / month) compared to Rs 70 for 3 and 120 for 5 points fixed charge. The scarcity of kerosene and exorbitant diesel cost is the reason for migration to solar power.
- The availability of solar power has ensured that students are able to work at night with study time increasing up to 2.25 h per day in some cases.

- 38% have reported a reduction in cooking time by 1.5h.
- 46% of the sample households support of view that this power will result in an increased income.
- 46% of the households want more power and are ready to pay 6-15 Rs more per month.

The author concludes that while SPV's are economically expensive it increases the quality of life in remote location no better options exists.

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Title: Participatory rural energy planning in India-a policy context		
Authors: Neudoerffer, R.C., Malhotra, P. and Ramana, P.V.		
Authors' affiliation: University of Guelph, TERI and Winrock International		
Name of publication: Energy Policy, Elsevier		
Volume: 29	**Year:** 2001	**Pages:** 371-381
Publication/author link: preetim@teri.res.in (P. Malhotra)		

Authors' Abstract: The problems of fuel insufficiency, over exploitation of biomass resources and poor reliability and quality of energy services available to the rural masses of India continues despite numerous initiatives by the government. These initiatives have largely been in the form of national level rural and renewable energy programmes aimed at improving people's quality of life and reducing the existing pressure on the natural resource base. The programmes have met with limited success on account of several reasons. One of these is the absence of a mechanism for ensuring the genuine participation of the local inhabitants. With this weakness in mind, the Tata Energy Research Institute (TERI) and the University of Waterloo (UW) undertook a joint research project (1994-1997), aimed at developing participatory planning and intervention design methodologies and tools to facilitate public participation and feature a meaningful role for women in rural energy planning. This paper presents the policy implications and recommendations of the work.

Key words: Rural energy; Decentralised participatory planning; India

Key observations:
This paper seeks to focus on the process of participation of people during the whole project process beginning from the planning till the implementation phase. "The research was based on the premise that a definite role for local communities, especially women, in every phase of planning, design and implementation of rural energy programmes would lead to more successful and effective dissemination results "(pp374) .It also calls for interventions based on understanding the local perceptions and past experiences of the people and rural areas.

While explaining the energy scenario in India, which is predominantly biomass based, it outlines the Government roles and policies since the 1970's and has gone on to state the problems due to which these household energy programmes have not reached the desired success rate .It says that limited outreach and poor performance are two main factors affecting the positive implications of these programmes. There has also been limited support for Research and development and product development in case of technology based programmes, while little flow of information between the laboratory and field performance, the choice of options for rural masses remains limited. Another reason affecting the successful implementation is that the actual needs of the people are not considered while making provision for such projects and it remains a top-down approach with fixed budget and fixed targets. Also the" product subsidy" aimed at benefitting the poor has not been quite successful with most poor in rural areas remaining untouched by these programmes. In pursuit of targets, the paper says that hardly is the focus on creating sustainable elements of programme like motivation, quality control, maintenance and repair, community mobilization and capacity building of the people .Another important barrier is the fact that the local people in rural areas are seen only as "beneficiaries" of a particular programme instead of participating wholeheartedly in the community process.

The research was carried out in the villages in Farukh Nagar block, district Gurgaon,Haryana with the various field activities allowing the team to experience the participation process in one village by studying the features of cooking energy system and its implications for the natural resource base, the role of women in the household energy management ,preparing the assessment of needs by various means of stakeholder analysis, community profile ,the problem analysis and intervention designing. In the other village, the impact assessment of biogas technology gave insights into reasons for success of an intervention and the ways to build a successful implementation approach and in another village they studied the impact of unsuccessful intervention.

The paper then moves on to talking of the learning of the research into policy recommendations .This is divided into three areas: programme planning, programme implementation and policy formulation.

- *Programme planning:*

It calls for the planning process to be decentralised from the national level and that it should be participatory to understand rural energy context and planning must be undertaken by the people wherein all the members of the group would be able to sit across and put forth their points and such like structures are created that fosters this equitable participation .This process also calls in for Government planners to be sensitised to local needs and understand the context and geography ,while taking these people as partners and not mere beneficiaries in the process. For the capacity building of the people, tools and institutional support mechanisms are required with the need for NGO 's playing an important facilitating role in the capacity building, community participation ,training for people in rural energy sector .It establishes the importance of local institutions established after the enactment of Panchayati Raj Act giving the Local Self-governing institutions a power to manage its own affairs and says that NGO' s also need to play a greater role in fostering the development of these village institutions.

- *Programme implementation:*

While the development of rural energy plan is the first step in the process, the implementation approach needs to take into consideration the local socio-cultural-economic context .Herein too the paper says that NGO's with their grassroots presence should also be involved actively in the rural development process .The Government here will also play the facilitating process and bring out access to rural people to range of financially and technically sound options .Different types of credit delivery mechanisms have to be established and links have to be established connecting these different mechanisms. Subsidy which is given to the poor households must be decided on the basis of collective decisions by community designating the "poor" households. While the paper talks of participation of women in equal measures in the whole process, it also accounts for the social and cultural norms that exist in Indian society. It says that a trap must be avoided in "over-enthusiasm" for women centered approach .A cautious approach has to be treaded not to earn the disinterest of men by just focusing on the aspect of women empowerment.

- *Policy formulation:*

The paper says that policy makers and planners need to be sensitised to the need for incorporating local knowledge in the process, consider social inequalities based on gender, class and caste in the programme design and help strengthen local governing institutions to take decisions for their areas. It also calls for formulation of policies that specifically encourage the development of rural energy enterprises involving women.

While recognizing the barriers to implementing such rural energy programmes ,the paper cautions that by just incorporating decentralization as the key word does not really ensure participation of people in the truest sense and there is a need to integrate participatory processes into the institutional framework for the systems to run and function effectively and while participatory planning has been said to be time consuming and resource intensive, the paper questions whether the projects have really achieved any critical milestones with the huge resources spent so far and roots for real development calling it indeed a time consuming process Thus participatory planning and participation of the people involved in the project are crucial for the success of any initiative undertaken and the Government and NGO's need to play a bigger facilitating role in ensuring these processes take place .

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Title: Case Studies on Small Scale Biomass Gasifier Based Decentralized Energy Generation Systems
Authors: G. Sridhar, H. V. Sridhar,Basawaraj,M.S.Sudarshan, H. I. Somsekhar, S. Dasappa, P. J.Paul
Authors affiliation: IISC, Mahatma Gandhi Institute of Rural Energy and Development, Bangalore
Year: N.A.
Name of publication: N.A
Publication/authorlink:http://cgpl.iisc.ernet.in/site/Portals/0/Publications/NationalConf/CaseStudiesOnSmallScaleBiomassGasifier.pdf

Authors' abstract: The growth of the economy is directly linked to the availability of quality power. As per the estimates of the Ministry of Power, Government of India [1], there is a power deficit to an extent of 8% in the country. It is planned to mitigate this shortfall by increasing the share of contribution of renewable sources in the energy portfolio. Renewable energy is also intended to be used in decentralized power generation systems in order to mitigate the power crises in the rural areas. This concept of decentralized power generation and distribution has been successfully demonstrated in two villages of India based on Indian Institute of Science (IISc) biomass gasification technology. One of them is a demonstration plant which had operated for more than 15 years in an un-electrified village named Hosahalli in Tumkur district, Karnataka. The other plant is related to the recently installed plant at Kasai village in Madhya Pradesh under the Village Energy Security Program (VESP) of the Ministry for New and Renewable Sources (MNRE), Govt of India. These two are presented as case studies in this paper along with the 5 kWe demonstration model working at the Mahatma Gandhi Institute of Rural Energy and Development (MGRIRED).

Key words: biomass gasification, community

While observing the power scenario in India, the paper notes that "energy situation in rural India is characterized by low quality of fuels, low efficiency of use, low reliability of electricity supply and access, leading to lower productivity from the use of land, water and human effort resulting in low quality of life and environmental degradation"(pp.1).There are continuing efforts to bring in electrification to all the villages and to those villages that cannot be connected to the grid, are to be electrified through a decentralised source .Among the renewables, Bioenergy technologies like biomass gasification are being explored for meeting rural electricity needs. One such technology is biomass gasification which uses locally available bio-resources converting them into a clean gas used in dual fuel or gas engines for power generation.

The paper then presents a consolidation of three case-studies of small –scale power generating units.

Hosahalli Village Gasifier:

A 3.75 kWe biomass gasification coupled to a diesel engine was installed in the year 1988 in the village of Hosahalli, 100kms from Bangalore in Tumkur district, Karnataka. "The project was planned by holding discussions and meetings with the Hosahalli village communities explaining the roles, responsibilities, benefits and the need for their participation"(pp.3) and a role was created for community to participate by way of raising and protecting an energy forest with different plants and was supported by Centre for Sustainable Technologies(CST) from funds from different projects .The biomass feedstock in the initial years came from social forestry plantations in the nearby villages. The gasifier was operated only in the evening hours to provide home lighting and drinking water requirement. Also local youth were trained to tend to minor repairs and they had an active village committee that looked into the management, supervision, protection of forest and ensuring repayment of services. Later the system configuration was increased to 20 kWe and power was provided for irrigation .The paper reports that this project was appreciated by women .But lack of community participation later to address the issue related to increased cost led to a halt in plant operations and the paper notes that even though in subsequent years the grid line was extended to the village, the quality is not comparable to the electricity supplied through the plant.

Kasai Village Gasifier:

The VESP programme of MNRE has the mandate to address the energy requirements of un-electrified villages in Madhya Pradesh, West Bengal and Uttaranchal(pp.7).One of the villages taken up for this project was Kasai ,in Betul district,MP .The electricity is generated in the 2 x 9 kWe gasification plant installed under this project. Electricity is generated using a producer gas engine, which has been specially developed for this purpose. The plant operates for 5 hours a day and currently services like home illumination, street lighting, drinking water supply, and flourmill are being provided and the day-to-day functioning is looked after by the village panchayat .Also local youth have been given training in the operation and maintenance of the plant. The system has been operational for over 10 months and has been giving satisfactory performance.

MGRIRED gasifier:

Mahatma Gandhi Institute of Rural Energy and Development (MGRIRED) is a training center under the Rural Development and Panchayat Raj (RDPR) ministry .The institute has installed various renewable energy technologies for the purpose of demonstration and has a 5 kWe rating open top biomass gasifier coupled to a standard diesel engine. The electricity generated is used for electrifying the administrative block during the office hours.

The paper concludes by saying that biomass gasification technology can be of great use as a decentralised energy which needs local resources, can be managed locally and can help empower lives of people by improving their overall quality of living.

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Title: Decentralised rural electrification: the critical success factors (experience of ITDG)
Authors: Holland, R., Perera, L, Sanchez, T. and Wilkinson, R.
Year:
Publication link: http://www.practicalaction.org/media/download/6548

Authors' Abstract: Rural areas of poorer countries are often at a disadvantage in terms of access to all types of services – roads, healthfacilities, markets, information, clean water. The high cost of providing these services in remote areas has led to new approaches being tried, based on self-help and the private sector rather than traditional government-led solutions. Energy services for household, agriculture and production are no exception. In the case of electricity, which has the potential to improve productivity and provide considerable welfare benefits (lighting, entertainment, etc.) traditional grid extension is no longer seen as the only solution. Decentralised supplies, whether at an individual household level or at community level, are now an established, cost-effective alternative for the two billion rural people who are currently without access to mains electricity.

In many cases renewables provide the most financially attractive means of providing that energy. Supplies may be of a similar standard to grid supplies (mini-grids supplied by diesel or micro hydro) or they may be low voltage household supplies (PV, battery charging).

This review of recent practice draws on ITDG's twenty years' experience of supporting off-grid solutions in Sri Lanka, Nepal, Zimbabwe and Peru in particular and on work by other organisations in other countries, such as Indonesia, Kenya, Vietnam, South Africa. It draws out the generic issues which are likely to be important in any country, but we also include others which are more context-specific on:

· Financing
· Institutional support
· Ownership
· Management
· Local Participation
· Energy Management
· Standards
· Market

ITDG is privileged to have worked with organisations in many different countries, particularly on community micro hydro-electric programmes, more recently on household PV systems, and we acknowledge the many innovative companies, governments and NGOs from whom we have learned.

Key points drawn:
This paper identifies key generic issues based on the field level experiences from off-grid electricity projects in rural areas. The issues identified by the authors have been categorised in the areas of energy services, financing, institutional support, ownership, management, local participation, energy management, standards and market. In the introduction, the paper explains that although electricity access is a basic human right, it is still a distant dream to almost two billion people residing in rural areas of different parts of the world. The authors are hopeful that this situation will improve due to the effective use of decentarlised renewable energy solutions to provide electricity access in rural areas that are being implemented through effective models. As far as the scope of electricity to

provide energy in rural areas, the authors conclude that electricity services suffice "only some of the rural energy needs" such as lighting, entertainment, powering some machines and appliances. Electricity is rarely used to substitute traditional cooking practices. Moreover, according to the authors, electricity access in rural areas does not initiate development, rather it stimulates the development that is already taking place. Thus very poor communities in rural areas, according to the authors, will probably derive significant "social" benefits due to belter lighting and communication, and unlikely to derive much "economic" benefit by having access to electricity.

While explaining the **issues regarding financing** to off-grid projects, the authors explained the difficulties in raising funds. Private investors and conventional banks seldom have little interest financing such projects as rural electrification investment does not offer maximum returns on the investments. Thus private finance to such projects is a complementary loan component to government subsidy and local equity. The authors, based on their experiences of rural electrification projects, are of opinion that the subsidies to such projects should be "smart", that is they should not b "open ended", and they should be available the customers and not to the suppliers.

While explaining **institutional support** to the rural off-grid projects, the authors suggest that such support should be at national level, local level, and more importantly, at an "intermediary" level. The national level support provides the regulatory and legal framework within which this sector will develop. Some of the activities under this level support will include fuel pricing, fiscal incentives for rural investment, import restrictions on generating equipment, etc. The local level support comes at the village where the off-grid project is being implemented which will include local planning, guidelines for a range of options and scope of electrification and tariff setting. The intermediary level support actually provides a link between the national and local level supports with the primary goal of "ensuring that the plans and policies match the needs of consumers". This support can be offered typically by NGOs, government bodies and private contracted agencies.

The authors support the idea that the electrical supply units should **be owned by** the important stakeholders of such rural electrification projects. In this regard, the authors suggest that the public or national utility ownership of decentralised electrification schemes will make sense for larger towns and district headquarters. In villages which are far away from the main grid, its communities will be ideal owners. The option of ownership franchisee to commercial operator by the state utility can also feasible in some cases, according to the paper.

The authors believe that **community participation** in decentralised energy project is a "pre-requisite" which is essential in "ensuring equity and sustainability" of the projects. But, the authors conclude that the success of ensuring effective community participation depends on local culture and community members' involvement. The authors think that "the planning of electrification by a community is best facilitated by someone who can explain the options in simple terms".

The authors insist that the **management of electricity usage** in decentralised projects is very important. For this purpose, they refer to different effective energy management methods, such as use of demand limiters, time diversity for high loads and use of pre-payment meters. The appropriate **technical standards** are also essential to ensure safety and reliability of energy equipment. The role of the associations of manufacturers is very crucial in setting standards and quality assurance procedures.

While elaborating on the aspect of markets for decentralizes rural electrification installations, the authors think that "initial stimulation" to make such schemes attractive to developers, manufacturers and financiers is very crucial. The examples of privatisation of some schemes in Nepal suggest that the new owners were benefited by reducing costs and raising tariffs.

In the end, the paper concludes that rural electrification through decentralised means is highly desirable. However, effective combinations of different technologies, depending on the loads levels in rural locations can be explored. Attention is required to reduce the capital costs of such types of projects. The experiences of successes and failures from different decentralised projects throughout the world should be shared to inform “best practices” in this sector.

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Title: Mero Gao Micro Grid Power
Authors: MGP
Year:N.A.
Name of publication: N.A
Publication/author link: N.A

Author's Abstract: N.A
Key words: low cost electrification, mobile charging
Key observations:

The project by Micro Grid Power (MGP) develops specific micro-grid to provide only for lighting and mobile charging purposes and the design requires 90% less solar power generation capacity per customer compared to traditional solar powered micro grids.MGP distributes power at low voltage direct current; inverters are not necessary, saving power loss due to conversion and reducing maintenance costs. Due to proper design and local factors they will be able to have repayment period in 3 years time.MGP is continually improving it's technical design with the aim of providing better service at lower price .They also intend to find ways in which mobile phone technology can be used to strengthen their base. With such like projects, MGP hopes to ensure clean fuel with income generating opportunities, education of children and they have also identified the demand for lighting from women and have plans to integrate women in their awareness programmes so as to become ambassadors for change and demonstrate the improvement in the lives of people through MGP's services.

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Title: Energy Technologies and Policies for Rural Development
Authors: Amulya K.N. Reddy
Year: 2001
Publication/author link: http://www.amulya-reddy.org.in/Publication/1999_12_ET&PSRD01222002.pdf

Key words: Human Development Index (HDI), energy policies, energy services

Key observations:
In this paper, the author expresses his views on the roles of energy technologies and policies in rural development. In the beginning of the text, the author insists on explaining the goal of energy systems by a clear statement. In his words, "rural energy systems must advance rural economic growth that is economically efficient, need-oriented and equitable, self-reliant and empowering, and environmentally sound."

The author explains that rural energy systems must first promote poverty alleviation to achieve "equity" aspects. Betterment of the life requires improvement in the Human Development Index (HDI) which has three dimensions: equity, empowerment and environmental soundness. The author then discusses the strategies for rural energy systems to achieve the goal of sustainable rural development namely: reduction in arduous human labour, modernisation of biomass as modern energy source in efficient devices, transformation into safe and healthy cooking, provision of safe water, electrification of all homes and promotion of energy generation activities.

After discussing the goals towards which the energy systems strategies should aim at, the author explains the different instruments through which they can be achieved. These instruments or means can be categorised into: government initiatives, market based initiatives and individually as well as community controlled initiatives. According to the author, the government led initiatives often involve bureaucracy, delays and corruption in their implementation schemes, while market mechanism may not be adequate instrument for addressing tasks characterised by low discount rates.

The author further explains the relationship between HDI and energy with the use of a figure. Here the author cautions that for rural energy systems to play the role of advancing sustainable rural development, the emphasis must be on "energy services" and not merely on energy consumption. The energy services can be "direct" (cooking, safe water, transportation) or "indirect" (motors, process heat). The figure showing a plot of per capita energy consumption against HDI shows that in the beginning of the energy consumption, the HDI increases rapidly. After certain amount of energy consumption, however, HDI reaches its plateau limit. This behavior has been explained in the paper through dividing per capita energy consumption into three regions. In the initial narrow amount of energy consumption, HDI increases rapidly with slight increase in the energy consumption ("elastic" region). Further increase in energy consumption leads to gradual but slow increase in HDI ("transition region") and further increase in energy consumption leads to very modest increment in the HDI values ("inelastic" region). Thus the elastic region guarantees direct improvement of HDI.

The author has roughly estimated the energy amount that rural household needs for HDI to increase significantly. Based on his estimates, the author has concluded that only "about 100 watts/capita is adequate to achieve the dramatic revolution in the quality of life corresponding to safe, clean and efficient cooking with a LPG-like fuel and home electrification for lighting, fans, a small refrigerator and a TV".

In selecting energy sources, the author is of opinion that the attention must be focused not only on the supply aspects of the energy system but also on the demand aspects. Some technologies, such as solar PV SHS, may be called as "elitist" and may not be preferred in selecting for providing energy services to rural poor since they cannot afford the costs of solar PV. Here author suggests that despite the relatively higher costs of solar PV SHS, they play important role in improving quality of life and augment income by helping after-sundown activities. In such scenario, solar PV SHS cannot be called as "elitist" technology. Besides, with rapid cost reductions in PV technology, the overall cost of solar PV SHS technology is expected to go down significantly in future.

Regarding the financing of rural energy technologies, the author believes that it is erroneous belief that the poor cannot afford priced basic services without subsidies. It is just a choice of the poor whether they will decide to opt for an alternative way of obtaining the service in preference to their current option.

In the concluding section of the paper, the author shares his views on the policies that are required to overcome the barriers in implementing strategies for rural energy services. According to the author, there should be policies to ensure a "level playing field for centralized supply and decentralised village-level supply and expansion end end-use efficiency improvement. Policies should promote integrated resource planning to identify sources and devices. Policies should promote direct HDI improvement and focus on immediate-term, medium-term and long-term time horizons for technology development and dissemination. Policies should promote "technological advances and organisational learning". Importantly, policies should ensure "people's participation" and enable proper monitoring and verification activities.

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Title: Energy and Social issues
Authors: Reddy, A.K.N.
Year: N.A.
Name of publication: World Energy Assessment: Energy and the Challenges of Sustainability
Publication/author link: N.A

Key observations: The paper attempts to establish a link between how energy strategies have impacts on poverty, women ,population, urbanisation and lifestyles and says that the interconnected nature of issues can enable energy as a contributing factor in solving these problems .While it has been realised that energy is essential for an improved quality of life, for social and economic development ,the current pattern of energy consumption is not sustainable and can be seen in the economic inequality between developing and developed nations and between the rich and poor in these nations. With the "supply-obsessed approach", the appetite for energy exceeds the capacity of local sources of supply, leading to import and export of these resources which then takes form of oil politics, control over resources and having deleterious effects on the environment.

"Poverty is said to be the most fundamental reality in developing countries"(pp.43).Poverty is not only the lack of money but lack of access to basic necessities and the "energy dimension of poverty is the absence of sufficient choice in accessing adequate ,affordable, environmentally benign energy services to support economic and human development"(pp.44).Income poverty leads to use of unclean and traditional fuels for cooking which leads to health issues and lowers the quality of life especially for women and children. It also influences a household's choice of which energy carrier is to be used .The "energy ladder" presents that wood, dung, biomass are on the lowest rung on the energy ladder whereas charcoal ,coal, kerosene represent higher levels and LPG and electricity being the highest level in the ladder. Poor households also may apply high discount rates to fuel consumption decisions and would prefer fuel carriers that involve lower up-front costs .This energy poverty also manifests in lower investments as they pay more for daily energy needs ,expenditure on health ,and lowers their overall quality of life .The paper offers that cost-effective improvements in energy efficiency have considerable potential to reduce poverty .Also energy carriers other than biomass or biomass used in modern ways can lead to health improvements which gives a cumulative effect on health, savings ,children being able to go to school. It calls into use the 1 kilowatt per capita scenario wherein if the most energy efficient technologies are implemented ,1 kilowatt per capita would be required for people in developing countries to access a decent standard of living as that if Western Europe in 1970's.

Poverty, lack of energy and women's woes go hand in hand .As the survival of people in developing countries depends on biomass based resources ,these have to be procured by women which has adverse health impacts like cuts ,falls ,back injuries .Also burning of firewood leads to indoor pollution which affects rural women and children the most."Fuel scarcity has wider implications. Women may be forced to move to foods that can be cooked more quickly or to eat more raw food. Such a shift can have health repercussions for the whole family, especially children"(pp.49).Energy scarcity also forces women to expend greater time and effort on survival activities which leaves less time for economic activities and keeps them away from getting education. Energy, the paper believes can be a vital entry point for improving the position of women in the society. Enhancing their access to affordable, clean energy resources would help remove the drudgery they face and can also improve their health, education and nutrition status.

Population and energy also have a linkage wherein the larger the population, the larger is the energy required. Also the "patterns of energy consumption in rich industrialised and poor developing countries and the rich and poor within developing countries are such that the industrialised countries and the rich within developing countries have due to their energy intensive consumption patterns ,a greater per capita impact on global atmosphere"(pp.51).There is a view that energy can play a key role in accelerating the demographic transitions, particularly by achieving dramatic reductions infertility to stabilise global population.

There is also a rapid rise in urbanisation which in turn is associated with a rise in energy demand. Urbanisation and excess energy usage is becoming a main cause for the unsustainability of human settlements and the environment. But, "urban areas offer potential for easing the demand for energy-intensive materials and increasing the efficiency of resource use"(pp.56).Energy interventions in the household level like labour –saving appliances ,energy efficient lighting can improve the quality of life while decreasing the negative aspects of urbanisation .There is an increasing need for awareness ,education for changing the wasteful patterns of energy consumption and to change to greener sources of technology.

Thus the paper while drawing connections between energy and the social dimensions ,the current consumption patterns which aggravating global problems calls for the role of energy to contribute in solving problems of poverty, situation of women, population growth .For poverty alleviation ,the energy strategy of universal access to adequate ,affordable modern energy services will help. Similarly the role of energy has been established in the case for improving the lives of women, for controlled population, alleviating negative aspects of urbanisation and bringing in positive aspects.

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Title: Community Based Micro – Hydro Power Plant Power to the People: The Putsil way
Authors: Gramodaya
Year:
Name of publication: N.A
Publication/author link: N.A

Key words: micro-hydro ,income, natural resources
Key observations:

Putsil village in Orissa has a micro-hydro plant of 25 kW and at present it generates 10kW by using cross flow turbine, sufficient to meet the energy requirements of 80 families to operate home lighting, run entertainment system (like television and radio set) and run mill and machines to grind and extract oil, and operate woodcrafts lathe. An average charge of Rs20 is levied which is flexible and they have an option to pay less during lean season and more when the incomes are more. This does not put pressure on the economic resources of the households. The report notes that this project has led to increase in income, work sharing, leisure time, community initiatives; sanitation and cleanliness; awareness and empowerment; management of local natural resources, forest protection, sustainable practices of land utilisation. It has also helped women in improving the quality of their lives overall.