FINAL REPORT

ON

"POLICY AND REGULATORY INTERVENTIONS TO SUPPORT COMMUNITY LEVEL OFF-GRID PROJECTS"

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ABBREVIATIONS

ABPS Infra	ABPS Infrastructure Advisory Pvt. Ltd.
BM	Build and Maintain
BOM	Build, Own and Maintain
BOOM	Build, Own, Operate and Maintain
BPL	Below Poverty Line
CA	Central Agency
CERC	Central Electricity Regulatory Commission
CFA	Central Financial Assistance
CO2	Carbon Dioxide
CPA	Central Procurement Agency
CUF	Capacity Utilization Factor
DDG	Decentralized Distributed Generation
DISCOM	Distribution Company
DRDA	District Rural Development Agencies
EA	Electricity Act
ESCO	Energy Service Company
ETC	Evacuated Tube Collector
FIT	Feed In Tariff
FOR	Forum of Regulators
FPC	Flat Place Collector
GBI	Generation Based Incentive
GDP	Gross Domestic Product
GEF	Global Energy Fund
GHG	Green House Gas
GLS	Generation Link Subsidy
GoI	Government of India
GW	Giga Watt
HH	House hold
IREDA	Indian Renewable Energy Development Agency
JNNSM	Jawaharlal Nehru National Solar Mission
kW	Kilo Watt
LED	Light Emitting Diodes
MNP	Minimum Needs Programme
MNRE	Ministry of New and Renewable Energy

MoP	Ministry of Power
MU	Million Units
MW	Mega Watt
NAPCC	National Action Plan on Climate Change
NEP	National Electricity Policy
ODGBDF	Off Grid Distributed Generation based Distribution Franchisee
PD	Project Developer
PV	Photo Voltaic
RE	Renewable Energy
REC	Renewable Energy Certificate
REDB	Rural Electrification Distribution Backbone
RET	Renewable Energy Technology
RGGVY	Rajiv Gandhi Grameen Vidyuti Karan Yojana
RLB	Rural Local Body
RPO	Renewable Purchase Obligation
RVE	Remote Village Electrification
SHP	Small Hydro Power
SLDC	State Load Dispatch Centre
SNA	State Nodal Agency
SPV	Solar Photo Voltaic
T&D	Transmission and Distribution
TOR	Terms of Reference
UERC	Uttarakhand Electricity Regulatory Commission
UNDP	United Nations Development Programme
VESP	Village Energy Security Programme
WB	World Bank

1 INTRODUCTION

This chapter outlines the scope of this assignment titled "Consulting Services to Support Community Level Off-Grid Projects through Policy and Regulatory Interventions", along with our Approach and Methodology adopted for execution of the assignment. This includes assessment of various renewable energy (RE) technology options, review of various policies and regulatory issues, and identification of potential business models for supporting off-grid projects through policy and regulatory interventions along with institutional and implementation plan.

1.1 Background of the Study

Since independence in spite of achieving substantial increase in electricity capacity additions in the last six decades, demand has outstripped supply in India. This is mainly because of rapid economic growth, urbanization and growing population leading to substantial energy and peak shortages that have consistently remained above 10% level. It is estimated that as a result, diesel based captive generation of the order of around 20% of the present grid connected capacity is in operation to meet the deficit. In addition to peak shortage, electricity spread is an equally serious issue with little or no commercial energy access to more than 40% of the population for their living and livelihoods, while others too have to cope up with insufficient and erratic power supply with increasing unscheduled load shedding. As a result vast rural population still has to depend on kerosene and diesel for meeting their lighting and for powering irrigation pumps and small enterprises. This not only deprives them of the basic human need for quality of life but also of productive activities and incomes and employment hampering development .

With continuously increasing energy shortages, it is difficult to expect significant improvement in energy access situation in near future. Though India has embarked upon an ambitious programme of rural electrification viz. RGGVY, which may expand the grid connectivity rapidly to several uncovered areas, the actual supply of electricity through the established grid would still remain unpredictable and limited. Therefore providing accessible, affordable and acceptable energy ensuring energy security for the poor would continue to be a major issue and problem.

Despite very low per capita GHG emissions, by virtue of its huge size and accelerating growth rates, India will exert a major influence on global energy investments and carbon trajectories.

Even after more than six decades of independence, only 44% of total rural households in the country are currently electrified while 88 per cent of urban households are electrified. Despite several ambitious programmes aiming 'electricity for all by 2012', the goal is quite far from being achieved in reality.

1.2 Purpose of the Study

Considering importance of electricity from socio-economic perspective, the Electricity Act 2003 contains supporting provisions for rural electrification and de-licensing rural power supply. The government also launched the Rajiv Gandhi Grameen Vidyutikaran Yojana (RGGVY) in 2005 to provide free electricity connections to 2.34 crore rural population below poverty line (BPL) in over one lakh un-electrified villages. The central Government has also notified Rural Electrification Policy in 2006, which identifies support mechanisms for grid connected as well as off-grid electricity solutions for rural population. Recently launched Jawaharlal Nehru National Solar Mission (JNNSM) also has specific targets for off-grid solar power projects in short as well as long term.

In areas remote from the grid and low population density, off-grid energy solutions seem most practical and economical. However, the most off-grid solutions, due to their source and size would be from renewable sources like biomass, solar, hydro or wind. Even with many government as well as non-government programmes and schemes in place, offering solutions ranging from policy support to fiscal support, India has a large population without adequate access to electricity.

On this backdrop, Central Electricity Regulatory Commission (CERC) and Forum of Regulators (FOR) are interested in evaluating possible options under the regulatory framework to support off-grid RE programmes thus enabling electricity access to a large section of society. The present work, supported by Shakti Sustainable Energy Foundation (SSEF) is thus aimed to provide analytical support to CERC/FOR to provide inputs and specifically focus on the measures that can support community off-grid renewable energy projects through possible policy and regulatory interventions.

1.3 Scope of Work

The Scope of Work as per the Terms of Reference is as given below:

- Background research and analysis of various government and non-government schemes and programmes available/applicable to India for supporting off-grid RE generation and distribution projects. Also capture key global best practices and innovative ideas.
- Broad RE technology options available (at least including wind, hydro, biomass, and solar) to serve off-grid markets and their sustainability analysis (generic analysis wherever feasible, or else based on specific case studies)
    - Capital costs and operational costs
    - Cost of generation and tariff requirements
    - Cost of balance of system (including distribution system) & their impact on tariff
    - Analysis of existing gap (viability gap) between the required user fees for viability and the capacity/willingness of the consumers to pay
    - Means to fill up the viability gap (capital subsides, revenue subsidies, RECs, cross subsidy by utility etc.) with brief details of each and possible ways to harmonize such various options
    - Impact of existing programmes and schemes on tariff
    - One Indian case study of each technology type to be examined in details
    - Key global best practices with a particular focus on ensuring tariff comfort for the users
- To expand on a few viability gap funding / filling options identified above, assess the possible policy and regulatory interventions with the off-grid projects
    - Existing global best practices
    - Learning for India
    - Policy decisions required for annuity based capital subsidy models or for generation based incentives (GBI) through concerned utilities
    - Analysis of key stakeholders in current REC regime and their potential counter-parts for the off-grid markets, with specific focus on monitoring, verification and validation protocols
    - Possible institutional structures including assessment of various stakeholders and role they can play in supporting off-grid projects e.g. utilities supporting off-grid through franchisee models. Regulatory interventions required (if any) including modifications to REC guidelines, need for new regulations etc.

- Expand in details on the possibility of integrating renewable energy certificates (RECs) scheme with off-grid projects capturing all above (3a to 3f) aspects.
- Eligibility requirements for projects to be considered for identified regulatory support:
  - Service obligation requirements
  - Reporting requirements
  - Monitoring and verification requirements
  - Administrative and institutional arrangements to establish regulatory compliance
- Possible regulatory interventions to ensure grid integration of RE project in case of grid reaching the location during life of the project. This should be at the option of RE project developer and is to ensure that he project does not become redundant. The possible grid integration mechanisms need to be worked on technical as well as regulatory aspects including:
  - Model grid connectivity protocol
  - Tariff/REC adjustments
  - Institutional mechanisms
- Assistance for public consultation process, if any, including summary of objections raised and responses thereto (objections summary).

1.4 Approach & Methodology

Providing access to modern energy source like electricity to last mile access villages which remained un-electrified so far despite several programmes (ongoing and past) is a challenge and needs innovative and approach based on vision and learning from past and leveraging on evolving supportive conducive policy and regulatory environment by government. Therefore for this assignment ABPS Infra adopted quite elaborative approach of visioning, strategising, analysis and detailed planning as summarized in the figure below.

Figure 1.1: Overall Approach and Methodology Framework

This approach and methodology framework of ABPS Infra, for evolving possible viable solutions for large scale deployment of off-grid projects to achieve goal of electricity for all, is based on visioning, designing and planning and institutionalization of implementation mechanism with thematic vision of **OFFGRID** "**O**perational **F**inancially viable **F**lexible **G**rid compatible **R**enewable systems **I**ntegrated with **D**istribution management".

In order to provide specialised focus to the various important components of the ToR with optimised use of the skills and experience available within the organization, various activities were regrouped into following five task groups drawing upon the skills, expertise and experience available within its team for the above tasks with broad allocation of the scope of work among these task groups is as follows:

A. Policy Task Group
- Review & Study of existing Policy framework & schemes at national level for rural electrification & distributed RE generation
  - MNRE VESP, MNRE – Off-grid solar guidelines
  - MOP – RGGVY & DDG scheme

- Analysis of Capital Subsidy & Interest Subsidy & Eligibility Conditions under various schemes.
- Review & study of International Policy framework & schemes for rural electrification & distributed RE generation
  - Salient features of key policy support & regulatory instruments
  - Key learnings: feasibility, governance structure, implementation issues etc.

B. RE Technology Task Group

- Evaluation of RE Technology Options & key considerations for deployment of small/off-grid RE systems (Wind, Biomass, SHP, Solar etc.)
- Integrated Operations – connectivity, distribution requirements
- Guidelines for Modular & flexible planning approach
- Establishment of Standard System Design tools
- Assessment of Capital Cost & Operating Cost

C. Regulatory Task Group

- Identification of Key Regulatory issues
- Review & modification of existing regulations
  - RPO & REC Regulations
  - RE Tariff Regulations
  - Open Access Regulations & SOP Regulations
  - Regulatory Compliance Monitoring & MIS framework
  - Licensee Obligation: Rural Electrification Plan
- Regulatory Challenges for Integration into REC framework
  - Denomination & registration aspects
  - Monitoring & Verification

D. Distribution Task Group

- Distribution Arrangement
  - Typical consumer profile & consumption pattern analysis
  - Typical unit size, modular requirements
  - User fee/charge analysis - Willingness & capacity to pay
  - Franchisee arrangement, role of entities including distribution licensee

- Guidelines for identification & prioritization of distribution circles/divisions/villages

E. Institutional Structure Task Group
- Formulation of Institutional Structure Requirement
- Role for various Entities for Implementation
- Participation of Village level entities, private sector entity
- Governance Structure

While the task group approach focused on specific tasks, all the groups worked together to undertake distinct modules during the development of policy and regulatory interventions for promotion of community level off-grid RE projects through following steps:

Step 1: Situation Analysis
At the beginning of the assignment, assessment of present status of rural electrification with specific reference to Off-Grid approaches was carried out by gathering insights from existing initiatives, identify the lacunae, if any, which will be useful in charting out overall methodology and areas for regulatory intervention to be focused at, in order to achieve our objectives outlined above.

Step 2: Analysis of policy framework & regulatory regime (domestic & international) (Group-A)
In this step we have undertaken a comprehensive review of prevalent regime & schemes under operation in an effort to gain insights into the difficulties/challenges encountered in their implementation to help in identifying key elements for regulatory intervention. These included Policy for rural electrification and stand-alone systems, Rajiv Gandhi Gramin Vidyutikaran Yojana (RGGVY) and Decentralised Distributed Generation (DDG) scheme of MoP, Village Electrification Supply Programme (VESP) and Guidelines for Off-Grid Solar power systems & applications by MNRE as well as Regulations & Orders by CERC/FOR/ related to Renewable Energy Certificate Mechanism and various State level notifications for Rural Areas under Section 14 of EA 2003.

Step 3: Evaluation of RE Technology options for Off-Grid applications (Group-B)
As a part of this activity, considering diversity of resource mix across various states in India and multiple rural energy supply options based on renewable energy technologies such as biomass/biogas, wind, small hydel, solar, hybrid etc, assessment of feasibility of these

technologies was carried out for large scale deployment in Off-Grid applications. Key considerations for assessment included: Minimum unit size/modular nature, generation profile and flexibility, seasonal operation, ability to address daily variation, grid connectivity & integrated operation issues, capital cost and operating cost considerations, requirement of skilled manpower for maintenance and operations, availability of spare parts etc.

Step 4: Identification of challenges for commercialization – financial viability issues (Group-B)
After assessing and short-listing feasible renewable energy technology options for off-grid applications, their financial viability was evaluated through development of a financial model to compute cost of generation taking into consideration available fiscal and financial incentives under ongoing programme as well as without it and comparison of the same with the cost of supply by utility in the region. The financial model was also used to assess the funding requirement for a particular technology option in terms of difference in cost of generation vis-a-vis current cost of supply. Additional revenue stream is also considered in terms of number of RECs that can be issued to a particular technology option at a floor price of non-solar REC or Solar REC, as the case may be.

Step 5: Evaluation of regulatory intervention measures & strategies (Group-C)
As a part of this activity, we undertook identification of key regulatory issues with regard to determination of tariff for supply under off-grid supply as per rural electrification policy, areas for modification of existing RPO/REC, RE Tariff regulations, Open Access Regulations & SOP Regulations, regulatory Challenges for integration into REC framework such as denomination and banding linked to RE technology, accreditation/registration issues, monitoring & verification protocol & procedures.

Step 6: Distribution Management issues & Implementation Models (Group-D)
This essentially included evaluation of various issues, based on field visits as well as analysis of secondary information, various case studies and based on past experience of team on off-grid projects, influencing management of local grid and exploring various options available for distribution management in off-grid mode. This included typical off-grid village and consumer profile and consumption pattern analysis, requirement of typical Unit size, modular requirement to cater to expanding load requirement, willingness to pay. Also insights gathered through several market models and ownership models being explored in field in different parts.

Step 7: Institutional Arrangement & Governance Structure (Group-E)
As a part of this activity, we have developed various business models to overcome the financial gap between cost of off-grid energy supply from shortlisted renewable energy technology options and revenue based on prevailing tariffs in the region. Based on consideration about various merits and de-merits of each option with regard to simplicity, role of various entities in implementations, complexities in modifications in prevailing regulations required a possible business model and institutional structure has been proposed for possible future implementation.

Step 8: Develop an Implementation Plan for roll out of Off-Grid RE applications (Group-E)
Under this step we have detailed out an implementation plan for shortlisted business model and institutional structure specifying the measures to be taken by CERC/FOR/SERCs and State Utilities for its implementation along with the critical issues and events that would need to be prioritized to ensure a speedy and effective implementation.

1.5 Outline of the report:

This report covering various areas of the current research study has been divided into following structured chapters as outlined below:

Chapter 1 presents the background, purpose, scope and approach adopted during execution of the consultancy support for development of policy and regulatory interventions for supporting community level off-grid projects .

Chapter 2 presents the overview of rural electrification in India giving status and challenges along with various issues that need to be covered in order to set framework for approach and methodology for carrying out the assignment.

Chapter 3 presents the overview of statutory and regulatory framework for promotion of renewable energy and rural electrification in India. This chapter also discusses about the overview of various regulatory issues in rural electrification and especially with regard to providing electricity access in remote un-electrified areas and related to recently implemented REC (Renewable Energy Certificate) mechanism along with possible suggestions to overcome them during proposed policy interventions.

Chapter 4 presents the overview of rural electrification policies in international perspective and tries to capture learnings from other policy interventions explored worldwide specially in developing countries.

Chapter 5 highlights the various renewable energy technology options for off-grid electrification projects viz. solar photovoltaic, micro hydro, biomass and solar-wind hybrid. Details about resource availability/requirement, present status of technology, specific requirements and suitability for off-grid application are also given here in this chapter.

Chapter 6 presents the various issues related to distribution of power under off-grid mode which need to be considered in advance such as typical village, consumer profile, their present energy use pattern, potential load demand and willingness to pay for electricity services. It also tries to capture learning gathered from various field visits as well as teams past experience on large number of off-grid projects-programmes and various case studies in different parts of the country as well as abroad.

Chapter 7 presents the financial analysis of shortlisted RE technology applications to arrive at cost of electricity generation in off-grid mode with prevailing available government financial incentives as well as without it under prevailing realistic operating parameters.

Chapter 8 presents the various business models along with their merits and de-merits as well as financial analysis to arrive at cost of energy supply in off-grid mode which has been done with technology specific financial assistance provided under prevailing government programmes and schemes and also without it so as to get economic cost of electricity supply.

Chapter 9 highlights the detailed discussion of the Off Grid Distributed Generation based Distribution Franchisee model, the operation structure of the model, roles and responsibilities of the key stakeholders, implementation plan etc.

Chapter 10 presents the conclusion of the study. It highlights specific actions that need to be taken by CERC/FOR/SERCs and State Utilities for implementation of the proposed business model.

2 POWER AND RURAL ELECTRIFICATION SCENARIO

This Chapter begins with the background emphasising importance of energy, electricity and further gives detailed scenario of India with regard to power generation, distribution and rural electrification.

2.1 Overview of Indian Energy sector

Energy use facilitates all human endeavour, as well as social and economic progress. Therefore production and consumption of sufficient energy is considered to be one of the main challenges for economic development. The magnitude of energy consumed per capita has become one of the indicators of modernization and progress of a country. Thus, energy issues and policies are strongly concerned with increasing the supply of energy. Although energy fuels economic growth, and is therefore a key concern for all countries, access to and use of energy vary widely among them, as well as between the rich and poor within each country. In fact, two billion people (one third of the world's population) rely almost completely on traditional energy sources and so are not able to take advantage of the opportunities made possible by modern forms of energy. Moreover, most current energy generation and usages are accompanied by environmental impacts at local, regional, and global levels that threaten human well being now and well into the future.

India's per capita energy consumption is very low, as are its per capita emissions of greenhouse gases—both currently and historically. Yet merely by virtue of its size and growth, India is expected to exert a major influence on global energy investments and carbon trajectories. Only 44 per cent of the total rural households in the country are currently electrified while 88 per cent of urban households are electrified. With 75 percent of its population living at income levels of less than $2 a day, India has set an ambitious target of eradicating poverty by 2031 through sustained economic growth of 8 to 10 percent per year. India also hopes to bring electricity services to all of its population by 2012.

In order to keep pace with its rapidly developing economy coupled with social changes, increasing pressure on energy demand, India would be facing a formidable challenge to build up its energy infrastructure. In recent years the energy requirements are rising very sharply and this trend is likely to continue in near future too in view of India's strong economic and population growth as well as by changing lifestyle patterns. The Planning Commission has estimated that the commercial energy supply would have to be increased by at least three to four times by 2031–2032 and the electricity generation capacity by five to six times over 2003–2004 levels if India has to maintain its GDP annual growth of 8%. Such a massive increase would require a fundamental restructuring of the entire power market within the country and the government has initiated the process through enactment of the Electricity Act but still achievements are far from expectations or requirements.

Over decade, India's share of the global commercial energy consumption increased from 2.9% to 3.8% making it the fifth largest consumer of commercial energy. With more than half the commercial energy supply, coal is by far the most important energy source for India followed by Oil, which is mostly imported. Nuclear and renewable energy play a minor role, though its share is projected to increase significantly in future. It is to be noted that approximately 139 million of the total 194 million households in India (72%) are using traditional forms of energy such as firewood, crop residue, wood chips, and cow dung cakes for cooking which has not been included here as a source of energy.

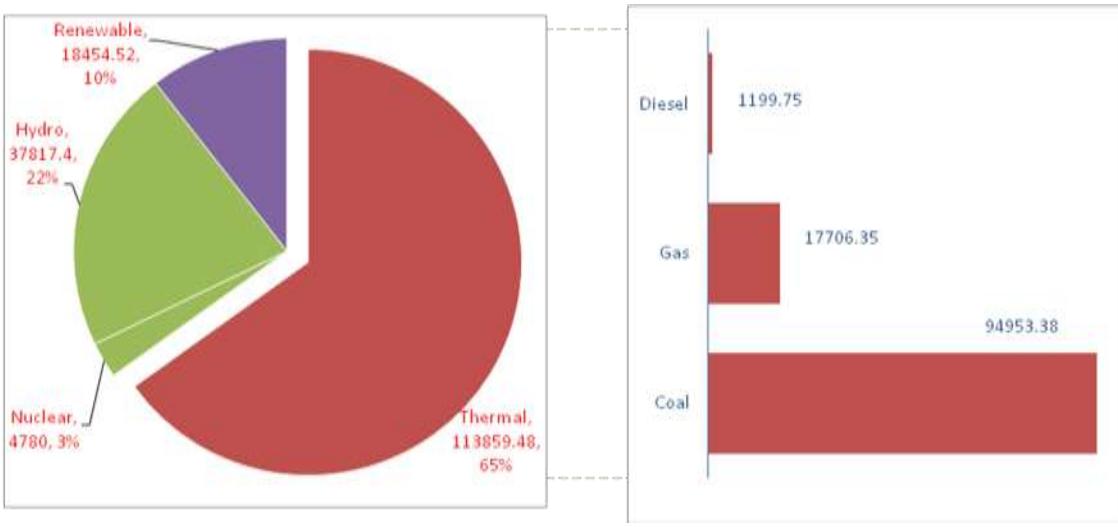
2.2 Indian Power Market

With growing economy the power infrastructure has not kept pace with the growing requirements and therefore India's power market is confronted with major challenges regarding the quantity as well as the quality of the electricity supply. In order to match the growing power demand there is a need to double its total installed capacity and also ensure a stable supply of fuels from indigenous and imported energy sources. With growing economy and lifestyle there is need to provide power to millions of new customers as well as there is need to provide cheap power for development purposes of rural areas to expand the access of electricity to achieve goal of electricity for all as well as eradication of poverty. With deteriorating global as well as local environment scenario and increased pressure to contain its adverse impact, expansion of supply would have to be achieved while reducing emissions.

2.3 Power Generation Capacity

The current total power generation capacity in India was about 175GW in May 2011 excluding about 20GW captive power plant installations. Thermal power (coal, gas, and diesel) still dominates the Indian power sector with installed capacity of 114GW (65.1%) followed by hydro power (38GW, 21.6%), nuclear power (5GW, 2.7%), and renewable energy (18.5GW, 10.6%) as represented in the figure below.

Figure 2.1: Installed generation capacity (MW) as on May 31, 2011



2.4 Power supply position

Even during the year 2010-11, despite increased total ex-bus energy availability and increased 'peak met' over the previous year, the shortage conditions prevailed in the country both in terms of energy and peaking availability. All the regions in the country namely Northern, Western, Southern, Eastern and North-Eastern regions continued to experience energy as well as peak power shortage of varying magnitude on an overall basis. The energy shortage varied from 4.3% in the Eastern region to 13.3% in the Western region. Region-wise picture in regard to actual power supply position in the country during the year 2010-11 in energy and peak terms is presented in the below table.

Table 2.1: Region wise power supply position during 2010-11

Region	Energy			Peak		
	Requirement (MU)	Availability (MU)	Surplus/Deficit (-) (MU)	Demand (MW)	Met (MW)	Surplus/Deficit (-) (MW)
Northern	258,780	237,985	-20,795 (-8.0%)	37,431	34,101	-3,330 (-8.9%)
Western	268,488	232,871	-35,617 (-13.3%)	40,798	34,819	-5,979 (-14.7%)
Southern	229,904	217,981	-11,923 (-5.2 %)	33,256	31,121	-2,135 (-6.4%)
Eastern	94,558	90,526	-4,032 (-4.3%)	13,767	13,085	-682 (-5.0%)
North-Eastern	9,861	8,992	-869 (-8.8%)	1,913	1,560	-353 (-18.5%)
All India	**861,591**	**788,355**	**73,236 (-8.5%)**	**122,287**	**110,256**	**12,031 (-9.8%)**

2.5 Renewable Energy Status

India achieved a cumulative installed capacity of 10.161GW of renewable energy By the end of the Tenth Plan (2007), and is targeted to achieve total installed grid-connected renewable generating capacity of over 25GW and 74GW by the of 12th and 13th Plan; with wind and solar expected to account for more than 80% of the installed renewable power. The table below presents the cumulative & targeted capacities of different renewable energy technologies in India.

Table 2.2: Development of grid connected Renewable Power

Technology\Plan	Cumulative by end of 9th Plan through 2002	Cumulative by end of 10th Plan through 2007	Anticipated by end of 11th Plan through 2012	Targeted by end of 13th Plan through 2022
Wind	1,667 MW	7,082 MW	17,582 MW	40,000 MW
Small Hydro	1,438 MW	1,958 Mw	3,358 MW	6,500 MW
Biomass	368 MW	1,118 MW	3,218 MW	7,500 MW
Solar	2 MW	3 MW	1,003 MW	20,000 MW
Total	3,475 MW	10,161 MW	25,161 MW	74,000 MW

The cumulative installed renewable power generating capacity in India was around 20 GW as of June 2011. Wind energy contributes maximum share with over 14GW capacity followed by small hydro (3GW) and biomass (2.7GW both biomass power plus bagasse cogeneration) while solar (SPV) contributing 39MW. Among off-grid and captive renewable power systems major contributors are waste to power and biomass (non-bagasse cogeneration) projects along micro hydro (7MW), SPV (69MW) and recently aero-generator hybrid systems (1MW) as summarized in the table.

Table 2.3: Development of various RE Systems

Renewable Energy Program/Systems	Cumulative Achievements (upto 30 June 2011)
Grid Interactive Power	
Wind Power	14550.68 MW
Small Hydro Power	3105.63 MW
Biomass Power	1045.10 MW
Bagasse Cogeneration	1742.53 MW
Waste to Power Urban Industrial	 19.00 MW 53.46 MW
Solar PV (SPV)	39.66 MW
Total	20556.05 MW
Off-grid/Captive Power	
Waste to Energy Urban Industrial	 3.50 MW 70.12 MW
Biomass non-bagasse cogeneration	316.76 MW
Biomass Gasifier Rural Industrial	 14.79 MW 118.84 MW
Aero-Generator/Hybrid systems	1.24 MW
SPV Systems (>1kW)	69 MW
Water mills/micro hydel	6.98 MW 1397 Nos

2.6 Grid Connection and Status

Indian power network had a total length of 7.49 million circuit kilometers in March 2009. Investments have been on decline into the transmission and distribution networks in recent years as compared to the power generation sector. Though the transmission network has improved considerably, the distribution network, however, remains in a poor state. During ongoing Eleventh Plan, the high-voltage network is to be extended by around 95,000 circuit kilometers to a capacity of more than 178,000 MVA and an additional 3,253,773 circuit kilometers to a capacity of 214,000 MVA are to be added in the low voltage area. The latter is has gained importance with the "Power for All by 2012" mission, declared by the Government of India with an ambitious goal of providing power to all Indian villages by 2012 .

2.7 Rural Electrification Status

Being an agrarian country, the Government of India (GoI) views Rural Electrification is a major prime mover for rural development, which is also considered as the basic pre-requisite for all industrial activity and also contributes significantly to increasing agricultural productivity, jobs and income generation activities. Several programmes have been initiated at the national level to promote electrification of remote villages and BPL households through deployment of various renewable energy technologies which include family biogas plants, solar street lights, solar lanterns, solar PV systems, biomass gasifiers and micro-hydro plants. Several programmes and policies have also been initiated that focus on the development of rural energy, economy, and electrification to improve rural livelihood with the help of renewable energy. Despite all such policy interventions across the years, actual performance on rural electricity services continues to be dismal. According to the International Energy Agency, in 2008, more than 400 million Indians did not have access to electricity, with electrification rates of 93.1% and 52.5% in urban and rural areas, respectively. Figures below present the percentage of villages still un-electrified in different states as of March 2010 and the percent of households electrified in different states.

Figure 2.2: Status of rural electrification: Statewise % of un-electrified villages

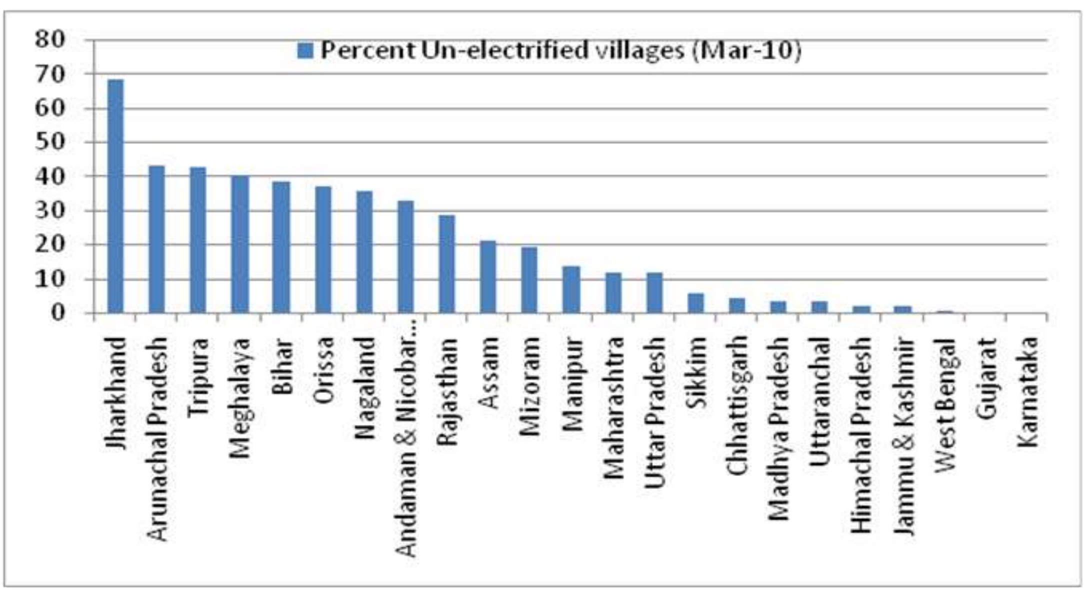
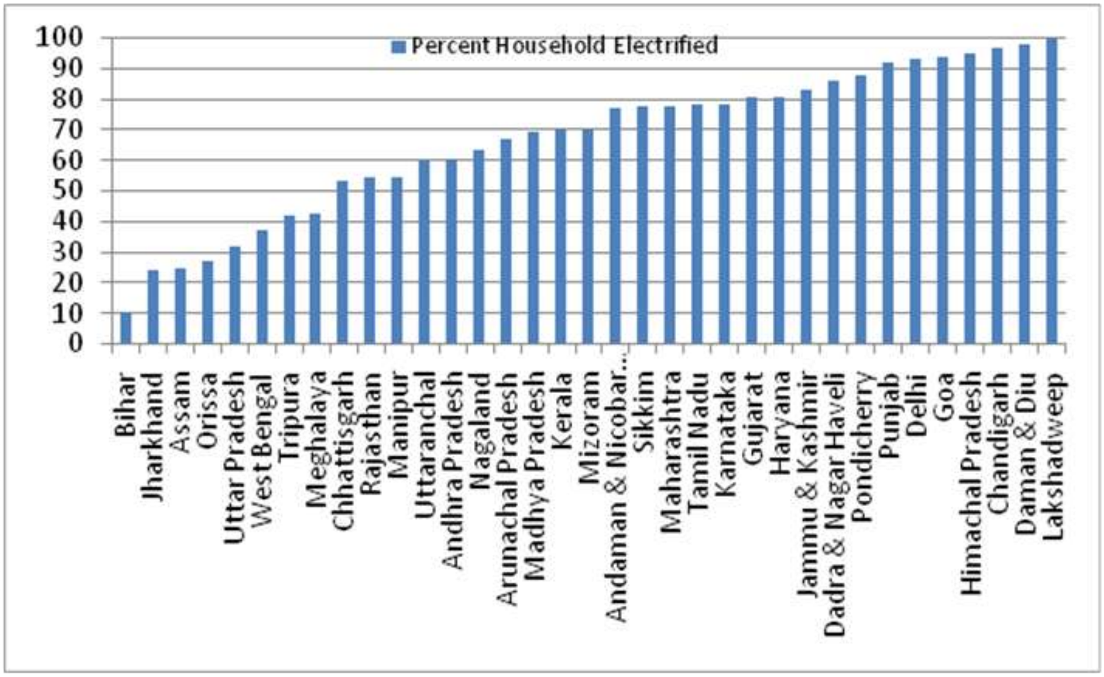


Figure 2.3: Status of rural electrification: Statewise % of households electrified



2.8 Renewable energy for rural electrification

Renewable energy technologies have substantial potential to provide reliable and secure energy supply as an alternative to grid extension or as a supplement to grid power and therefore suitable for electrification of rural and especially remote areas which are still lacking access to modern energy source like electricity; perceived major barrier for rural development. In India, locally available, renewable energy sources such as solar energy, biomass, wind, or hydro energy can go a long way in alleviating the problem of lack of electricity and can play a prominent role in extending access to energy.

The major barrier for large scale deployment of renewable and its utilization for rural electrification is large capital investment and therefore higher cost of electricity generation making it unviable in comparison to subsidized grid tariffs. Also there exists obvious risk of these renewable off-grid installations becoming redundant once grid reaches. Therefore there is a need to develop policy and regulatory interventions that would address these two primary risks, which is the main objective of this assignment.

3 FRAMEWORK FOR RENEWABLE ENERGY AND RURAL ELECTRIFICATION IN INDIA

3.1 Enabling Framework under the Electricity Act, 2003

Enactments prior to the Electricity Act 2003 (EA 2003 or 'the Act') had no specific provisions for promotion of renewable or non-conventional sources of energy. This caused the policies for renewable sources of energy being left to whims and fancies of the State Governments and Electricity Boards. However, the Ministry of Non-conventional Energy Sources (now, Ministry of New and Renewable Energy) attempted to give necessary impetus to sector by way of announcing the Policy Guidelines in 1994-95. These efforts had mixed results in the development of renewable energy sector in the Country.

Similarly, the guiding framework prior to the EA 2003 did not have any specific provision for enabling rural electrification and it was responsibility of State Electricity Boards created under the Electricity (Supply) Act, 1948. However, the initiatives for rural electrification were undertaken following several schemes announced by the National and Local Governments as a part their political agenda. The schemes announced by the Governments, from time to time, have shown mixed results.

The EA 2003 has radically changed legal and regulatory framework for the renewable energy sector. The Act was passed by both Houses of Parliament and made effective from June 10, 2003, making it the single most important piece of legislation for the sector and effectively nullifying all earlier enactments that governed the electricity businesses of the State Electricity Boards, Licensees and other sectoral entities. The Act provides for policy formulation by the Government of India and mandates State Electricity Regulatory Commissions to take steps to promote renewable and non-conventional sources of energy within their area of jurisdiction.

Further, the EA 2003 has explicitly stated the formulation of National Electricity Policy (NEP), Tariff Policy and Plan thereof for development of power systems to ensure optimal utilization of all resources including renewable sources of energy. It has also created several other enabling provisions to accelerate the development of renewable energy based generation. The EA 2003 has also laid special emphasis on the rural electrification. The Act mandates Central

Government to formulate policy permitting standalone systems, including systems based on renewable and non-conventional energy, for rural electrification.

The relevant Sections of EA 2003 are presented below:

a) **Section 3**: This provision empowers the Central Government to formulate two (2) policies, viz. the National Electricity Policy and the Tariff Policy. It also empowers the Central Electricity Authority to prepare National Electricity Plan in accordance with the National Electricity Policy. It mandated the Central Government to prepare the National Electricity Policy and Tariff Policy to ensure optimal utilisation of resources, including fossil fuel, renewable or non-conventional sources of energy.

   The relevant extract of provision of EA 2003 is as under;
   "The Central Government shall, from time to time, prepare the National Electricity Policy and tariff policy, in consultation with the State Governments and the Authority ***for development of*** *the power system based on optimal utilization of resources such as coal, natural gas, nuclear substances or materials, hydro and* ***renewable sources of energy***". ***Emphasis added***

b) **Section 4**: It mandates the Central Government to formulate policies for 'Stand Alone' systems for rural electrification and utilising renewable or non-conventional energy resources. Further, Section 2(63) of the EA 2003 defines 'stand alone systems' as electricity systems setup to generate power and distribute electricity in specified area without connection to the grid.

   The relevant extract of provision of EA 2003 is as under;
   "The Central Government shall, after consultation with the State Governments, prepare and notify a national policy, permitting stand alone systems ***(including those based on renewable sources of energy and non-conventional sources of energy) for rural areas***."

c) **Section 5**: It mandates the Central Government to formulate policy for rural electrification empowering Panchayat Institutions and local community for purchase of power and management of distribution in rural areas. In order to make rural electrification effective, the policy measure shall focus on decentralised distribution of electricity involving Panchayat Institutions, users' association, cooperative societies, non-governmental organisations or franchisee.

Further,

The relevant extract of provision of EA 2003 is as under;

"The Central Government shall also formulate a national policy, in consultation with the State Governments and the State Commissions, for rural electrification and for bulk ***purchase of power and management of local distribution in rural areas through Panchayat Institutions, users' associations, co-operative societies, non-Governmental organisations or franchisees****."*

d) **Section 6:** The Electricity Act, 2003 was amended with this section that obligates the State Government and Central Government to make joint efforts to implement policies for rural electrification.

The relevant extract of provision of EA 2003 is as under;

"The concerned State Government and the Central Government shall ***jointly endeavour*** *to provide access to electricity to* ***all areas including villages and hamlets*** *through rural electricity infrastructure and electrification of households."*

e) **Section 13:** read with Section 5 of the EA 2003 provides that Appropriate Commission, on recommendation by the Appropriate Government shall exempt, local authority, Panchayat Institutions, users' association, cooperative societies, non-governmental organisations or franchisee, from taking licence from the appropriate Commission for distribution of electricity in rural areas.

The relevant extract of provision of EA 2003 is as under;

The Appropriate Commission may, on the recommendations, of the Appropriate Government, in accordance with the national policy formulated under section 5 and in the public interest, direct, by notification that subject to such conditions and restrictions, if any, and for such period or periods, as may be specified in the notification, the provisions of section 12 shall not apply to any local authority, Panchayat Institution, users' association, co-operative societies, non-governmental organizations, or franchisees

f) **Section 14:** provides the framework for generation and distribution of electricity in rural areas. The *eighth proviso* Section 14 read with Section 4 of the EA 2003 provides that a person undertaking generation, based on renewable energy or non-conventional energy sources, and distribution of electricity in a rural area, specified by the State Government, shall not require any licence. However, the measures specified by the Central Electricity Authority may apply.

The relevant extract of provision of EA 2003 is as under;
"Provided also that where a person intends to generate and distribute electricity in a rural area to be notified by the State Government, such person shall not require any license for such generation and distribution of electricity"

g) **<u>Section 61(h)</u>**: It prescribed the philosophy to be followed by SERCs while determining tariffs. It stated that the Commission shall be guided by promotional aspect as regards renewable energy sources. The relevant extract of provision of EA 2003 is as under:

"61. The Appropriate Commission shall, subject to the provisions of this Act, specify the terms and conditions for the determination of tariff, and in doing so, shall be guided by the following, namely:-
…
(h) the promotion of co-generation and generation of electricity from renewable sources of energy;…"

h) **<u>Section 86(1)(e)</u>**: Under Section 86 of EA 2003, the Regulatory Commissions are required to specify obligations of various entities to procure specific percentage of renewable energy out of total consumption of electricity in the area of distribution licensee. The relevant extract of EA 2003 is as under:

"86. The State Commission shall discharge following functions, namely –
(1)
(e) promote cogeneration and generation of electricity from renewable sources of energy by providing suitable measures for connectivity with grid and sale of electricity to any person, and also specify, for purchase of electricity from such sources, a percentage of total consumption of electricity in the area of distribution licensee".

3.2 National Electricity Policy – Aims and Objectives

In compliance with the Section 3 of the EA 2003, the Central Government on February 12, 2005 has notified National Electricity Policy. Significant regulatory developments have taken place since the notification of NEP by Central Government. Various provisions of these Policies in fact, re-emphasize the need for harnessing renewable energy generation and rural electrification. The NEP aimed at increasing per capita availability of electricity to 1000 units by 2012. Further, it also aimed to expand access to supply of reliable and quality power for all households.

The Clause 5.1 of the NEP outlines several measures to address challenges in rural electrification. The relevant extract of the Clause 5.1 is reproduced below,

> *"5.1.1 The key development objective of the power sector is supply of electricity to all areas including rural areas as mandated in section 6 of the Electricity Act.*
> *…….*
> *About 56% of rural households have not yet been electrified even though many of these households are willing to pay for electricity.* ***Determined efforts should be made to ensure that the task of rural electrification for securing electricity access to all households and also ensuring that electricity reaches poor and marginal sections of the society at reasonable rates is completed within the next five years.****"*

Further, Clause 5.1.2 stipulates creation of reliable rural electrification system at places where it is feasible to expand the grid. In order to do so the NEP stipulates creating a Rural Electrification Distribution Backbone (REDB). Further, it emphasises the development of decentralised distributed generation facility, based on conventional or non conventional resources whichever is suitable and economical, for rural electrification where the grid expansion is neither cost effective nor technically feasible option.

> *"5.1.2 Reliable rural electrification system will aim at creating the following:*
> *(a) Rural Electrification Distribution Backbone (REDB) with at least one 33/11 kv (or 66/11 kv) substation in every Block and more if required as per load, networked and connected appropriately to the state transmission system*
> *................*
> *(d) Wherever above is not feasible (it is neither cost effective nor the optimal solution to provide grid connectivity)* ***decentralized distributed generation facilities together with local distribution network*** *would be provided so that every household gets access to electricity. This would be done either* ***through conventional or non-conventional methods of electricity generation***

> ***whichever is more suitable and economical**. Non-conventional sources of energy could be utilized even where grid connectivity exists provided it is found to be cost effective."*

The Clause 5.1.5 recognises that the access of grid electricity to rural households may be achieved if the host distribution licensee is able to recover the cost of supply together with the operation and maintenance expenses from the consumers. Further, the Government shall provide necessary capital subsidy and soft loans for investment in rural electrification projects to reduce the cost of supply to reasonable limits.

> *"5.1.5 ………..*
> *Subsidies should be properly targeted at the intended beneficiaries in the most efficient manner. **Government recognizes the need for providing necessary capital subsidy and soft long-term debt finances for investment in rural electrification as this would reduce the cost of supply in rural areas**. Adequate funds would need to be made available for the same through the Plan process. Also commensurate organizational support would need to be created for timely implementation. The Central Government would assist the State Governments in achieving this."*

Recognising the need of appropriate institutional framework for ensuring rural electrification infrastructure, Clause 5.1.6 recommends responsibility of operation and maintenance of rural electrification system and recovery of cost to be delegated by the host distribution licensee, following appropriate arrangements, to local authority, Panchayat Institutions, users' association, cooperative societies, non-governmental organisations or franchisee etc.

The Clause 5.1.7 mentions the cooperation and involvement of various entities to achieve successful and effective rural electrification.

> *"5.1.7 The gigantic task of **rural electrification requires appropriate cooperation among various agencies of the State Governments, Central Government and participation of the community**. Education and awareness programmes would be essential for creating demand for electricity and for achieving the objective of effective community participation."*

Further, the NEP also stipulates several conditions for promotion and harnessing of renewable energy sources. The Clause 5.2.20 of NEP stipulates that, non-conventional energy resources need to be exploited fully to create additional power generation capacity. The relevant extract of Clause 5.2.20 is as under:

> *"5.2.20 **Feasible potential of non-conventional energy resources**, mainly small hydro, wind and bio-mass would also **need to be exploited fully** to create additional power generation capacity. With a view to **increase the overall share of non-conventional energy sources** in the electricity mix, efforts will be made to **encourage private sector participation** through suitable promotional measures."* **(emphasis added)**

Further, Clause 5.12 of the NEP stipulates several conditions in respect of promotion of renewable energy sources. The salient features of the said provisions of NEP are as under:

> *"5.12.1 Non-conventional sources of energy being the most environment friendly there is an urgent need to promote generation of electricity based on such sources of energy. For this purpose, **efforts need to be made to reduce the capital cost of projects** based on nonconventional and renewable sources of energy. Cost of energy can also be reduced by promoting competition within such projects. At the same time, **adequate promotional measures would also have to be taken for development of technologies and a sustained growth of these sources.***

> *"5.12.2 The Electricity Act 2003 provides that co-generation and generation of electricity from non-conventional sources would be promoted by the SERCs by **providing suitable measures for connectivity with grid** and **sale of electricity to any person** and also by **specifying,** for purchase of electricity from such sources, a **percentage of the total consumption** of electricity in the area of a distribution licensee. Such percentage for purchase of power from non-conventional sources should be made **applicable for the tariffs to be determined by the SERCs at the earliest**. Progressively the **share of electricity from non-conventional sources** would **need to be increased** as prescribed by State Electricity Regulatory Commissions. Such purchase by distribution companies shall be through competitive bidding process. Considering the fact that it will take some time before non-conventional technologies compete, in terms of cost, with conventional sources, the **Commission may determine an appropriate differential in prices to promote these technologies**."* **(emphasis added)**

3.3 Tariff Policy – Aims and Objectives

The Tariff Policy notified on January 6, 2006 has further elaborated on the role of Regulatory Commissions, and the mechanism for promoting renewable energy and timeframe for implementation, etc. Clause 6.4 of the Tariff Policy addresses various aspects associated with promotion and harnessing of renewable energy sources. The salient features of the said provisions of Tariff Policy are as under:

> *"(1) Pursuant to provisions of section 86(1)(e) of the Act, the Appropriate Commission shall **fix a minimum percentage** for purchase of energy from such sources **taking into account availability of such resources in the region** and its **impact on retail tariffs**. Such percentage for purchase of energy should be made applicable for the tariffs to be determined by the SERCs latest by April 1, 2006.*
>
> *It will take some time before non-conventional technologies can compete with conventional sources in terms of cost of electricity. Therefore, **procurement by distribution companies shall be done at preferential tariffs determined by the Appropriate Commission**.*
>
> *(2) Such procurement by Distribution Licensees for future requirements shall be done, **as far as possible**, **through competitive bidding process** under **Section 63** of the Act **within suppliers offering energy from same type of non-conventional sources**. In the long-term, these technologies would need to compete with other sources in terms of full costs.*
>
> *(3) The Central Commission should lay down guidelines within three months for pricing non-firm power, especially from non–conventional sources, to be followed in cases where such procurement is not through competitive bidding." **(emphasis added)***

From the above, it is clear that promotional aspect for renewable is not only limited to 'tariff' related matters but also need to address various associated issues that influences growth/harnessing of renewable energy such as:

- Connectivity with grid for power evacuation
- Sale to any person, and
- Purchase obligation as percentage of consumption by all

Further, the tariff policy has been amended by the Central Government on January 20th, 2011. The amendment to the tariff policy stipulates separate RPO for purchase of energy by the Obligated Entities from grid connected solar energy sources. It further mentions the purchase of energy from non-conventional energy sources to be in same proportion across the State. For the Renewable Energy Certificate Mechanism may be one of the mechanisms to achieve such target. The relevant section is elaborated below,

> "***6.4 Non Conventional and renewable sources of energy generation including co-generation***
> ***...................***
> *(i) Within the percentage so made applicable, to start with, the SERCs shall also reserve a minimum percentage for purchase of solar energy.... which shall go up to 0.25% by the end of 2012-13 and further up to 3% by 2022.*
>
> *(ii) It is desirable that purchase of energy from non-conventional sources of energy takes place more or less in same proportion in different States. To achieve this objective in the current scenario of large availability of such resources only in certain parts of the country, an appropriate mechanism such as Renewable Energy Certificate (REC) would need to be evolved. Through such mechanism, the renewable energy based generation companies can sell the electricity to local distribution licensees at the rates for conventional power and can recover the balance cost by selling certificates to other distribution companies and obligated entities enabling latter to meet their renewable power purchase obligations. In view of the comparatively higher cost of electricity from solar energy currently, the REC Mechanism should also have a solar specific REC."*

3.4 Rural Electrification Policy

In compliance with Section 4 and 5 of the EA 2003 the Government of India has notified Rural Electrification Policy on August 23, 2006. The policy aimed at providing quality and reliable power supply at reasonable rates to all households by year 2009. Further, it also envisaged provision of minimum lifeline consumption of 1 unit per household per day by the year 2012.

The policy recommended grid connectivity as the primary way of electrification of villages by the development of substations and augmentation of the network. However, where grid connectivity is neither feasible nor cost effective, off-grid solutions based on stand-alone systems may be developed for supply of electricity so that every household gets access to electricity. Further, where neither standalone systems nor grid connectivity is feasible the use isolated lighting technologies, such as solar lanterns etc., may be adopted.

In case of decentralised distributed generation, the policy suggests, the facilities including the local distribution network may be developed considering conventional or non-conventional methods of electricity generation whichever is more suitable and economical. The policy also advocates utilisation of non-conventional sources of energy, even where grid connectivity exists, after evaluating its cost effectiveness. The policy mandated State Governments to prepare and notify a Rural Electrification Plan to achieve the goal of providing access to all households, mapping the electrification delivery mechanisms (grid or stand alone) considering available technologies, environmental norms, availability of fuel, number of un-electrified households, and distance of village from the existing grid.

The salient features of the policy are presented below:

a) A village shall be deemed to be electrified if, basic infrastructure such as distribution transformer etc. is established, electricity is provided to public places and at least 10% of the total number of households in villages electrified.
b) The policy seeks involvement of local community. The Gram Panchayat or the Village Council or equivalent shall issue the certificate for village being electrified and shall confirm the status on the end of every financial year.
c) For implementation of rural electrification programmes, higher capital subsidy is necessary. Similar capital subsidy is necessary for the distribution networks in the un-electrified remote villages.
d) The system of franchisee to be developed in a phased manner so as to monitor the projects financed under the scheme. If the conditionalities of the scheme are not implemented, the capital subsidy may be converted into interest bearing loan.
e) In order to maximise the benefits energy efficiency measures are to be promoted as a mass campaign in rural areas.
f) Exempted under Section 14 of the Electricity Act, a person, taking up the responsibility of generation and distribution of electricity in rural areas, shall be free from licensing obligations. However, technical standards, safety measures shall continue to apply.
g) Special dispensation for standalone systems of up to 1MW which are based on cost effective proven technologies
h) For revenue sustainability and improved services, deployment of franchisee for management may be considered necessary
i) Exempted under Section 13 of the Electricity Act, a person may procure power from the existing licensee of the area or from some other source at a price determined by appropriate Commission.

3.5 Review of Past Rural Electrification Programmes

This section discusses the select rural electrification schemes that have shown varying degree of success.

3.5.1 Rural Electrification under Minimum Needs Programme

With an objective of at least 60% of villages in each State and Union Territory to be electrified by 1990 as one of the components, the Minimum Needs Program (MNP) was introduced in the first year of the Fifth Five Year Plan (1974-79). The overall objective of the programme was to provide certain basic minimum needs and thereby improve the living standards of the people. The funds were provided to the States, as Central assistance, in the form of loans and grants. The programme was implemented through State Electricity Boards.

Initially the objective of the scheme was to cover 40 per cent of the rural population which was later shifted from coverage of rural population to coverage of villages and to ensure that at least 60 per cent villages in each state and union territory to be electrified by 1990. After 2004-05, the scheme was merged with Rajiv Gandhi Grameen Vidyutikaran Yojana.

3.5.2 Pradhan Mantri Gramodaya Yogana

The Pradhan Mantri Gramodaya Yojana (PMGY) was launched in 2000-01. However the rural electrification scheme became operational only in 2001-02. The funds were provided to the States as additional Central assistance on a principle of 90% grant and 10% loan for special category States and 30% grant and 70% loan for other States. The States were given liberty to decide on the allocation of funds amongst the basic services. For the implementation of the scheme, the State Electricity Boards, Power Utilities etc., were designated as implementing agencies. The funds were released by the State Governments to the implementing agencies. The States were given the flexibility to utilise the funds, made available as Central Assistance, for different components of the scheme at their priority. It has been observed that the States have diverted funds to other needs and rural electrification was neglected in the process. The scheme was discontinued in 2005.

3.5.3 Kutir Jyoti Yojana

The Kutir Jyoti Yojana was launched in 1988-89 with an objective to extend single point light connection to households of rural BPL families. Under this programme one time cost of wiring and service connection was provided by way of 100% grant to the States. Around Rs. 612Cr have been released under this programme for providing connections to approximately 7 million BPL households in 16 years by May, 2004. During 2004, the programme was merged with Accelerated Electrification of One Lakh Villages and One Crore Households and now with Rajiv Gandhi Grameen Vidyutikaran Yojana.

It has been observed that the Kutir Jyoti Yojana was criticised for being responsible for increase in transmission & distribution (T&D) losses over the years.

3.5.4 Accelerated Rural Electrification Programme

Accelerated Rural Electrification Programme was introduced in the year 2003-04 under which interest subsidy of four (4) percent was provided on the loans availed by State Governments/ Power Utilities from Financial Institutions like Rural Electrification Corporation, Power Finance Corporation, Rural Infrastructure Development Fund, and National Agricultural Bank for Rural Development, etc. for carrying out rural electrification. The assistance was limited to electrification of un-electrified villages, electrification of hamlets/dalit bastis/tribal villages and electrification of households in villages through both conventional and non conventional sources of energy.

3.5.5 Accelerated Electrification of One Lakh Villages and One Crore Households

Government of India in 2004-05 introduced a scheme Accelerated Electrification of One Lakh villages and One Crore households by merging the interest subsidy schemes, Accelerated Rural Electrification Programme and Kutir Joyti Programme. Under this scheme Grid based as well as stand-alone projects based on distributed generation were eligible for capital subsidies. The projects were eligible for a capital subsidy, up to 40% of the capital cost, and the balance as loan assistance on soft terms from REC.

3.5.6 Limitations of the Past Rural Electrification Schemes

1) The rural electrification formed one of the components in the scheme such as Minimum Needs Programme and Pradhan Mantri Gramodaya Yojana. The flexibility was given to the implementing agencies to use the funds as per the needs. It has been observed that rural electrification was neglected against other components of the schemes.
2) In most of the schemes the Central Assistance was provided to the State Government, which in turn was passed on to the implementing agencies. It has been observed that owing to

such administrative process timely availability of the funds to the implementing agencies was an issue.

3) The responsibility of the village electrification was left to the implementing agencies, i.e. the State Electricity Boards, which were in bad financial health and not in a position to mobilise sufficient funds. The programme was not implemented by the State Electricity Boards on top priority.
4) The focus of the electrification in rural areas was primarily for irrigation purposes.
5) The extent of the local community participation was limited in the schemes and it was only Accelerated Electrification of One Lakh Villages and One Crore Households scheme, initiated in 2004-05, which had made provision of constituting District Electricity Committees under Section 166(5) of the EA 2003.

A need was felt for a more comprehensive policy, which shall address the shortcomings of the rural electrification schemes and which shall provide effective infrastructure in the rural areas.

3.6 Current Rural Electrification Programmes

National Electricity Policy stipulates creation of reliable rural infrastructure providing accessibility of electricity to all households in rural areas. Taking into consideration the recommendation of the NEP, a new scheme Rajiv Gandhi Grameen Vidyutikaran Yojana (RGGVY) was announced by the Government of India for creating rural electricity infrastructure and undertaking household electrification.

3.6.1 Rajiv Gandhi Grameen Vidyutikaran Yogana (RGGVY)

In 2005, the Ministry of Power launched Rajiv Gandhi Grameen Vidyutikaran Yojana (RGGVY) merging all ongoing rural electrification schemes, under the initiative "Power for all by 2012". The RGGVY scheme aims to provide electricity to rural areas through extension of existing grid and by augmenting the infrastructure. Under the programme, the State Governments shall be given 90% of the requirement as grant and the remaining 10% as loan from the Rural Electrification Corporation. The RGGVY aimed at providing electricity to all rural households by electrifying all villages and habitats according to the new definition of village electrification, discussed in above paragraphs. The scheme also envisages electrification of all un-electrified below poverty line households by way of 100% capital subsidy for the activity.

With a capital subsidy of Rs. 5000 Crore, the scheme was launched during the 10th plan period with a target of electrifying one lakh villages. However, around 235 projects were sanctioned across the States with an estimated cost of Rs. 9732 Crore covering 68763 un-electrified villages, intensive electrification of around 111936 villages, and around 12 million households (including BPL connections). The scope of the scheme is mentioned below,

Scope of the Scheme

Under the scheme the projects would avail assistance for establishment of electricity distribution infrastructure through,

- Rural Electricity Distribution Backbone (REDB) with provision of 33/11 KV (or 66/11 KV) sub-stations of adequate capacity and lines in blocks where these do not exist
- Creation of Village Electrification Infrastructure with at least one distribution transformer of adequate capacity in a electrified villages/habitiation(s)
- Development of standalone grid with generation based on conventional or non-conventional where grid extension is not feasible

Conditionalities for availing assistance

The conditionalities for availing the assistance are elaborated below,

- States to make adequate arrangements with no discrimination in the hours of supply between rural and urban households
- States should deploy franchisee for the management of rural distribution
- State Government should have provision of requisite revenue subsidies to the State Utilities
- Determination of bulk supply tariff for franchisees in a manner that ensures their commercial viability

Consequences of not meeting the Conditionalities

- In the event the projects are not implemented satisfactorily the capital subsidy may be converted into interest bearing loans

It was decided by Government to further extend the scheme, for a capital subsidy of Rs. 28000 Crore, during 11th plan period. However, for better implementation of the scheme following conditions were included,

- States to finalise and notify their Rural Electrification Plans in consultation with Ministry of Power within six months.

- States to ensure minimum daily supply of 6-8 hours of electricity in the RGGVY network with the assurance of meeting any deficit in this context by supplying electricity at subsidized tariff
- Deployment of franchisees for the management of rural distribution in projects financed under the scheme and to undertake steps necessary to operationalise the scheme
- Development of Three-Tier Quality Monitoring Mechanism to ensure quality of material & implementation

Status and achievements of the Scheme

As on April 15, 2011, a total of a total of 573 projects across the States had been sanctioned under the RGGVY, covering the electrification of 118499 villages, the intensive electrification of 354967 already electrified villages and the free electricity connections of 24.6 million BPL households at an estimated cost of Rs. 32336 crores as show in table below,

Table 3.1: Physical & Financial Progress of RGGVY Projects

Particular	Project	Outlay (Rs.Cr.)	Revised Outlay (Rs.Cr.)	Un-Electrified Villages		Intensive Electrification of Electrified Villages		No. of Connections to BPL Households (Lakh)	
				Target	Achi.	Target	Achi.	Target	Achi.
X Plan	235	9733.00	13092.47	68763	62823	111936	92647	83.10	71.05
XI Plan	338	16616.18	19242.12	49736	33842	243031	110218	163.34	93.75
Total	**573**	**26349.18**	**32333.59**	**118499**	**97759**	**354967**	**202865**	**246.45**	**164.80**

(Source: www.rggvy.gov.in) as on June 28, 2011

3.6.2 Decentralised Distributed Generation Programme

RGGVY seeks to accomplish extension of grid for rural electrification. However, where grid extension is either neither feasible nor cost effective, RGGVY recommends standalone power generation systems. With the capital subsidy outlay of Rs.540 Crore, the scheme was launched by the Government of India in January 2009. The capital subsidy for eligible projects under the scheme would be given through REC.

Salient features of the scheme

- 90% of the total project cost (capital cost and soft cost) shall be provided by the Government as capital subsidy, remaining 10% to be arranged on own or through financial institution
- Standalone systems can be powered by either conventional or non-conventional sources
- All infrastructure must be grid compatible to ensure that the investments are not stranded on grid extension and there is sufficient engagement and support from local community.
- Villages where grid connectivity is not foreseen for next 5-7 years should be given priority.
- All un-electrified villages and hamlets, having population more than 100, are eligible for receiving assistance under DDG scheme of RGGVY.
- DDG projects may be based on technologies which have reached a stage of commercial maturity or their technical viability has been proven under real life conditions
- Preferred technologies could be Diesel generating sets using biofuels, producer gas, biogas; Solar PV, Small Hydro, Wind Hybrid Systems, other hybrid systems using new technology.
- Eligible Project developers shall be: State agencies, technology suppliers, Corporate houses, Equipment Manufacturers and Contractors, Self Help Groups, Users Associations, individuals, Registered Societies, Cooperatives, Panchayats, Local bodies, their Consortiums / SPVs / JVs etc .
- Successful developer shall be responsible for supplying the required quantum of power for 6 to 8 hours per day at identified timings, at least 25 day in a month.
- Concerned implementing agency shall issue guidelines for determination of tariff.
- Implementing Agency shall also ensure proper utilization of the funds.
- In the event the projects are not implemented satisfactorily the capital subsidy may be converted into interest bearing loans.

Financing of Projects and Administering of Funds

The developer shall be eligible for the following financial assistance for implementing the DDG projects,

a. Capital Cost

The developer shall be eligible to receive the assistance for project capital cost comprising of,

1) All plant equipment & auxiliary systems and accessories required for the power plant operation
2) All associated civil works (Cost of land to be borne by the State Government)
3) Distribution Network with necessary control equipment
4) Initial cost for plantation for sustainable supply of bio energy

5) Initial cost of setting up non-domestic loads as specified by the implementing agency

b. Revenue Cost

The revenue cost shall comprise of cost of spare parts for 5 years after commissioning of the project. However, the cost of consumables and labour will not be included in the capitalized project cost.

c. Cost of providing power

The developer shall also be eligible to recover cost of providing power for a period of 5 years from the date of commissioning. However, such cost shall be computed after taking into account the recovery from village households as per the tariff to be decided by the State Utility/SREDA/Implementing Agency.

d. Soft Cost

The developer of the project shall also be eligible for soft cost towards,

1. Pre-selection of villages, technologies and preparation of DPRs
2. Cost of social engineering to ensure community engagement

e. Pattern of payment

The following payment terms are recommended for the payment of capital cost to the project developer,

- 70% of the capital cost excluding cost of providing power as stated above till commissioning of the project, linked to project completion milestones.
- Balance 30% of the capital cost excluding cost of providing power as stated above over the 5 year period (@ 6% per annum)
- Cost of providing power shall be paid on annual basis after taking into account recovery from village households.

f. Administration of funds

- The payment to the project developers, as per the terms outlined above, will be routed through the implementing agencies.

3.6.3 Remote Village Electrification Programme

With a view to supplement the efforts of Ministry of Power, the Ministry of New and Renewable Energy announced Remote Village Electrification (RVE) Programme in 2005. The RVE scheme aimed at providing basic lighting/electrification to rural areas through renewable energy sources. The villages should be selected in such a way where grid connection is neither feasible nor cost effective and where DDG projects are not being implemented. A total outlay of Rs. 80 Crore was sanctioned for the year 2010-11.

Scope of RVE Programme

The scope of the programme is follows,

- All census un-electrified villages and their hamlets not covered under RGGVY
- Un-electrified hamlets of electrified census villages having population of more than 300 which are situated at least 3km from the nearest substation

Financial Assistance and Pattern of Release

The RVE programme is implemented in the States through Central Financial Assistance of up to 90% of cost of renewable energy generating system from MNRE. The balance cost of the project can be made available through own contribution or through financial institutions. The assistance for approved projects shall be made available as per following pattern,

- 70% of the total assistance along with the initial sanction order
- Remaining 30% after commissioning of the project

Activities Eligible for Financial Assistance

The activities eligible for financial assistance under this programme are,

- Installation of power plants based on small hydro power, biomass, wind, biofuels, biogas, etc. for electrification of remote villages/hamlets.
- Solar photovoltaic power plants may also be supported if found to be cost effective.
- Hybrid systems and systems based on combination of renewable energy systems would also receive financial assistance.
- Where no other renewable energy technology is found to be feasible, solar home lighting systems for domestic and community lighting would be supported
- Initial surveys and studies for firming up of State-wise lists of remote un-electrified census villages and hamlets

- Studies for assessing the renewable energy resources available in the villages and energy requirements of the community; and, identification of appropriate technology options for electrification
- Preparation of State-wise Master Plans
- Institutional development and capacity building, development of repair and maintenance infrastructure, etc
- Monitoring and evaluation of individual projects or the Programme as a whole, including technical, operational and socio-economic aspects, user feedback, impact assessment, etc., development of management information systems for coordination & monitoring, etc.
- Training, orientation and awareness programmes for various target groups, conferences/seminars/workshops for experience sharing among various stakeholders, etc
- Development of remote village specific electricity generation systems and packages based on different renewable energy technologies

Progress of Implementation of Programme

The cumulative sanctions under the Programme since its inception reached around 10,000, villages and hamlets of which work *has been completed in around 6200 villag*es and hamlets. A target of 10,000 villages and hamlets has been set for the 11th Plan, of which 3280 villages and hamlets have been taken up by December 31, 2009. The main States where the programme has greater relevance due to difficult access issues are Jammu and Kashmir, Madhya Pradesh, Orissa, Chhattisgarh, Jharkhand and the North Eastern states. The table below presents the progress of implementation of RVEP as on December 31, 2009.

Table 3.2: Progress of Implementation of Remote Village Programme

S No	Description	Details
1	Total Villages Sanctioned	7998
2	Villages Completed	4997
3	Ongoing Villages	2725
4	Total hamlets sanctioned	2016
5	Hamlets completed	1257

(Source: Annual Report – 2009-10, MNRE)

3.6.4 Guidelines for Off-Grid and Decentralised Solar Application – JNNSM

The scheme has been launched by the MNRE, as a part of Jawaharlal Nehru National Solar Mission (JNNSM), to promote the off grid application of Solar Energy. The scheme is focused on promoting off grid and de-centralised systems, including hybrid systems to meet lighting, electricity and heating/cooling requirements.

Scope of Scheme

- Scheme is applicable to all parts of India and would be co-terminus with Phase-I of JNNSM
- Various Off-grid Solar PV Systems / Applications: up to a maximum capacity of 100 kWp per site and off-grid and decentralized solar thermal applications, to meet / supplement lighting, electricity/power, heating and cooling energy requirements would be eligible for being covered under the Scheme
- Mini-grids for rural electrification: Applications up to a maximum capacity of 250 kW per site shall be supported

Boundary Conditions for Assistance

For Solar PV Applications

The best/competitive and innovative technologies available globally would be allowed following the terms and conditions specified by the MNRE

Table 3.3: Boundary Conditions for Support (Solar PV Applications)

1	**Individuals**		
A	All application except 1B	1kWp	Capital Subsidy & Interest Subsidy
B	Pumps for irrigation and community drinking water	5kWp	
2	**Non-Commercial Entities**		
A	All applications except 2B	100kWp/site	Capital Subsidy & Interest Subsidy
B	Mini-Grids for Rural Electrification	250kWp/site	
3	**Industrial/Commercial Entities**		
A	All applications except 3B	100kWp/site	Capital Subsidy & Interest Subsidy
B	Mini-Grids for Rural Electrification	250kWp/site	

Scale of Capital Subsidy		
Based on benchmarking annually	Rs. 90 /Wp	With Battery Storage
	Rs. 70 /Wp	Without Battery Storage
Scale of Interest Subsidy		
	Soft Loan @ 5 % p.a.	On the amount of project cost
		Less promoter's contribution
		Less capital subsidy amount

For Off Grid Solar Thermal Applications

Table 3.4: Boundary Conditions for Support (Solar Thermal Applications)

Solar Collector Type	Capital Subsidy/ Collector Area (Rs/sq m)
Evacuated Tube Collector (ETCs)	3000
Flat Plate Collectors (FPC) with liquid as working fluid	3300
Flat Plate Collectors (FPC) with air as working fluid	2400
Solar collector system for direct heating applications	3600
Concentrator with manual tracking	2100
Non-imaging concentrators	3600
Concentrator with single axis tracking	5400
Concentrator with double axis tracking	6000

Funding Pattern

- Detailed project report shall be submitted for evaluation. The total project cost shall be funded through a mix of debt and incentives where the promoters' equity contribution would be at least 20%
- MNRE would provide financial support through a combination of 30% subsidy and/or 5% interest bearing loans.

- For year 2010-11, benchmark price for photovoltaic systems with battery back-up support is considered as Rs. 300/- per Wp and Rs. 210 per Wp for systems, which do not use storage battery such as water pumping systems.
- Capital Subsidy of 90% of the benchmark cost for special Category States (NE, Sikkim, J & K, Himachal Pradesh & Uttarakhand)
- Use of the best/competitive and innovative technologies available globally would be allowed, subject to standards and technical parameters, laid down by MNRE.

Release of funds

The release of the funds for a project shall be back ended as reimbursement on completion and verification thereof.

- In respect of credit linked capital subsidy and interest subsidy, the scheme would be implemented through IREDA (designated nodal agency).
- MNRE would place 50% of the estimated annual requirement of funds with IREDA upfront at the beginning of the year. The balance 50% would be released as second and final tranche of the annual requirement to IREDA after receipt of utilization certificate, of not less than 50% of the first tranche released to IREDA.

3.6.5 Village Energy Security Projects

The Village Energy Security Project was launched, by the MNRE, with the objective of providing energy security in villages, which do not have access to grid connectivity. The programme aims **meeting total energy needs for cooking, electricity and motive power through various forms of biomass material** based on available biomass conversion technologies and other renewable energy technologies, where necessary. Under this initiative, the MNRE to provide CFA of Rs. 20000 per households.

Identification of Villages / hamlets

The village/hamlets should be selected taking into consideration the availability of common or uncultivated non-grazing land for raising plantations. The village / hamlet should have minimum of about 50 and maximum of 400 households. The Villages shall be identified in consultation with rural development departments / agencies.

Guidelines for Implementation of Test Projects

The test projects would be undertaken by the Panchayats with facilitation by implementing Agencies such as District Rural Development Agencies (DRDA), forestry departments, NGOs, entrepreneurs, franchises, other corporate entities, co-operatives and State Nodal Agencies. The projects should be owned by the village community with the responsibility for overall operation / management resting with them. The District Advisory Committees on Renewable Energy with the Collectors as the Chairman, Project Director, DRDA as Member-Secretary and comprising district-level functional heads and prominent citizens should be involved in the implementation of the test projects. The concerned State Nodal Agency would have to closely monitor the implementation of the projects and provide monthly progress reports to the Ministry until commissioning.

Guidelines for Central Financial Assistance for the Test Projects

The 90% of the project cost approved by the Ministry would be met through central grant. The balance 10% towards the project cost would have to be mobilized by the community / implementing agency / State Nodal Agency. Support is also provided towards professional charges to Implementing Agencies and administrative / service charges to State Nodal Agencies and towards O&M for a limited period. The funds released by the Ministry are placed in a bank account called Capital Account opened for this purpose by the Village Energy Committee (VEC). A Village Energy Fund is also created with initial contribution from the villagers.

Status of Village Energy Security Test Projects

The MNRE has sanctioned implementation of 120 no. of village energy security test projects during 2008-09 and 2009-10. However, since its commencement 54 test projects have so far been commissioned, of which 17 test projects were commissioned during the year 2009-10.

3.7 Evaluation of Regulatory Intervention Measures & Strategies

In compliance of Section 4 and 5 of the EA 2003, the Government of India has notified policy on 'Rural Electrification' on August 23, 2006. The policy had highlighted several measures for the promotion of rural electrification through off grid or stand alone generating systems. However, in spite of having several legal and statutory provisions, more than 20% of villages and around 40% of rural households do not have access to electricity. Further, the villages having access to electricity are experiencing severe power cuts of around 10 to 15 hours per day. Harnessing the generation based on renewable resources and locally available resources is identified as one of the possible solutions for effective rural electrification. However, it is necessary to provide enough clarity to the participants and entities, in order to bring the off grid renewable energy based generation for rural electrification into mainstream. In this regard, it is necessary to identify potential issues and address solution through regulatory intervention to safeguard the interests of various stakeholders and to promote rural electrification standalone renewable energy generation, wherever feasible.

3.8 Key Legal and Regulatory Issues for Effective Rural Electrification

The extension of electricity grid is one of the prominent and obvious solutions to effective rural electrification. However, such mechanism shall entail significant investment in building the necessary infrastructure. The rural electricity consumption is low as it aims to meet at least basic electricity requirements of lighting, motive power for agriculture and hence extension of electricity grid is perceived imprudent. Further, option for extension of electricity grid for rural electrification is knotted with associated transmission and distribution losses. The alternate solution for effective rural electrification is through deployment of off grid/decentralised generation systems exploiting resources available locally. However, encouraging rural electrification through installation of off grid systems based on renewable energy sources shall require identification of specific issues and finding suitable technical and commercial solution with adequate support of regulatory measures.

The clause 8 of Rural Electrification Policy permitting establishment of Standalone Systems for Rural Areas envisage duties and obligations of various entities as under:

State Government	Appropriate Commission	State Distribution Utility	Project Developer
• Notification **of Rural Area in State** • **To formulate guidelines and simplify procedures for single window clearance for such**	• To lay down guidelines so as to pass on benefits of financial assistance/ subsidies from Govt. (Central and State) to end consumers.	• Universal service obligations to continue	• Being exempt licensee, be responsible for generation & distribution • However, it would have choice to outsource arrangement

State Government	Appropriate Commission	State Distribution Utility	Project Developer
projects to enable exploitation of such opportunities by small/medium enterprises. • **To create institutional arrangements for back up services and technical support for such installations.**	• Guidelines to address different fuels, technology & size. • Right to intervene to scrutinise tariff in particular case, if guidelines are not implemented.		for distribution of power. • Being exempt licensee, would be free from licensee obligations and purview of the Commission for Tariff determination & universal supply obligations applicable to licensees • However, technical standards, safety measures (S 10, 53) to be applicable. • Retail tariff arrangement to be based on mutual agreement

Thus, the role of regulatory intervention as envisaged under the policy for standalone system(s) is limited to formulation of appropriate guidelines to ensure benefits of financial assistance/subsidies are passed onto the end consumers and regulatory oversight to address discrepancy in tariffs, if any. This holds good so long as standalone off-grid system and distribution thereof continues to be operational without grid extension over economic life of the installation. However, the complexity of issue increases as and when grid is extended by distribution utility in the area where standalone off-grid system is operational. The Regulatory Commission would have jurisdiction under such cases including on issues such as tariff determination for power supplied by distribution utility.

In addition, the feasibility of emerging market instruments such as renewable energy certificates (RECs) as revenue option for off-grid renewable energy systems needs to be explored from regulatory perspective. Accordingly, the key issues identified for promotion of off grid/decentralised generation based on renewable energy sources of energy are,

- Jurisdiction of Appropriate Commission
- Applicability of tariff for sale of surplus electricity to the grid in case of extension of grid
- Grid connectivity protocol
- Terms and conditions determining charges for Open Access
- Qualification of off grid RE based generation for issuance of renewable energy certificates

These issues have been discussed and solutions have been proposed in the following pragraphs.

3.8.1 Jurisdiction of Appropriate Commission in determining retail tariff

Brief Description of the Issue

In light of eighth proviso of Section 14 of the EA 2003, whether the Appropriate Commission shall have jurisdiction to determine the tariffs for electricity generated from off grid/decentralised systems for 'Sale to Rural Consumers'?

Suggestion

Section 14 of the EA 2003 provides for the grant of license, to any person, undertaking transmission, distribution or undertake trading in electricity. However, as per the eighth proviso of the Section 14, a person undertaking generation, based on renewable energy or non-conventional energy sources, and distribution of electricity in a rural area, specified by the State Government, does not require any licence. However, the safety measures and technical standards as specified by the Central Electricity Authority shall apply. The relevant portion of the Section is reproduced below,

> ***Section 14. (Grant of license):***
>
> *The Appropriate Commission may, on application made to it under section 15, grant any person licence to any person -*
>
> *(a) to transmit electricity as a transmission licensee; or*
>
> *(b) to distribute electricity as a distribution licensee; or*
>
> *(c) to undertake trading in electricity as an electricity trader, in any area which may be specified in the license:*
>
> *……Provided also that where a person intends to generate and distribute electricity in a rural area to be notified by the State Government, such person shall not require any license for such generation*

and distribution of electricity, but he shall comply with the measures which may be specified by the Authority under section 53 ………

Thus the ‘person’ exempted from licensing, under eighth proviso of Section 14 of the EA 2003, shall be free from the purview of the Appropriate Commission. Those ‘persons’ shall be free to determine the retail tariff based on the mutual agreement between such person and rural consumers. However, it is also envisaged that in case the person is availing the benefit of subsidies or financial assistance by the Government or other agencies, that benefit must be fully passed on to the consumers.

Clause 8.6 of Rural Electrification Policy envisages that benefit of financial assistance/subsidy is being passed on to the consumers. Since, it would be difficult to determine the tariff for individual off-grid project, owing to size and number, entailing different renewable energy technology, it was envisaged that the Appropriate Commission shall lay down guidelines for various types of projects receiving subsidy instead of determining the tariff on a ‘case to case’ basis. Further, in case such guidelines are not implemented in particular case, the Appropriate Commission shall have the right to scrutinise the retail tariff set between the off grid project developer and the rural consumer.

Exercising the mandate vested under Section 166(2), the Forum of Regulators may formulate the **model guidelines** addressing above requirements which shall be further adopted by the State Electricity Regulatory Commissions to protect the interest of the consumers and ensuring benefit of financial assistance/subsidy to the consumers.

Further, in order to scrutinise the retail tariff, the Appropriate Commission may ask necessary information such as cost of service, technical and operational performance of the generating system etc. from the person exempted under Section 14 of the EA 2003. However the information template/formats should be such that compilation, monitoring and verification of such data submitted simplified to great extent.

Furthermore, as and when grid is extended in the area of operation of standalone system, the decentralised system may be connected with the electricity grid and the electricity can be drawn during the time of planned and unplanned outage of the standalone system, to meet load requirement of the rural area. Section 5 of the EA 2003 enables the person for bulk purchase of power from the host distribution licensee or any third party. In such instances the Appropriate Commission shall determine the 'Bulk Purchase Price'.

3.8.2 Applicability of tariff for sale of surplus electricity to licensee during 'extension of grid'

Brief Description of the Issue

1) What shall be the mechanism to safeguard the interests of the person undertaking the decentralised generation based on renewable energy and distribution of electricity if the host distribution licensee extends its network/system in the area of such person?
2) Should the State Commission specify separate grid connectivity protocol for such small systems?

Suggestion

In case of extension of the electricity grid by the host distribution licensee, it is likely that the rural consumers may initiate purchase of electricity from such licensee if the electricity is offered at a lower rate. It has been observed that under such scenario, the efforts made to build the infrastructure for the decentralised generating system would be redundant and the system becomes idle. Thus, in order to safeguard the interests of stakeholders and to reduce the risk on the developers of such decentralised renewable energy based generating systems, it is necessary to have appropriate mechanism for evacuation and purchase of electricity generated from such renewable energy based decentralised systems.

Section 61 (h) of the EA 2003 envisages Appropriate Commission to specify the terms and conditions for the determination of tariff for promotion of co-generation and generation of electricity from renewable energy sources. This falls under jurisdiction of the State Electricity Regulatory Commission. Thus, the Appropriate Commission, in order to promote co-generation and generation of electricity from renewable energy sources, is mandated to determine the tariff for purchase of electricity generated from decentralised systems based on renewable sources of energy as and when electricity grid is extended by the host distribution licensee in the area of operation of standalone system operator.

Section 61 (h) has to be read with Section 62, under which section the SERC has the power to determine tariff of a generating plant for supply to a distribution licensee.

Further, under Section 86 (1), the SERC is required to discharge the following functions namely, *(a) determine the tariff for generation, supply, transmission and wheeling of electricity, wholesale, bulk or retail, as the case may be within the State:*

……………

(b) regulate electricity purchase and procurement process of distribution licensee including the price at which electricity will be procured from the generating companies or licensee or from other sources through agreements for purchase of power for distribution and supply within the State.

From the aforesaid it is quite clear that the tariff for electricity supplied by a generating company to a distribution licensee is required to be determined by an Appropriate Commission. Further, Section 86 (1) (e) of the Act requires the State Electricity Regulatory Commission to promote sale of renewable energy to any person. The relevant portion of the section is reproduced below,

Section 86 (1) (e)

"promote co-generation and generation of electricity from renewable sources of energy by providing suitable measures for connectivity with the grid and sale of electricity to any person, and also specify, for purchase of electricity from such sources, a percentage of the total consumption of electricity in the area of a distribution licensee;"

A scrutiny of Section 86(1) (e) reveals that it envisages and empowers SERC to,

a. Provide suitable measures for connectivity with the Grid, and
b. Specify the minimum purchase obligation

Thus, in order to promote the co-generation and generation of electricity based on renewable sources of energy the State Commission has a clear mandate to provide suitable measures for connectivity with the grid. Further, Section 177 (2) read with Section 73 (b) of the EA 2003 empowers the Central Electricity Authority (CEA) to specify guidelines/regulations on technical standards for connectivity to the grid. The CEA has already initiated process to specify the technical standards for grid connectivity of small scale RE generating systems.

3.8.3 Determination of Open Access Charges

Brief Description of the Issue

Shall rural licensee, exempted under Section 13 of the Act be allowed Open Access? Who shall determine the Open Access Charges?

Suggestion

The EA 2003 permits distribution licensee, non-discriminatory open access to the transmission systems without payment of any surcharge. Further, those exempted under Section 13 of the EA 2003 for management of local distribution in rural areas also discharge the function of distribution licensee/rural licensee and hence would not be liable for payment of any surcharge on wheeling/transmission charges in case they avail open access to transmission and/or distribution network.

Further, enabling the sale of surplus power from the decentralised generation facility to the third party and/or other buyers shall also encourage deployment of renewable energy based generation in rural areas. Such revenue from the sale of surplus power to the third party may be utilised to cross subsidise or reduce the retail tariff applicable to rural consumers. Thus, specifying terms and conditions for availing open access from such generating facilities shall provide clarity to the stakeholders and shall also encourage investment in the renewable energy generation for rural electrification. The SERC under Section 42 of the EA 2003 may determine the applicable open access charges for such transactions. However, this situation is not envisaged in case of off-grid community based projects envisaged in this report.

3.8.4 Should generation from off grid RE based generating facility qualify for RECs?

Brief Description of the Issue

CERC and FOR have already put in place the Renewable Energy Certificate Mechanism for grid connected renewable energy. Should such framework be replicated for off grid renewable energy generation?

Suggestion

The Regulatory Framework for REC Mechanism for grid connected renewable energy projects is already in place. However, it may be required to amend the regulations suitably so as to accommodate off-grid renewable energy generation into the existing framework for REC Mechanism.

Section 3 of the EA 2003 necessitates formulation of policy for optimal utilisation of resources including renewable sources of energy. Further, Section 66 read with Section 3 of the Act empowers Appropriate Commission to promote the development of market. Furthermore, Clause y of Sub-Section (2) of Section 178 empowers Central Commission to make regulations for the development of market in power including trading of electricity. In pursuance of aforesaid the Central Commission may amend the regulations notified for implementation of REC Framework for grid connected renewable energy generation. Further, state level guidelines for amendment to the RPO /REC Regulations can be developed by FOR which can bring uniformity in REC mechanism to include off-grid RE solutions within ambit of REC mechanism being implemented at State level across States.

3.9 Challenges for Integration into prevailing REC Framework

The integration of off-grid renewable energy generation into the prevailing REC framework could be one of the possible measures to promote the deployment of renewable energy. It could also play a critical role in achieving the targets set under the National Action Plan on Climate Change. However, certain issues need to be resolved before integrating off-grid RE generation into the prevailing REC Mechanism.

a) What should be the qualifying criteria for RE sources and technology for participating in REC Mechanism?

Under the prevailing REC Mechanism, all grid connected renewable energy technologies as approved by the MNRE are considered eligible for participation. However, owing to the significant difference in the prevalent capital cost structure for solar projects vis-a-vis non-solar RE projects, the RE certificates are categorised into Solar and Non Solar category.

MNRE, Government of India is the nodal ministry to develop policy and programmes to promote large scale deployment of RE based applications and address all matters related to renewable energy. MNRE is providing subsidy/grant for deployment of renewable energy based systems for rural electrification through various schemes such as Village Energy Supply Project, Remote Village Electrification Programme etc. Thus, it would be preferable to include all the renewable energy sources and technologies, which qualify the criteria for availing the subsidy/grant from the MNRE, to participate in the REC Mechanism.

b) Whether there is any need to have Specific category for Off-Grid RE Certificates?

It may be useful to have separate classification of RECs for off-grid RE based application, due to inherent disadvantage of such small RE system applications against economies of scale enjoyed by large RE projects. However, in order to facilitate this, it is essential to have separate RPO targets also to be specified for off-grid RE based applications. However, such off-grid RE based

RPO targets may not be feasible in all States, particularly where 100% or near 100% electrification has already been accomplished. Another option is to issue multiple RECs (banding of RECs) for off-grid RE based applications. However, this may not be possible under existing legal framework wherein REC denomination is linked to quantum of electricity since the RPO targets are linked to percentage of electricity consumption.

c) What should be the metering arrangement for off-grid renewable energy generation?

The off-grid renewable energy generation could qualify for renewable energy certificates, provided that such generation is appropriately metered so that it may be verified and certificates are issued accordingly. Under the prevailing mechanism, it is the responsibility of the State Load Despatch Center (SLDC) to provide the energy injection report to the Central Agency (nodal agency for issuance of RECs). RECs are issued on the basis of this report.

It is observed that the off grid generating facility may be located at remote place and the distribution licensee would incur significant costs to certify the energy generation on regular intervals. In order to overcome such constraint, standard procedures and protocols needs to be formulated as part of REC mechanism. Information about metered data should be easily accessible through modern technology e.g. use of remote metering devices and suitable communication links. These aspects can be insisted at the design stage itself.

d) Who shall certify and audit the energy generated from such off-grid plants?

In order to minimise the uncertainty, it is suggested that the certification of energy injection should be done by the single authority in the State. Under the prevailing mechanism it is the SLDC who certifies the energy injection and which forms the basis for the issuance of renewable energy certificates by the Central Agency to the respective renewable energy generator.

The off grid renewable energy may be located at remote places and it would not be economical to undertake manual inspection of energy generation at a regular interval. Under such circumstances mechanism may be devised which transmits the energy generation to the SLDC at regular intervals i.e. maybe once a day etc. However, the sealing of meters used for recording the energy generation and testing may be carried out at appropriate period.

e) What would be the floor and forbearance price of such REC?

The Central Commission has devised mechanism for determination of floor and forbearance price for Solar and Non Solar technology respectively. Same pricing will have to be used by off-grid RECs as off-grid RECs are not going to be different from RECs for grid connected projects.

f) Should accounting of subsidy received from MNRE, if any be considered while assessing eligibility for participation in REC Mechanism?

The issue has been discussed in one of the meetings among the task group. The following situations could emerge,

i) Standalone Generation and Distribution <u>without</u> Government Subsidy
ii) Standalone Generation and Distribution <u>with</u> Government Subsidy
iii) Decentralised Generation <u>with</u> Grid Support

I. <u>Standalone Generation and Distribution without any Government Subsidy/Grant</u>

In such instances it is expected that the retail tariffs for sale of electricity to the rural consumers shall be market determined or determined through mutual agreement. Therefore, such off grid renewable energy generation may be qualified for participation in the REC mechanism and eligible for receiving the certificate. However, these projects will not be eligible for feed-in tariff determined by the State Regulator.

II. <u>Standalone Generation and Distribution with Government Subsidy</u>

In instances where the person mandated under Section 13 of the EA 2003 undertakes the generation and distribution of electricity with the support from the Government in the form of Subsidy/Grant, the Clause 8.6 of Rural Electrification Policy mentions that the benefit of the subsidy/assistance shall be fully passed on to the consumer.

In such scenario, where the full cost of generation would be recovered by the generator including the subsidy received, such generation may not be eligible for receiving the renewable energy certificates. However, since the generation shall be based on renewable energy sources the buyer may qualify to fulfil it renewable purchase obligation by procurement of such generation.

Further, the subsidy could be in the form of 'Capital Subsidy' from the Central Government. Further the State Government may provide 'Tariff Subsidy' to the relevant consumer categories of the incumbent licensee. In such case tariff determination for the electricity generated and distributed would be done by the SERC following a normative approach. ODGBDF model recommended in this report is a special variation of this scenario.

III. Decentralised Generation with Grid Support

In instances where the decentralised generation is supported with the electricity grid, the SERC may specify guidelines/regulations taking into consideration the additional costs incurred by such small generators coupled with lower tail end losses in the system of distribution licensee. The SERC would also need to specify appropriate grid connectivity protocol for such facilities, including the treatment of deemed generation in case of non-availability of system.

In such cases, where the tariff for generator is determined by the SERC or the Appropriate Commission, taking into consideration the subsidy/assistance provided by the Government, the generator would not be eligible for receiving the certificates for sale of such electricity to the host distribution licensee. However, the distribution licensee would be eligible to fulfil its renewable purchase obligation to the extent of electricity purchased.

4 OVERVIEW OF RURAL ELECTRIFICATION POLICIES IN INTERNATIONAL PERSPECTIVE

Rural Electrification is a process which enables access to electricity to households/villages located in rural and/or remote areas. According to the estimates by International Energy Agency around 22 % population across the world does not have access to electricity. Countries, across the world, have taken measures to encourage the rural electrification in their province. This section elaborates the policy framework prevailing in Brazil, China, and South Africa.

4.1 Initiatives for Rural Electrification in Brazil

The Government of Brazil, in order to provide access of electricity to rural communities and areas, has initiated several programmes. In 1994 with an objective to electrify the rural communities, the Brazilian Government initiated (PRODEEM - *Programa de Desenvolvimento Energético de Estados e Municípios*). Further, in 2000, Luz no Campo (LnC or Light in the Countryside) was initiated. During 2003, PRODEEM and LnC were merged into Luz para Todos (LpT or Light for All).

4.1.1 PRODEEM

With an objective to promote the supply of energy to the rural community which are distant away from the conventional electricity grid, the Brazilian Government, during 1994, has initiated Programme for Energy Development of States and Municipalities (PRODEEM - *Programa de Desenvolvimento Energético de Estados e Municípios*). The programme was coordinated by National Energy Development Department (DNDE). The initiative aimed at utilising renewable sources of energy to provide electricity to rural communities. PRODEEM focused on community level electrification rather than providing electricity for households. It involved three types of standalone systems i.e. PV electric energy generation systems, PV water pumping systems, and PV public lighting systems to improve the quality of life of rural communities. From 1996 to 2000 photovoltaic panels of around 3MW were distributed to 3050 villages which benefited more than six (6) lakh people. PRODEEM is no more in existence and is superseded by Luz para Todos (LpT or Light for All).

4.1.2 Luz no Campo

In 1999, the Government of Brazil has initiated *Luz no Campo* (LnC or Light in the Countryside) with an objective to provide electricity to one million rural households in three years which was expected to benefit a population of around five (5) million. In 2002, the programme covered around 480000 connections. Under this programme the rural consumers are supposed to pay the full cost of connection typically spread over a number of years. The programme has a provision to provide 75% of the investment as loan on easy terms at 6 per cent rate of interest, with a two-year grace period and a five to ten year repayment period to the energy companies implementing such projects. The programme is superseded by Luz para Todos (LpT or Light for All) during 2003.

4.1.3 Luz para Todos

In November 2003, the programme *Luz para Todos* (LpT or Light for All) was initiated with the objective to provide access to electricity to twelve (12) million people who are not connected with the electricity grid. The programme was implemented through partnership between the Federal Government, the State Government and the energy companies. The programme aimed to improve rural electrification through expansion of network, distributed generating systems with isolated networks or individual plants, with renewable energies also used for generating electricity. The programme superseded earlier rural electrification programmes initiated by the Government.

It has been observed that earlier schemes were unable to reach significant progress and accordingly authorities formulated the idea of universal electricity access programme that would supply electricity to all rural communities within the five year span. The Brazilian Electricity Regulatory Agency, ANEEL, shall have the oversight for authorisation of concessionaries and other service providers along with setting and verifying the targets set under LpT. The Ministry of Mines and Energy is responsible for coordinating the programme and setting its general policy. The operational implementation of the LpT involved three options i.e. extension of grid, decentralised generation in isolated grids and standalone individual systems. Despite of have three options, it has been observed that the LpT model was primarily based on the extension of the electricity grid for providing access to rural communities.

Initially, the renewable energy resources were not utilised for rural electrification however, the programme identified that solar, wind, mini hydro and in some instances natural gas as most practical solution to provide access to electricity even in far remote areas. The community witnessed improvement in social programs related to health services, education, water supply and sanitation among others which strongly affect the HDI with the arrival of electricity. During 2009, the scheme has achieved two (2) million connections which translated to more than ten (10) million beneficiaries.

The key parameters for success of 'Light for All' are identified as,

- Strong political will, the LpT is treated as key component of the national strategy for poverty reduction and sustainable development
- Community to be the part of the process which translate to improve the effective and prompt responsiveness of the electrification model
- Well defined guidelines for transfer of responsibilities from Government to the implementing agencies. The compulsory completion of specific and prioritised targets has promoted development of projects.
- Key issues related to efficiency, quality and costs of service to be appropriately addressed

4.2 Initiatives for Rural Electrification in China

The evolution of rural electrification in China may be divided into three phases. During the first phase spanning 1949 to 1977, the rural electrification efforts were mainly attributed to the rural communities. During the second phase (1978 to 1997), the efforts were taken by the Governments at various levels, Both, Central and Local Governments, played pivotal role in the rural electrification. In the last phase that started in 1998, Central Government played a key role in the rural electrification. It has been observed that the rural electrification process in China has slowed down, not because of lack of support by authorities but because of universal electrification which has crossed the mark of 99 per cent. Various prevailing schemes and programmes are elaborated in the paragraphs below,

4.2.1 Brightness Programme and Township Electrification Programme

With an objective of providing access to electricity to 23 million people living in remote rural areas through decentralised energy systems based on renewable energy, the State Development Planning Commission, in 1996, initiated the 'Brightness Programme'. Further, as a part of Brightness Programme, Township Electrification Programme (2002 – 2005) with an investment of Chinese Yuan 4.7 billion was initiated with the support from Central and Local Government funds. The Township Electrification Programme is one of the largest renewable energy based rural electrification programme in the world and it aimed to provide access to electricity to a population of approximately 1.3 million.

4.2.2 County Hydropower Construction of National Rural Electrification

The programme aimed to provide access to electricity to a population of 880,000 and to 4.85 million people, through utilising hydro power, by 2010. By the year 2008, around 45,000 small hydro power stations were installed with an installed capacity of 51GW which supplied electricity to a population of around 300 million.

4.2.3 Power to all

The programme 'Power to all' was initiated by the State Grid Corporation which aimed to provide electricity to 4.5 million people by 2010 in 26 provinces. It has been observed that by the end of 2007, the programme has achieved around 99.66% electrification of villages and around 99.87% in terms of providing access of electricity to households.

4.2.4 China Southern Grid Electrification Efforts

The programme aimed to have completed the construction of power grids at the county level by 2010, for the supply of electricity to 410 000 households through extension of electricity grid. The programme has achieved success rate of 99.94% and by the end of 2008, out of a total of 63249 administrative villages, only 37 were remain un-electrified. Further, in terms of electrification of rural households the programme as achieved 99.51% success rate and provided electrification to more than 47million rural households.

4.2.5 Golden Sun Programme

The Ministry of Science and Technology (MOST), the Ministry of Finance (MOF), and National Development and Reform Commission (NDRC), during 2009, had announced support the deployment of up to 500-600 MW of large-scale solar PV in both on-grid and off-grid areas by 2012. The programme aims at all provinces with a cap of 20 MW per province. The Government proposed to provide a Capital subsidy for grid connected solar power projects to the extent of 50% and for off-grid systems around 70% of the total investments.

The keys to the success of rural electrification in China are mentioned below,

- Strong commitment by the Government has proven primary role to the success of electrification
- Flexibility in selection and utilisation of wide range of technologies
- Involvement of community to generate sense of ownership among individuals

- Involvement of private sector for implementation through competitive bidding

4.3 Initiatives for Rural Electrification in South Africa

The emphasis on rural electrification in South Africa has been given serious consideration only after announcement of Integrated National Electrification Programme in 2001. Prior to the announcement of the scheme, the electrification was concentrated only to urban areas. It has been observed that during 1993 the around 30 per cent of households were electrified which has increased to around 75 per cent by 2009. The electrification was mainly achieved through extension of the electricity grid.

Before 1994, the ESKOM – the national power utility was responsible for electrification in the country. In 1994, the parliament approved the plan to provide access to electricity on equal basis and appointed National Energy Regulator to develop and manage the implementation of Integrated National Electrification Programme (INEP). The INEP aims to provide access to electricity to all households by 2012. The programme has been running since 2001 and during April 2002 the Department of Minerals and Energy took over the responsibility for implementation and managing of the programme.

A special allocation of funds, on an average of US$160 billion per annum since 2003, has been made in the National Budgets for the electrification programme. The INEP envisages supply to even remotely located areas through extension of grid and plans to achieve full scale electrification by 2014. However, in remote rural areas where extension of grid was found not feasible, the provision is made to provide Solar Home Systems (SHS). The Off-Grid electrification is carried out through engaging private sector participation through bidding process. Under the Off-Grid electrification, the rural consumers purchase electricity from the service provider who is also responsible for the maintenance of the SHS.

Key lesson learnt from the electrification programme in South Africa are discussed in the following paragraphs,

- It has been observed that the installed generation capacity is insufficient to meet the demand for electrification. The installed generation capacity in South Africa is around 40GW. There are now national plans to expand the generation capacity and double it by 2025. This shall aid to successful electrification in urban as well as rural areas.

- It has been observed that the tariff offered by the national power utility had become one of the reasons for capping the installation of new generation capacity in the country. For example, it has been found that, during 2005, the ESKOM has sold the electricity at US$0.027/kWh and imported from the neighbouring country at price of around US$0.007/kWh which has made the installation of new generating capacities in the country non profitable. There was very less generation margin which led to endless power cuts and load shedding. Owing to such fact it has been decided that the tariff shall be doubled within a span of three year period.
- In past, supply of power at low tariff led to use of energy in inefficient manner. During 2005, the Government announced first national strategy towards energy efficiency. However, with increasing shortage of supply, the nationally mandated energy efficiency targets were introduced.
- Off Grid electrification programme involved private sector participation. However, it has been observed that lack of political will and government support has led to the defeat of the programme.
- The poor deployment of renewable energy was attributed to the lack of requisite policy framework. During 2009, the first national feed in tariff scheme was established. In spite of having the best solar radiation across the world, the Solar Home Systems were viewed as temporary solution until the extension of the grid. The authorities had to arranged campaigns and community development programmes to change the perception towards renewable energy.
- Owing to non payment of electricity bills, the prepaid meters are now made part of all the installations for all new connections under the INEP.

4.4 Key Lesson Learnt – International Perspective

4.4.1 Separate Institution to promote Rural Electrification

A dedicated institution to address the issues is a key to success and promotes rural electrification. It has been observed that most of the successful rural electrification programmes have a separate institution or authority, rural electrification authority (Bangladesh); setting up rural electric cooperatives (Costa Rica); allocating rural electrification to a new department in the national distribution company (Thailand); or delegating it to a specialized office within the utility (Tunisia), which looks after the electrification of rural areas/community.

4.4.2 Commitment from the Government

In order to make any programme a success, the continuous support from the Government is utmost. It has also been observed in South African Off-Grid Electrification programme that because of the lack of support and commitment from the Government the programme has not achieved desired success. On the other hand support from the Government has led to more than 99 per cent electrification in China. Thus, without firm policy support from the Government the probability of success is less for the electrification process.

4.4.3 Subsides for grid expansion capital costs

In most successful programs, a substantial proportion of the investment has been obtained at reduced or low interest rates or in the form of subsidies/grants. However, an oversight on the agencies/authorities implementing the programme was found necessary to make sure that the fund is utilised for the desired purpose. Penalties may be imposed for unsuccessful implementation. For example, the capital subsidy provided for rural electrification may be translated into interest bearing loans if it is found that the implementing authorities are not utilising the funds properly.

4.4.4 Tariff and Collection

The price to be charged for supplying the electricity should be dealt appropriately. Further, a proper mechanism for collection of charges towards supply of electricity should be in place. Such collection shall be used to meet operational and maintenance cost required in the process of rural electrification.

4.4.5 Involvement of Local Community

It has been observed that the rural electrification programs may benefit greatly from the involvement of local communities and suffer because of its absence. The involvement of local community shall instill the sense of ownership. Further, the development of local community through appropriate training shall aim at reducing the operational and maintenance cost of the implementing agency. Such involvement shall also reduce the dispute and damage in the process.

4.4.6 Participation of Private Sector Players

The private sector participation, across the world in various rural electrification programmes, has shown positive results. Involvement of private sector through transparent mechanism not only creates competition in the market but also increases the coverage of the programme. The participation of private sector was found important when providing access to electricity to remotely located population through developing off grid generating system or stand alone systems. However, in order to safeguard the interest and increase the participation from private sector, a strong commitment from the Government is necessary.

5 RET OPTIONS FOR OFF-GRID GENERATION

In this chapter, several technology options for off-grid renewable energy generation for community based electrification have been analysed.

5.1 Solar Photovoltaic Power Systems

5.1.1 Resource Potential and Achievements

Energy from the sun has many features making it an attractive and sustainable option viz. global distribution, pollution free nature, and the virtually inexhaustible supply. Being located in earth's tropical region with annual average temperature in the range of 25-28°C, solar is an important energy resource in India having vast potential to offer an improved power supply (especially in remote areas) to enhance its energy security. Most parts of India has around 250–300 sunny days in a year and receive about 4–6.5 kWh (kilowatt-hour) of solar radiation per square metre per day. It is estimated that around 12.5% of India's land mass (or 413,000 km2) could be used for harnessing solar energy, which could be further increased by the use of building-integrated PV.

Desert region of western Rajasthan receives the highest annual radiation energy while generally cloudy north-eastern region receives the lowest annual radiation. Solar photovoltaic route converts the light in solar energy into electricity, which can then be used for a number of purposes such as lighting, pumping, communications, and power supply in remote un-electrified areas.

India's installed solar power capacity of 15.2 MW (at the end of June 2010) was mainly based entirely on PV technology. Out of this approximately 20% of the capacity is being used for off-grid applications. Since Phase 1 of JNNSM aims to install 500 MW of grid-connected solar PV power by end of 2013, India currently more attention is being paid to large-scale solar PV projects. Many of the projects registered under state programs in Punjab, Gujarat, West Bengal, Rajasthan, and Karnataka are being migrated to JNNSM.

As of June 2010, SPV accounted for only 12.28 MW, or 0.07%, of the total 17,174 MW of grid-connected renewable power capacity of India. Relatively off-grid and decentralized solar applications have been more successful in India due to several schemes with direct subsidies and government-financed pilot projects. The total decentralized installed solar capacity was 2.92 MW, or 0.7%, of the total 420 MW of off-grid renewable power in India (as of June 2010) which mainly included applications like solar street and home lighting systems, solar lanterns, solar cookers, and water pumps.

5.1.2 SPV Technology

Solar photovoltaic (SPV) process converts solar radiation (sunlight) into electricity using a device called solar cell. SPV systems utilize semiconductor-based materials (solar cells) which directly convert solar energy into electricity. The amount of electric current generated depends on many factors such as solar material of fabrication, exposed area, ambient temperature etc. PV modules are generally made from strings of crystalline silicon solar cells made of extremely thin (about 300µm) fragile silicon wafers which are hermetically sealed between a layer of toughened glass and layers of ethyl vinyl acetate (EVA) to protect from damage with an insulating tedlar sheet placed beneath to give further protection. This is then assembled with an outer frame to give strength and enable easy mounting on structures to make it a PV module.

Most solar cells are made of a single crystal or multi-crystalline silicon material. The thin film solar cell technologies are at various stages of development and have not yet reached the maturity of crystalline silicon. The thin-film solar cells are made from amorphous silicon (a-Si), copper indium selenide/cadmium sulphide (CuInSe2/CdS) or cadmium telluride/cadmium sulphide (CdTe/CdS), by using thin-film deposition techniques.

Capacity of individual PV module ranges from 5Wp to 120Wp that can provide power for different loads. The wattage output of a SPV module is rated in terms of peak watt (Wp[1]) units. Required power can be obtained by making solar cell modules connecting several solar cells in series and parallel combinations.

In an SPV system, the components other than the PV module are collectively known as 'balance of system' (BoS), which includes batteries for storage of electricity, electronic charge controller, inverter, etc. During daytime the batteries are charged using the DC power generated by the SPV module which in turn is used to supply power to loads during the night or non-sunny hours. For operating normal AC loads, an inverter is required to convert the DC power from the

[1] W_p is the maximum power output that can be delivered by the module under standard test conditions of solar radiation intensity of 1000 W/m^2, air-mass 1.5 reference spectral distribution, and ambient temperature of 25°C.

PV module or battery to AC power while DC pumps can operate without an inverter or even a battery bank.

The major advantages of SPV systems are:

- Abundant availability of solar radiation in the most parts of the country
- Modular nature of SPV systems enabling to use them for small and large applications
- No running costs due to free input solar radiation
- Noise free generation of electricity using solar cells
- No wear and tear of PV systems in absence of any moving parts
- Quick and easy installation due to pre-fabricated parts, hence short gestation periods.
- SPV modules have long-life requiring negligible maintenance, only BoS components such as batteries and inverters require minor maintenance.

In an SPV power plant, the electricity is generated centrally and is made available to users either through a local grid in a 'stand-alone' mode, or connected to the conventional power grid in a 'grid-interactive' mode. Stand-alone power plants are preferred over individual SPV systems if a number of users are in close proximity and grid-quality power is supplied locally to people to meet their requirements for lighting and other needs.

5.1.3 SPV Lighting Systems

SPV lighting systems are becoming popular in both urban as well as rural areas. In rural areas they are being used mainly in the form of portable lanterns, home-lighting systems with one or more fixed lamps, and street-lighting systems. Various popular applications in urban areas include glow-sign display systems on the streets, traffic signalling, LED (light-emitting diodes) based message display systems, and illuminated advertisement hoardings.

Solar lantern

The solar lantern is a portable lighting system, easy to carry around both indoor and outdoor usage, being light in weight. It consists of a 8 to 10 Wp capacity PV module along with 12V-7AH capacity sealed maintenance-free battery and 5-7W CFL (compact fluorescent lamp). A solar lantern is usually designed to provide light for 3-4 hrs with 3 days backup. Typical cost of solar lantern is in the range of Rs 3000–3300.

Solar home system

A solar home system (SHS) is designed to provide a comfortable illumination level for 3-4hrs daily in one or more rooms of a house with 3 days backup. Typical SHS consists of 18, 37 or 74 Wp capacity PV module along with a 12V sealed maintenance-free (or flooded lead–acid battery) of required capacity (20, 40 or 75 AH capacity) and 9 or 11 W rating CFLs. There are various models featuring one, two, or four CFLs and also possible to run a small DC fan or a 12-V DC television. The cost of an SHS depends on load, capacity of PV modules used and battery to meet the required autonomy.

SPV power plants

In an SPV power plant centrally generated electricity is either made available to users through a local grid in a 'stand-alone' mode, or connected to the conventional power grid in a 'grid-interactive' mode. Grid-quality power is locally provided using a stand-alone power plant to people to meet their requirements for lighting and other daily needs. If large number of users is in close proximity, power plant would be a preferred option over several individual SPV systems. The cost of power works out to be of the order of Rs 15-17 per kWh for a grid-interactive power plant and more than Rs 20 per kWh for stand-alone power plant.

Stand-alone SPV power plant

The capacity of a typical stand-alone power SPV power plant varies from 1 kWp to 25 kWp (even higher) typically designed for specific requirements. These are normally used where conventional grid supply is either not available or is erratic/irregular; most common use is electrification of remote villages. Other uses include power for hospitals, hotels, communications equipment, railway stations, border outposts, etc.,

Stand-alone SPV power plants comprise PV array, battery bank, inverter, and charge controller. SPV modules are arranged in series and parallel combinations depending on the required voltage levels (24 to 240 V). The battery bank capacity depends on user requirements and is determined by the system voltage and ampere-hour requirements of the load.

5.2 Bioenergy

Since dawn of civilization biomass has been one of the major energy sources for the mankind, though its importance might have faded after the expansion in use of more convenient to use high energy intensity fossil fuels such as coal, oil, natural gas since late19th century. With deteriorating global environment scenario there is renewed interest in biomass energy in many countries which can be attributed to the benefits it offers viz. renewable, widely available, and carbon-neutral with potential to provide significant productive employment in the rural areas. Biomass is also capable of providing firm energy. Currently, about 11% of the world's primary energy is estimated to be met with biomass with estimates of 15%–50% of the world's primary energy coming from biomass by 2050.

Being agrarian based economy, biomass has always been an important energy source in India. Despite growing dependence on the conventional forms of energy, about 32% of the total primary energy use in the country is still derived from biomass and more than 70% of the country's population depends upon it for its energy needs.

MNRE has initiated a number of programmes for promotion of modern biomass technologies for its use in various sectors of the economy for exploitation of biomass energy resource. Modern biomass energy is derived from organic material and can be used in a variety of conversion processes to yield power, heat/steam, and fuel. In India, the use is focused on waste materials such as municipal, agricultural, or forest residues. Biomass is generally divided into three categories: biogas, liquid biofuels and solid biomass.

5.3 Biogas

Biogas is a clean fuel obtained via an anaerobic digestion of a variety of organic wastes such as animal waste, crop residues, and waste from industrial and domestic activities to produce the combustible gas methane.

Anaerobic digestion comprises three steps – (i) decomposition (hydrolysis) of plant or animal matter to break down complex organic materials into simple organic substances, (ii) conversion of decomposed matter into organic acids, (iii) conversion of acids into methane gas. Apart from temperature, the rate of biogas production also depends on factors such as the carbon: nitrogen ratio, hydraulic retention time, solid concentration, and types of feedstock. Biogas consists of methane, carbon dioxide, and traces of other gases such as hydrogen, carbon monoxide, nitrogen, oxygen, and hydrogen sulphide.

With about 28% of the world’s total cattle population, India ranks first in the world. Despite huge estimated availability of cattle population in different parts of India, potentially supporting about 12 million family-size biogas plants, around 4 million family-size biogas plants (mostly of 2m3 capacity) have been installed in India. For family-type biogas plants, approved models are available for 1–6 m3 and 1–10 m3 capacities for fixed-dome and floating-drum plants, respectively. The commonly used capacities of these models are 1–4 m3. Biogas has been mostly used for small, rural, and off-grid applications.

Biogas can be combusted directly as a source of heat for cooking, used for space cooling and refrigeration, or used as fuel in gas lamps for lighting. It may also be used to fuel internal combustion engines for production of mechanical work or for electricity. The slurry produced after digestion can be used directly as a valuable fertilizer.

An additional 1,300 MW could be supported from biogas using industrial wastewater (primarily from distilleries and sugar and starch processing plants). The larger-scale biogas facilities use wastewater generated from beverage, meat processing, pulp and paper, food packaging, and other industries to produce electricity. It is estimated that the liquid organic waste generated every year by the urban population in India could support over 2.5 GW of installed capacity. Recently 70 projects with aggregated capacity of 91 MW electricity equivalent were installed in India through larger scale biogas facilities using wastewater generated from beverage, meat processing, pulp and paper, food packaging, and other industrial sectors.

Electricity is being produced by biogas plants installed under the Biogas Distributed/Grid Power Generation Program (BGPG) launched by MNRE in 2006. Under this program, the projects are developed at the village level by a community organization, institution, or private entrepreneurs, and the produced electricity is sold to individuals or communities or to the grid on mutually agreed terms. The unit capacity ranges from 3 kW to 250 kW. There are around 73 projects installed with a total capacity of 461 kW have been installed under distributed/grid power generation program. There is also one biogas micro turbine based grid connected (2 x 30kWe capacity) pilot biogas power plant at goshala in Purlia district of West Bengal.

Majority of the biogas plants in India are cowdung based for individual households and operate at a household level to meet cooking and lighting needs in rural areas throughout the country. Wastewater or industrial effluent based plants are resource specific and generally of large megawatt scale capacities with grid connectivity. Therefore, biogas for off-grid application is more suitable to meet cooking energy to save fossil fuel and/or woody biomass used for cooking. Also managing biogas based small (kilo watt size) plants for rural application is difficult in absence of monetization of feed material (cow-dung-slurry).

However as observed in some SVO based VESP pilot plants there is scope for biogas based power generation and can be economically viable too if deoiled cake is used as feed material for biogas production to run kilowatt (sub-megawatt) scale gas engine based off-grid power plant. However it becomes too site specific and hence biogas based power generation option is not considered here for community based off-grid power for rural electrification.

5.4 Liquid Biofuels

India's biofuel strategy is focused on using non-food sources for the production of biofuels: sugar molasses and non-edible oilseeds. In India, ethanol is produced by the fermentation of molasses, a by-product of the sugar industry. Efforts to produce ethanol from other feedstock such as sweet sorghum, sugar beet, and sweet potatoes are at an experimental stage in India. Additionally, various public and private institutions in India are conducting research in the area of cellulosic ethanol, which uses feedstock such as agricultural and forest residues.

India's commercial production of biodiesel is very small, and what is produced is mostly sold for experimental projects and to the unorganized rural sector. The existing biodiesel producers in India are using non-edible oilseeds, non-edible oil waste, animal fat, and used cooking oil as feedstock.

Liquid biofuels, namely ethanol and biodiesel, are used mainly as a substitute to petroleum-derived transportation fuels. Though few pilot plants have been installed using SVO based power generation for off-grid villages under pilot demonstration phase of VESP they are facing shortage of bio-oil as well higher prevailing price of bio oil due to demand supply gap. Therefore bio-fuel based power generation option is not considered here under this study.

5.5 Solid Biomass based power generation

Solid biomass includes forest residues and agricultural residue as well as organic household and industrial wastes for direct combustion or gasification to provide electricity or combined electricity and heat (cogeneration). MNRE estimates that the surplus biomass resources potentially available for power generation could support roughly 25 GW of installed capacity, while cogeneration plants has a potential of about 15 GW using cogeneration in various industries including sugar mills, breweries, textile mills, distilleries, fertilizer plants, pulp and paper mills, and rice mills.

Biomass resources in India are used for power generation in three general applications:

- Grid-connected biomass power plants (using combustion and gasification conversion technologies).
- Cogeneration (simultaneous production of both heat energy and electricity from one energy source).
  - Bagasse cogeneration in sugar mills.
  - Non-bagasse cogeneration in other industries.
- Off-grid/distributed biomass power applications (using primarily gasification conversion technology).

The first two are normally large (several megawatt capacities) grid connected plants. The technology for generation of electricity from biomass materials is similar to the conventional coal-based thermal power generation. The biomass is burnt in boilers to generate steam, which drives a turbo alternator for generation of electricity.

Alternatively, gasifier systems that convert biomass resources into a combustible gas could be installed for the generation of electricity. Here, sub-megawatt size small capacity biomass gasifier based power generation systems are considered as an option for off-grid community level power generation option for further study.

5.5.1 Resource potential

The estimated amount of biomass resources in India is about 565 million tonnes per year, including agricultural residues (resulting from crop harvesting and processing) and forest residues (resulting from logging and wood processing). The agricultural residues, which provide most of the biomass resources in the country, include rice husk, rice straw, bagasse, sugar cane tops and leaves, groundnut shells, cotton stalks, and mustard stalks. Some of the agricultural and forest residues are already in use as animal feed and fuel for domestic cooking, among other purposes. Thus, the amount of surplus biomass resources available for power generation annually is about 189 million tonnes, which could support roughly 25 GW of installed capacity. States with the highest potential include Maharashtra, Madhya Pradesh, Punjab, Gujarat, and Uttar Pradesh with significant biomass based installed capacity.

It is estimated that about 15 GW of electricity generating capacity could be achieved through adding cogeneration capabilities in various industries including sugar mills, breweries, textile mills, distilleries, fertilizer plants, pulp and paper mills, and rice mills. Alternatively, gasifier systems that convert biomass resources into a combustible gas for the generation of electricity and heat could be installed at these plants to meet their captive energy requirements.

The total installed grid-connected biomass power and bagasse cogeneration capacity was 2,322 MW at the end of June 2010. The cumulative installed off-grid capacity as of June 30, 2010, was 238 MW of biomass and non-bagasse cogeneration and 125 MW of biomass gasifiers.

5.6 Biomass Gasifier based Power Generation

5.6.1 Biomass Gasification

Biomass gasification is a process of converting solid biomass fuel into gaseous combustible gas (called producer gas) through a sequence of complex thermo-chemical reactions. In the first stage partial combustion of biomass to produce gas and char occurs along with generation of heat. This heat is utilized in drying of biomass to evaporate its moisture as well as for pyrolysis reactions to bring out volatile matter and provide heat energy necessary for further endothermic reduction reactions to produce producer gas which mainly consists of mixture of combustible gases such as CO (carbon monoxide), hydrogen (H2) and traces of methane (CH4) and other hydrocarbon.

Normally air is used as gasifying agent; however use of oxygen can produce rich higher calorific value gas but due to cost implications is not usually preferred. Typical volumetric composition of producer gas is as follows.

Carbon monoxide - 18%–20%
Hydrogen - 15%–20%
Methane - 1%–5%
Carbon dioxide - 9%–12%
Nitrogen - 45%–55%
Calorific value - 1000–1200 kcal/Nm3

The clean producer gas obtained through gasification of biomass in gasifier can be used for electrical power generation, either through dual-fuel IC engines (where diesel oil is replaced to an extent of 60%–80%), or through 100% gas-fired spark ignition engines.

What can be gasified?

Most commonly available gasifiers use wood/woody biomass; some can use rice husk as well. Many other non-woody biomass materials can also be gasified. These include mustard stalks, and residual stalks of various agricultural crops like corn, flower stems, cashew nut shells, lantana, coconut shells, and briquettes of residues like sawdust, coir pith, groundnut shells, rice husk, etc. Although gasifiers have to be specially designed to suit these materials and the biomass may have to be compacted in many cases. Therefore briquetted biomass (with bulk density more than 400-600 kg/m3) can be used to enhance multi-fuel capability of gasifier.

Sources of fuel for biomass gasifiers

Various uses to which land is put in India are as follows.

- ✓ Approximately 14.30 crore hectares of land is under agriculture.
- ✓ Forests cover over 67.55 crore hectares of which 41.40 croroes hectares is dense forest.
- ✓ About 8.15 crore hectares of land is covered by tree plantations.
- ✓ Finally, 10.70 crore hectares is identified as degraded forests, also known as wasteland.

This 10.70 crore hectares of wasteland (fallow land and common or uncultivated, non-grazing land) is controlled by the government and the panchayats. These lands could be used to grow the biomass necessary to run gasifiers, through forestry or agro-forestry.

While mixed tree plantations can also yield twigs and branches to feed biomass gasifiers, it would be wise to invest in some of the fast-growing, wood yielding plant species of India, which have been identified as ideal to fuel biomass gasifiers. These are as follows.

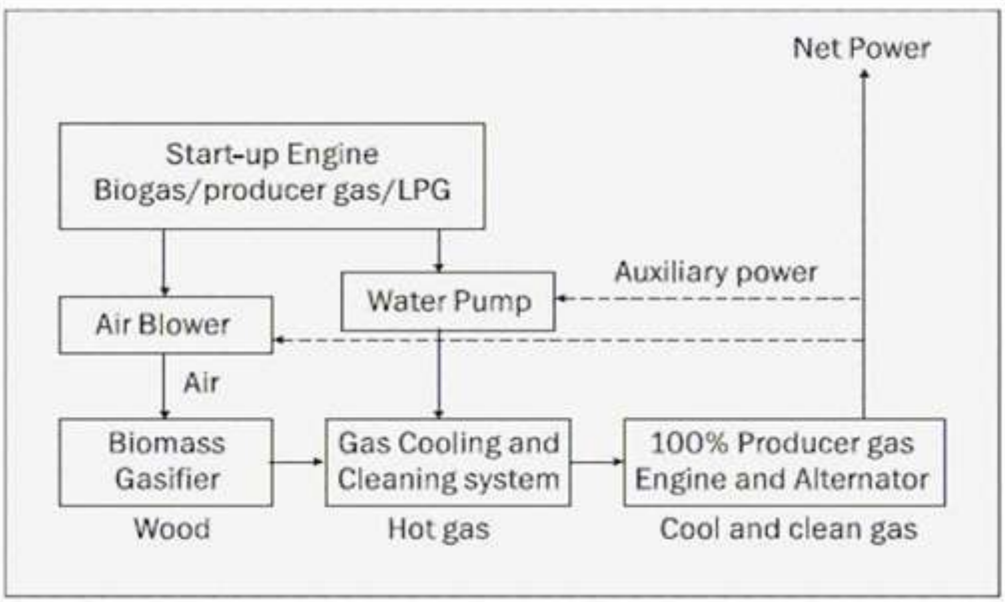
- ✓ Acacia aurifuliformis (Australian kikar)
- ✓ Acacia nilotica (kikar)
- ✓ Various species of bamboo
- ✓ Various species of eucalyptus
- ✓ Populus deltoids (Populas)
- ✓ Prosopis cineraria (khejari)
- ✓ Prosopis juliflora (safed kikar)

- ✓ Acacia mangium (Mangium)
- ✓ Leucaena leucocephala (Leucaena)
- ✓ Casuarina equisetifolia (Casuarina)

5.6.2 Biomass Gasifier based Power Generating System

A biomass gasifier based 100% producer gas (modified diesel) engine power generation system normally consists of:

- ➢ a biomass gasifier that converts biomass into combustible producer gas
- ➢ a gas cooling-cleaning train that cleans and cools the gas so that it can be safely used in engine, and



- ➢ a gas (modified diesel) engine generator system capable of operating on 100% producer gas mode.

Gasifier types:

Gasifiers can be of 'updraft' or 'downdraft' types, the latter is preferred for power generation as it gives relatively clean gas (low tar). In a typical downdraft gasifier, fuel and air move in a co-current manner. In updraft gasifiers, on the other hand, fuel and air move in counter-current manner. However, the basic reaction zones remain the same. Fuel is loaded into the reactor from the top. As the fuel moves down, it is subjected to drying and pyrolysis. Air is injected into the reactor in the oxidation zone, and through the partial combustion of pyrolysis products and solid biomass, the temperature rises to 1100°C. This helps in breaking down heavier hydrocarbons and tars. As these products move downwards, they enter the reduction zone where producer gas is formed by the action of carbon dioxide and water vapour on red-hot charcoal. The hot and dirty gas is passed through a system of coolers, cleaners, and filters before it is sent to engines.

Majority of commonly available gasifiers use wood/woody biomass as fuel, while some can use rice husk also. Many other non-woody biomass materials can also be gasified, although gasifiers have to be specially designed to suit these materials and/or available biomass can be pre-processed through chopping, pulverising and compaction (briquetting) to convert them into more uniform size and shape.

Producer gas engines

For power generation, producer gas can be used in IC (internal combustion) engine. Existing petrol (Otto Cycle) or spark ignition (CI) engines can be used but normally they operate on lower compression ratio (and hence with lower efficiencies) and also results in large derating when operated on low heating value producer gas. Therefore, normally diesel engines are preferred for the use of gas in engine operation as they normally operate with a higher compression ratio and excess air levels resulting in reduced derating. Existing diesel engines can easily be operated on dual fuel (diesel + gas) mode (70-80% gas and 20-30% diesel). The development of a modified diesel engine capable of operating on 100% producer gas has been initiated at several research institutes. The engine modification basically involves:

- Modifying piston and/or cylinder head to reduce the compression ratio
- Replacing diesel injectors with spark plugs
- Using a diesel pump governing mechanism for spark distribution
- Adjusting the spark ignition timing

Several engine manufacturers are now supplying engines for 100% producer gas operation by either modifying diesel engine or using natural gas engines.

Biomass gasifier-based systems are being made in capacities ranging from a few kilowatts to a megawatt. The typical costs of biomass gasifier-based electricity generation systems range from Rs 40-50,000 per kWe and the cost of power generation depends on cost of biomass, plant load factor, etc., and is estimated to be between Rs 6/kWh and Rs 12/kWh depending on the CUF.

5.7 Micro hydro power plants

Hydro power is the largest renewable energy resource being used for the generation of electricity. Small and micro hydro power projects are considered environmentally benign as compared to large hydro plants with storage reservoirs. This is because large hydro power projects with huge water storage dams can cause habitat destruction and community displacement while small and micro hydro plants are generally run-of-river with only small amounts of water stored, if any.

According to MNRE, the potential for small hydro in India is estimated to be 15,386 MW for 5,718 prospective plant sites identified so far. Out of this major share of about 42% (6,592 MW) is in four northern mountainous states of Himachal Pradesh, Uttarakhand, Jammu and Kashmir, and Arunachal Pradesh. The state-level potential estimates from MNRE are shown in Table below along with total installed capacity and projects in progress as of December 2009. Thus, small hydro can make a significant contribution to power supply in India, especially in remote areas in these hilly regions where alternative supply solutions face many challenges.

Hence development of small hydro is one of the focal areas of MNRE and is supporting its deployment through several schemes like capital subsidies and preferential tariffs. With focus on reducing capital costs and enhancing reliability, plant load factors, and average plant lifetime, government aims to develop half of the identified potential in the next decade. Grid-connected small hydropower contributes about 16.2% to India's total grid interactive renewable energy based power plants with a total of 2,735 MW of installed capacity till March 2010.

Small hydropower is very well-suited for rural, remote, and hilly regions, such as the Himalayas, due to the high capacity factors of plants established in these areas. MNRE has developed a special financial incentives package for on- and off-grid small hydropower in northeast India. As of March 2010, 151 projects, totalling 241.27 MW, have been implemented and another 53 projects, totalling 58.05 MW, were under execution.

Classifications

Classifications of Micro, Mini & SHP in India

- Upto 100KW – Micro Hydro Power
- 101Kw to 2000Kw – Mini Hydro Power
- 2001Kw to 25000Kw – Small Hydro Power

Table 5.1: Small Hydro Potential by Indian States, Number of Sites, Installed Capacity, Installed Projects, and Capacity under development as on December 31, 2009

State	Number of Prospective Sites	Total Potential Capacity (MW)	Projects Installed (MW)	Projects in Progress (MW)
Andaman & Nicobar Islands	7	7	5	-
Andhra Pradesh	497	560	187	63
Arunachal Pradesh	550	1,329	67	21
Assam	119	239	27	15
Bihar	95	213	55	3
Chhattisgarh	184	993	19	-
Goa	6	7	0	-
Gujarat	292	197	7	5
Haryana	33	110	69	5
Himachal Pradesh	536	3368	255	185
Jammu & Kashmir 246 1,418 129 6	246	1418	129	6
Jharkhand	103	209	4	35
Karnataka	138	748	588	107
Kerala	245	704	134	24
Madhya Pradesh	299	804	71	20
Maharashtra	255	733	221	67
Manipur	114	109	5	3
Meghalaya	101	230	31	2
Mizoram	75	167	28	9
Nagaland	99	189	29	4
Orissa	222	295	64	4
Punjab	237	393	128	29
Rajasthan	66	57	24	-
Sikkim	91	266	47	5
Tamil Nadu	197	660	90	13
Tripura	13	47	16	-
Uttar Pradesh	251	461	25	-
Uttarakhand	444	1577	133	234
West Bengal 203 396 98 79	203	396	98	79
Total	**5718**	**15386**	**2556**	**938**

Classifications Based on Head

- Ultra Low Head – Below 3 meters
- Low Head – Less than 40 meters
- Medium/High Head – Above 40 meter

Benefits of the hydropower

- ✓ Hydro power is a clean, domestic and renewable source of energy.
- ✓ It does not produce greenhouse gases or other air pollutants

- ✓ Hydropower leaves no waste.
- ✓ One time capitalization is required for set up of a Hydro Power station.
- ✓ Like other fuel energy like fossil fuel, Water is not destroyed during the production of electricity – it can be reused for other purposes.

Small hydro power has following benefits

- ✓ Flexibility of installation and operation in a distributed mode
- ✓ Compatible with use of water for other purposes such as irrigation and drinking water
- ✓ Environment-friendly because it causes negligible or no submergence; minimal deforestation; and minimal impact on flora, fauna, and biodiversity
- ✓ Standard indigenous technologies and manufacturing base available.

Technology

Hydro power is obtained from the potential and kinetic energy of water flowing from a height. The energy contained in the water (both potential and kinetic) is converted into electricity by using a turbine coupled to a generator. Thus, the hydropower potential of a given site is dependent mainly on the head available as well as discharge of water, which can be estimated by the following equation.

$$P \text{ (power in kW)} = Q \times H \times 9.81 \times \eta$$

Where

Q = discharge (rate of flow) in m3/s;

H = head (height) in metres; and

η = overall power generating system efficiency.

Small hydropower has a capital cost of about Rs 50–60 million per MW, which is slightly higher than wind, and a levelized energy cost of about Rs 1.50–2.50 per kWh, which is the lowest among renewable energy technologies in India. Small hydropower equipment has been undergoing steady improvement in efficiency and reliability. This is primarily because of a shift from mechanical to automated electronic control systems and grid integration. Further improvements include remote operating projects and utilization of automatic data collection systems to allow remote monitoring of system performance. The technological trend is to continue to improve reliability and reduce capital cost while increasing efficiency. Logistical and civil construction processes need to be redesigned to reduce installation time. Advancements can also be made in sediment management to reduce silting of equipment.

5.8 Wind Energy Power Generator

Wind energy has been utilized by mankind for centuries for variety of mechanical applications. However recently wind energy has emerged as a viable renewable energy option, as environmentally benign without emitting any GHGs for applications such as water pumping, battery charging and large power generation. Especially large power generation has emerged as the most important application of wind energy world-wide.

5.8.1 Wind Power Potential

Wind power potential has been estimated by C-WET based on the assumption that 1% of each state's land area is available for development and that each megawatt of wind capacity requires 12 ha of land. The assessment shows that India's total wind potential is 48,561 MW, with Karnataka, Gujarat, and Andhra Pradesh as the leading states. Estimated the potential for wind power for nine major states has been given in the table below.

Table 5.2: Wind Potential for major States (C-WET)

State	Wind Power Potential (MW)
Andhra Pradesh	8,968
Gujarat	10,645
Karnataka	11,531
Kerala	1,171
Madhya Pradesh	1,019
Maharashtra	4,584
Orissa	255
Rajasthan	4,858
Tamil Nadu	5,530
Total	48,561

5.8.2 Technology

The concept is very simple, when wind flows over blades of a turbine it rotates and electricity is produced using generator unit. The blades and generator (housed in a unit called 'nacelle') are mounted at the top of a tower. Wind turbines generally have three rotor blades, which rotate with wind flow and are coupled to a generator either directly or through a gear box. The rotor blades rotate around a horizontal hub connected to a generator, which is located inside the nacelle. The nacelle also houses other electrical components and the yaw mechanism, which turns the turbine so that it faces the wind. Sensors are used to monitor wind direction and the tower head is turned to line up with the wind. The power produced by the generator is controlled automatically as wind speeds vary. The rotor diameters vary from 30m to 90m, whereas the tower on which the wind electric generators (WEGs) are mounted range in height from 25 m to 80 m.

Wind speed data of potential locations is compiled for a period of one to two years, to identify suitable sites for the installation of WEGs. WEGs are installed on the sites with appropriate distances between them to ensure minimum disturbance to one another. The power generated by wind turbines is conditioned properly so as to feed the local grid.

The unit capacities of WEGs range from 225 kW to 2 MW, and they can operate in wind speeds ranging between 2.5 m/s and 25 m/s. At the end of June 2010, India's installed wind capacity totalled 12,009 MW, representing 70% of India's total renewable energy capacity.

The current WEG turbines in India range in capacity from 250 kW to 2,100 kW compared to a global maximum of 5,000 kW; hub heights range from 41 m to 88 m compared to a global maximum of 117 m; and rotor diameters range from 28 m to 80 m, compared to a global maximum of 126 m.

The wind energy based power generation is very site specific and even actual power availability even at potentially good site varies with wind availability and therefore grid connected power is preferred. Recent trend is on installing large MW scale WEG units in order to minimize on installation costs, requirement of land for equal installed capacity, reduced operation and maintenance, and faster commissioning. Therefore wind energy generation is not considered here as option for remote off-grid community based power generation for electrification where requirement is of sub-megawatt (even <100kW) demand.

5.9 Wind–solar hybrid systems

For off-grid operation, a hybrid system consisting of an aero-generator and an SPV system are interfaced for mutually supplementing the power generation in order to provide reliable and cost-effective electric supply in a decentralized mode. The wind–solar hybrid system mainly consists of one or two aero-generators along with SPV panels of suitable capacity, connected with charge controller, inverter, battery bank, etc. to supply AC power. The major advantage of the system is that it meets the basic power requirements of non-electrified remote areas, where grid power has not yet reached. The power generated from both wind and solar components is stored in a battery bank for use whenever required.

The cost of the system varies from Rs 2.50 lakhs to Rs 3.50 lakhs per kW depending on the ratio of wind and solar components. The approximate cost of installation, including civil works, is about Rs 10,000 per kW. Repair and maintenance cost is about Rs 3000 per kW per annum. Subsidy of up to 50% of ex-works cost of the system is provided, subject to a maximum of Rs 1.25 lakhs per kW to individuals, industries, and R&D and academic institutions. The MNES provides a subsidy for community use and direct use by central/state government departments and defence and para-military forces of up to 75% of the ex-works cost of the system subject to a maximum of Rs 2 lakhs per kW. For non-electrified islands, subsidy of up to 90% of ex-works cost subject to a maximum of Rs 2.4 lakhs per kW is available. This type of system is eminently suitable for off-grid applications. Hence, this has been considered for further analysis.

6 OFF-GRID POWER DISTRIBUTION MANAGEMENT ISSUES AND CHALLENGES

The off-grid renewable projects are intended to cover those un-electrified villages, which are remote and unlikely to get electrified through extension of grid in near future through various ongoing rural electrification schemes. For large scale deployment, it is necessary to develop robust policy and regulatory intervention. In order to evolve such viable alternative mechanism there is a need to analyze key parameters such as prevailing situation of target community/villages, their requirements as well as expectations and unit size of the proposed RE based off-grid electrification system.

Therefore, in this section, effort has been to study target village profile, their paying capacity, different user categories, merits and demerits of various ownership and institutional models experimented in different parts to get insights from their learnings. The analysis is based on field visits, past experience on various off-grid projects, reports/papers/literature available on internet and other resources. These include but not limited to:

- Field visits undertaken to various field sites
- MNRE's VESP pilot test program
- TERI-NTPC off-grid pilots
- Husk and DESI power systems in Bihar
- BERI program under UNDP-GEF
- Other various national/international case studies and literature

6.1 Typical village and consumer profile of off-grid villages

The villages targeted for rural electrification through community based off-grid RE technology typically face the most challenging last mile access issues due to their locations from the grid. Being remote and deprived off of modern energy resources such as electricity for lighting and productive/economic activities and LPG/kerosene for cooking energy, these are basically tiny in nature and many a times comprise of group of small hamlets locally called as pada, wadi, or basti. As a result they mostly lack basic infrastructure such as school, hospital, office(s), commercial establishment and generally depend on nearby village/town for these facilities.

Though a lot of progress has been made to improve economic status, literacy rate etc through various programmes and schemes of rural development, their penetration and effectiveness in these off-grid villages is much lower than average achievements in their respective regions/states. For example, the baseline survey of selected sample VESP pilot project villages in different regions indicated the distance of these villages from nearest 11kV grid and block head quarter is more than 5km and 10km respectively. The distance from grid of village is much longer in case of tribal areas in Orissa, MP, Chhatisgarh in central region (~30km) than in case of Gujarat and Maharashtra (~20km). It may need to be emphasised here that majority of around 80+ pilot villages selected for the test phase of VESP were still relatively easily accessible off-grid or "not so remote" villages. Situation of other off-grid un-electrified villages is expected to be grim.

India being a agriculture based country, rural population depends mainly on agriculture for their livelihood. Therefore, in absence of commercial activity, majority of the off-grid village population comprises of household self farming (mainly single rain fed crop and in some case gypsy zoom cultivation type) followed by workers mainly under various rural development schemes or as agriculture worker. The baseline survey of large sample of households in select VESP pilot phase villages in different regions indicated that overall literacy rate in these off-grid un-electrified villages is around 40-45% and has more than 40% BPL population with average per capita monthly income of around Rs 300.

6.2 Typical energy consumption pattern and load demand

As mentioned earlier, the economic status of rural population in remote un-electrified areas is quite poor. Also in absence of significant economic/commercial activity, the demand for electricity is mainly for lighting purposes; at least for initial period till other productive load gets developed. Visits to Husk Power Systems in Bihar and information gathered from other VESP and off-grid power projects in different parts of India indicate that power requirements are mainly for:

Domestic lighting:	25-30W (around 2-3 bulbs of 5-15 watts CFL each) or
	80-120W in case of use of cheaper incandescence bulbs
Commercial load:	20-100W (lighting-shops/office; 2-10CFL bulbs)
	100W to few kilowatts (few electrical/electronic gadgets)

Once village is electrified, electricity demand from the following applications is expected to grow quickly.

- Cell phone charging (10-100W)
- Water pumping (0.5-3.5kW)
  - Drinking water supply
  - Vaccine storage
  - Irrigation, fish farming etc
- Grinding (0.5-3.5kW)
  - Floor mill (wheat/jowar/bajara/corn/rice etc)
  - Milling (paddy)
  - Masala (chilli/spices)
- Briquetting (5-50kW)
- Oil expelling (5-15kW)
- Refrigeration/ice making (1-10kW)
- Dona patta making etc (1-10kW)

As mentioned earlier, initially the major demand is going to be for lighting loads with share of around 70-80%. The commercial load would get developed over a period as economic activities get developed and streamlined with the availability of power and its enhanced reliability.

6.3 Present energy use pattern and Willingness to pay

In most un-electrified villages, kerosene is used to meet the lighting requirement. In some cases, particularly for commercial loads, portable generator set using kerosene/diesel fuel are used to meet the power demand for electrical/mechanical power applications. For domestic lighting purpose the monthly kerosene consumption is generally in the range of 3-9 litres (average of about 4.5 litre/kWh), which is generally restricted by PDS quota or availability or purchasing power depending on monetary income level. The average price of kerosene is around Rs 9-10 per litre and varies slightly in different states depending on variation in prevailing taxes and surcharges. Therefore willingness to pay for domestic lighting requirements is in the range of Rs 30-120 per month.

The average specific fuel consumption of the generator set is in the range of 300-500 ml/kWh which is relatively high due to smaller capacity and part load operations and lower efficiencies due to poor quality of engines as well as poor maintenance. Therefore willingness to pay for commercial lighting as well as other productive applications is in the range of Rs 10-15 per unit (kWh).

In Bihar, the Husk Power Systems are used to provide electricity in un-electrified as well as de-electrified villages which were earlier using DG set for meeting electricity demand for mainly lighting loads. As mentioned in the case study, villagers were earlier paying around Rs 80-90 per month for one 15W CFL bulb operation for 3 hours. The HPS is collecting monthly charges of the order of Rs 50-60 for 2CFL bulbs of 15W each operating for 6 hours. Thus, villagers are getting far more benefit (double electricity at half the price) even though per unit rate is Rs. 15-18/kWh, very high as compared to the grid tariffs.

6.4 Typical unit size and modular requirement

As mentioned in earlier chapter on renewable energy technology options, choice of renewable energy technology depends on the type of load and its demand. For example the lighting load can be met using any renewable energy technology option viz. SPV, gasifier, micro-hydro, solar-wind hybrid. The typical size of solar and solar-wind hybrid project for meeting lighting load can be in the range of 1-10kWp (kilowatt peak).

However, larger productive loads cannot be met through solar or solar-wind hybrid systems due to very high capital cost. Hence gasifier or mirco-hydro would be obvious choice if productive load is to be connected. In order to optimize capital investment, the gasifier and micro-hydro plants can be installed in modular form with capacity additions of 10 or 20kW depending on load requirement. Larger capacities of 50-100kW could be considered in specific cases if the productive load already exists or is expected to get developed. It is always better to have two modules instead of one large single capacity module, especially in case of biomass gasifier power plant, to have better PLF as well as backup option.

6.5 Challenges in off-grid rural electrification

It has been observed that major barrier in off-grid rural electrification is low load and energy requirement. This results in losing interest by distribution utilities because low collection efficiency due to low electricity loads coupled with large investment cost for building network resulting in high cost to serve.

6.5.1 Typical load and energy requirement

Apart from basic requirements of lighting and fan, the electricity requirement in a rural area is essentially for charging of mobile phones, entertainment purposes (radio/television etc.), pumping water for domestic as well as irrigation purposes, commercial activities such as grinding of floor , milling of paddy, grinding of spices etc. Further, briquetting, oil expelling, refrigeration etc. could be other commercial loads in a rural setup. The Table 6.1 below presents the illustration of typical load and energy requirement in rural setup,

Table 6.1: Load and Energy Requirement in Rural Setup (Illustration)

Category	HH Load	Duration	Monthly HH Energy Demand	Number of HHs per Village	Total Village Demand (kWh)
Domestic					
Lighting	25 – 35 W	4 – 6 hrs	5 – 6kWh	100 – 500	500 – 3000
Other	50 – 150 W	2 – 3hrs	6 – 9kWh	100 – 500	2500 – 3750
Likely Domestic Energy Requirement					***3000 – 6750***
Commercial					
Lighting	20 – 100W	4 – 6 hrs	12 – 18kWh	2 – 8	30 – 120
Equipment	100 W to few kW	4 – 6 hrs	150 – 750kWh	1 – 3	300 – 1500
Likely Commercial Energy Requirement					***330 – 1620***

(Source: ABPS Infra analysis)

6.5.2 Single phase vs three phase supply

Various renewable energy technology options are available which may cater to the load profile in the rural areas, however, it is essential to evaluate the financial viability of such options. Presently both single phase as well as three phase supply has been tried in decentralized renewable based pilot power projects in different case studies. Though initially single phase supply is sufficient to take care of prevailing lower loads, mainly domestic in nature, it becomes major barrier for growth in commercial load specially income or livelihood generating enterprise. In many VESP pilots too large commercial load like pumps, floor mill could not come up due to limited 10kW capacity. Therefore it is chicken or egg like situation in most of remote off-grid renewable project whether to go for large investment in three phase high capacity power plant with low prevailing load and energy demand (making it unviable for private investor) or go for single phase low capacity plant with higher plant load factor. Based on husk power experience here in potential business model in subsequent chapter modular 10-20kWe capacity systems are considered.

6.5.3 Controlling lighting load

As discussed earlier major share of load in remote village electrification is lighting load be it domestic or commercial. Generally in DD G scheme the tariff is fixed monthly amount per household connection for example Rs 30-80 per month is fixed by VEC in VESP project per household for two light point and one plug point. It is experienced that in such cases being cheaper in price and readily available people tend to use higher wattage incandescent bulbs than costly energy efficient low wattage CFLs. However in case of privately implemented model like Husk Power tariff is based on HPU (Husk Power Unit) which in itself is supplying electricity to energise one 15W CFL for 6hrs daily for one month. In such cases consumers are supplied with CFLs or forced to purchase CFLs. Several agencies have tried different innovative methods like load limiter MCBs or fuses for controlling the misuse of electricity and controlling connected loads.

6.6 Distributed renewable electricity generation implementation models

There is lot of information, experience available on distributed generation and rural electrification and various institutional models which are basically grid connected renewable based power plants mainly biomass, wind and SPV to limited extend. However, there is very little experience and information available with regard to "off-grid" renewable energy systems for electricity generation and distribution. There is recent resurgence of off-grid renewable as potential viable option as clean energy resource with announcement of electricity for all being promised by the government. This renewable based power has also gained importance as against polluted fossil fuel dominated grid power and its inability to cover many remote villages due to non-viability of grid extension for their electrification. Majority of the off-grid initiatives are either government subsidy driven or isolated attempts by individuals or NGOs in more or less exploratory or unorganized or informal manner with limited information available in public domain. The discussion and analysis is generally based on case studies being experimented in different parts (nationally-internationally) and learnings from them in recent past.

Various types of institutional models exist for providing energy access to rural areas through various forms of renewable energy. Decentralized distributed generation (DDG) implementation model mainly depends on status of local governance, type and quantum of load/demand, renewable technology option available. Generally cooperative and/or NGO based model is successful where local governance, community involvement and grass root NGO presence is quite strong which helps in its acceptability, adoptability as well as sustainability. In its absence more commercial and business/entrepreneur based model may work but would still need to ensure community involvement in management and revenue collection.

In India various off-grid renewable case studies or experiments are being tried out using various renewable energy technologies in different regions which can be summarized as in the table below,

Table 6.2: Different Technological options with the load profiles

Load profile	Technology options	Example
High load areas (>50kW) • Rural industry • Irrigation	• Gasifier • Micro hydro	• Husk Power System • Desi power/BERI • Many micro hydro sites
Medium load (10-20kW) • Domestic load • Livelihood/irrigation	• Gasifier • Micro hydro	• VESP/TERI-NTPC pilot projects • Many micro hydro sites
Low load (<10kW) • Domestic (lighting/basic) • Commercial lighting	• SPV • Gasifier • Micro hydro	• Solar Home RVE sites • VESP pilot projects • Many micro hydro sites

6.6.1 Husk Power System Business Model

HPS has adopted a demand driven approach and quantifies the potential demand in watt-hours, catering to minimum of around 500 – 600 households. Households are required to pay an installation charge of Rs 100, ensuring compliance by the users and cover a substantial portion of grid distribution expenditure. HPS has mainly 3 business Models

- BOOM (Build, Own, Operate and Maintain)
- BOM (Build, Own and Maintain)
- BM (Build and Maintain)

BOOM: Under this first starting model, all the activities of the gasifier power plant is carried out by HPS. HPS has 100% ownership of the plant. HPS installs (builts) the plant, owns and operates as well as maintains it regularly.

BOM: Under this modified model, HPS still has 100% ownership of the plant, HPS installs the plant and provide regular maintenance for the contract period of six (6) years. The plant is operated by the local entrepreneur and has to pay the maintenance fee of Rs 15,000 per month for six years and after completion of the contract period, the plant will be owned by the local entrepreneur. In order to start this plant, the local entrepreneur has to deposit a non refundable fee of Rs 2 Lacs.

BM: Under this latest business model for rapid scaling up, HPS install/builds the plant and provide maintenance service of the plant. The plant is fully owned and operated by the local entrepreneur who invests all the capital cost. Any financial assistance/subsidy on plant gets transferred to the local entrepreneur.

The operators are trained by HPS in Patna (Bihar), for two months and then sent for on the job training in one of the operational plants. In addition, two more people are associated with each plant - one of them handles husk buying and ensures a regular supply of raw material and also involved in the revenue collection activities, where as another one is an electrician for the cluster of villages. In addition HPS has cluster level manager who looked after the plants in the range of 20-25km or about 5-7 plants. Besides trained manpower, HPS has also taken due care to ensure smooth supply of low cost raw material. At the market end, the promoters have evolved strong relationship with the rice husk suppliers. This husk is transported by tractors simultaneously to about 7-8 plants in one cluster. HPS has plans to have one rice mill in each operational region to ensure sustained fuel supply at reasonable price.

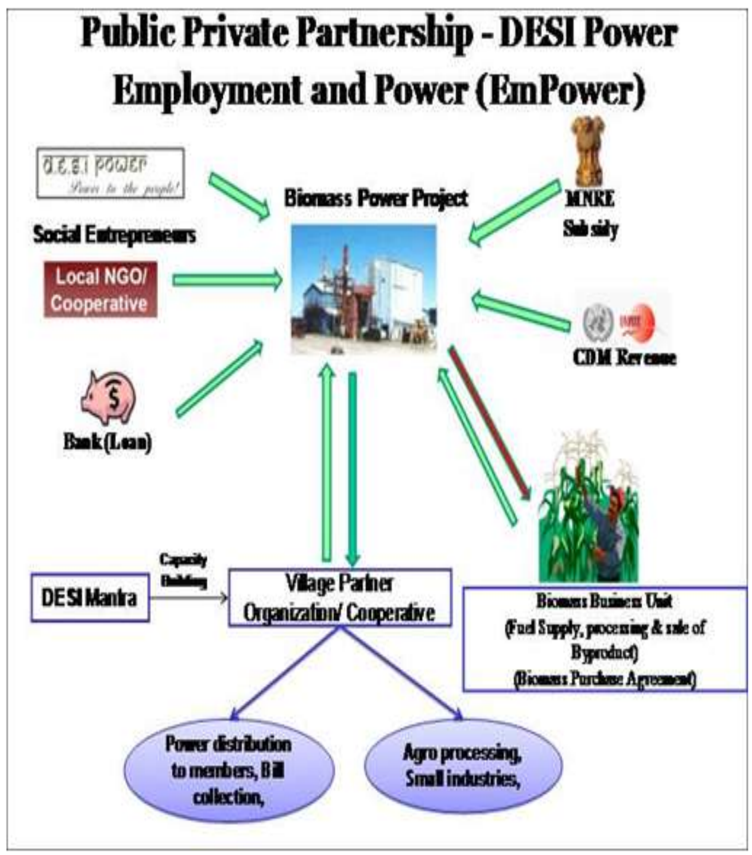
A differential pricing method is adopted by HPS to calculate the electricity charges. Accordingly, every household has to pay a fixed monthly charge of Rs 45 per CFL of 15 W, whereas shops pay a per month charge of Rs 80 per CFL. For households seeking connection to operate fan and television etc. charges are calculated on similar wattage basis.

1 unit of HPS (HPSU) = 15W * 6hrs * 30days = approx. 2.7 kWh equivalent

On an average, the monthly revenue collection of a typical 32kVA HPS plant is the plant is around Rs 60,000. The total monthly plant operating cost including the cost of manpower works out to Rs 25,000. This insures profit margin of approximately Rs 35,000, out of which the local entrepreneur has to pay a sum of Rs 15,000 to HPS per month making the project financially sustainable.

6.6.2 DESI Power – PPP service delivery model

Under this type of model the project developer sets up power plants in villages jointly with the local partners. In order to enhance economic viability, the power plant is integrated with energy services and with a number of micro enterprises, mainly in agro-processing work. The plant is managed by the village community, members of whom are trained by the project developers. The local partner organization ensures the supply of the biomass and the purchase of the generated electricity at agreed prices.

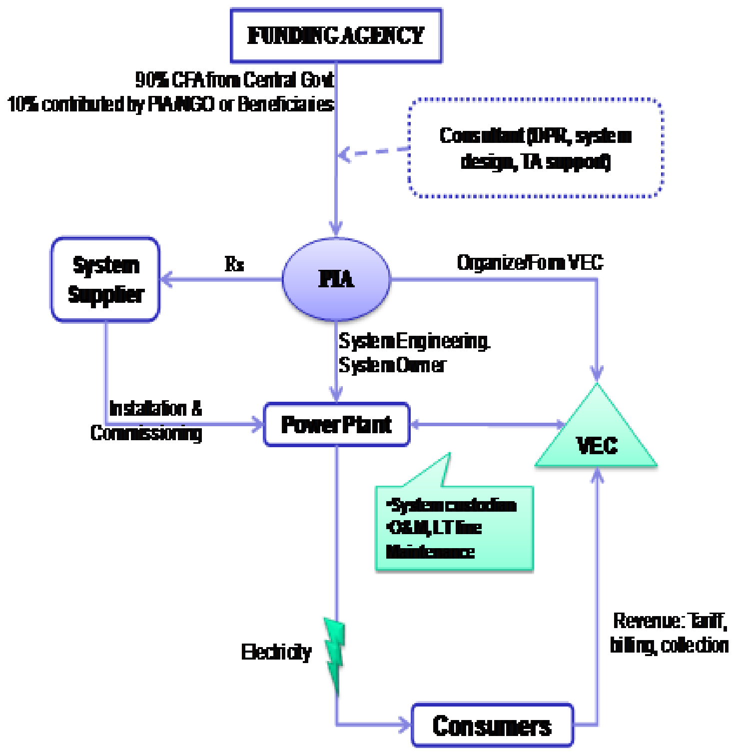


For example: DESI Power has successfully implemented biomass gasifier based power projects in TARA Gram, Orchha in Madhya Pradesh, Baharbari and Gayari villages in Bihar based on similar model. DESI Power facilitated the formation of a local cooperative at Baharabari and Gayari, and has jointly implemented the rural electricity related activities in these villages. DESI Power is acting here as an Independent Rural Power Producer (IRPP) with the local partner assuming the responsibility of arranging biomass, distribution of power and bill collection. DESI Power also acts as an intermediary to promote small and micro enterprises in these villages by providing power from the power plant, train the people and standing as a guarantee to repay the loan by these local micro enterprise/industries. DESI Power enters into biomass supply agreement with local group formed who in turn manages the supply of biomass. DESI Power has successfully sourced funds from ICICI bank for financing and fuelling power requirements in rural areas.

6.6.3 VESP – VEC model

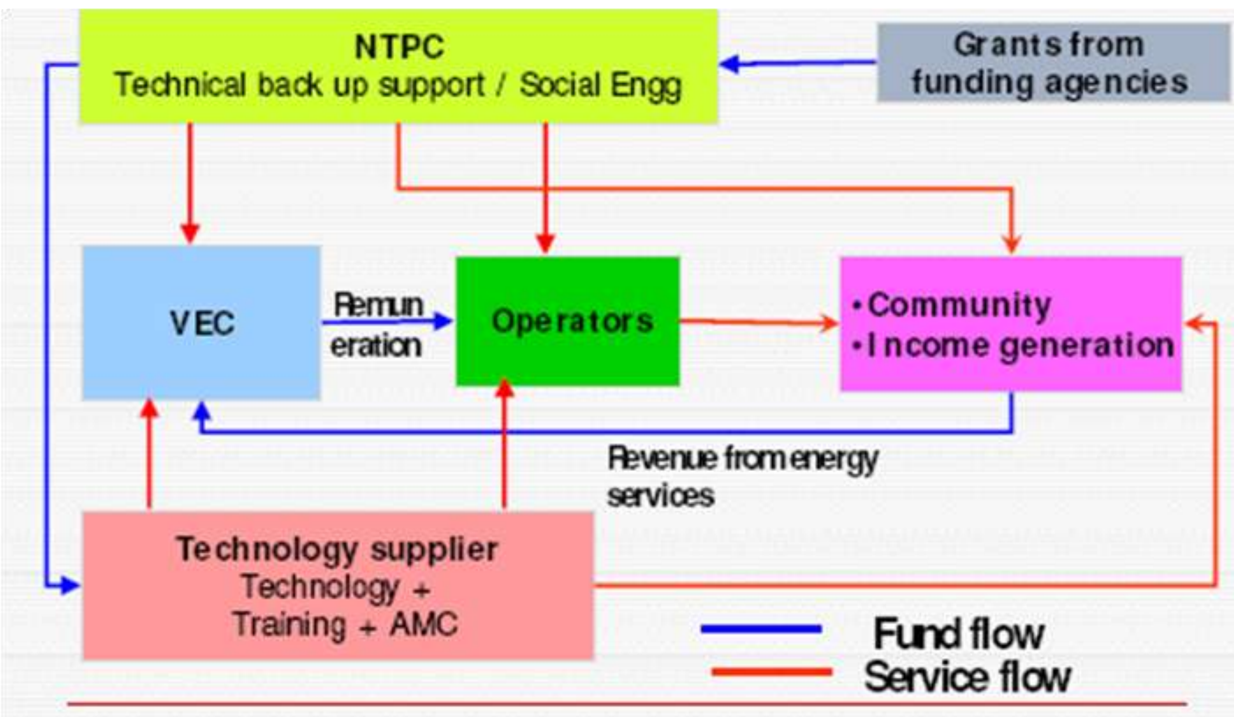
In majority of the government subsidy driven models for the off grid village electrification being implemented by various implementing agencies in different parts of India, formation of a Village Energy Committee (VEC) with representation from villagers and local governance body (panchayat) is key feature. The VEC plays the role of stand-alone power producer, distributor and supplier of electricity, manages the revenues through collection of payments for the electricity used from consumers and dispute resolution in case of power supply disruption.

Usually for decentralized systems, the electricity generated from say the biomass gasifier system under VESP programme is distributed to the consumers through a local mini-grid. As most of such projects are subsidy driven, the tariff is set by the VEC in consultation with the PIA (Project Implementation Agency) in such a way that it takes care of the fuel and the O&M costs. In most of the cases the tariff is set at a flat rate based on the ability and willingness to pay of the local community, ranging between Rs 10- 20 per light point per month and Rs 50 per socket point per month for a 4-5 hours of supply, equivalent to Rs 3-6/kWh.

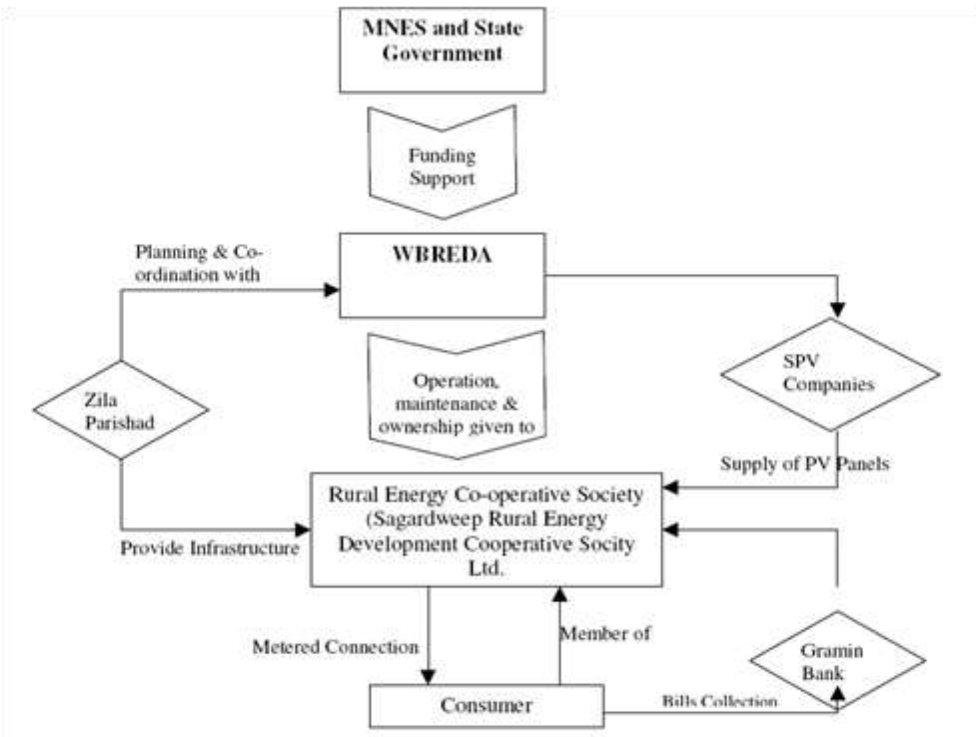


6.6.4 TERI model

NTPC, the largest power generation company in the country has been setting up distributed generation projects for village electrification based on a model similar VEC model. NTPC provides the technical back up support and does the social engineering in the project area either directly or involving a NGO or a consultant agency. Till now about 10 projects in off grid mode have been commissioned, of which 9 projects are based on small capacity biomass gasifiers (10-30 KW) and others is small hydro. The VEC acts as the project custodian and responsibility of revenue collection and O&M also remains with the VEC. Local youths from the village are trained to operate the systems. The tariff is based on flat rate and is usually @Rs 30 per light point.



6.6.5 Mini grid model – Sunderban



Another institutional model for delivery of energy which WBREDA (West Bengal Renewable Energy Development Agency) is exploring at in electrifying remote villages in Sunderban area is through creation of local mini grid. Both 11 kV and LT grid network is created by WBREDA depending on the capacity of the power plant and evacuation of power from the plant. In order to maximize the PLF, WBREDA established the plant near the load centre and creates a 2-4 km of mini grid in the area for supply. The mini grids are operated by cooperative societies formed by the local people. The responsibilities of the societies includes selection of consumers, planning for the distribution networks, tariff setting in consultation with WBREDA, revenue collection from consumers and passing them to WBREDA and consumer grievance redressal.

7 FINANICAL ANALYSIS OF RET OFF-GRID ELECTRIFICATION OPTIONS

It has been observed that owing to the low electricity load, large investment cost for building network, high cost to serve and low collection efficiency has led the distribution utilities losing interest in rural electrification. It has resulted in an opportunity for establishment of off-grid power generation facilities based on conventional as well as non-conventional fuel options for rural electrification. The Government has announced schemes for off-grid rural electrification projects, however the impact of such schemes was limited. The case studies have also revealed that the limited involvement of the private sector players has been one of the key issues for rural electrification in India as well as in many other countries in the world.

Apart from lighting and fan, the electricity requirement in a rural area is essentially for charging of mobile phones, entertainment purposes (radio/television etc.), pumping water for domestic as well as irrigation purposes, commercial activities such as grinding of floor , milling of paddy, grinding of spices etc. Further, briquetting, oil expelling, refrigeration etc. could be other commercial loads in a rural setup.

It has been noted that a rural household consumes around 3 – 9 litre of kerosene per month purchased at a rate of approximately Rs.9/litre. Kerosene has been primarily used for lighting during evening hours in rural areas. It has been further observed that the rural household is indifferent and have willingness to pay for electricity if it is available at a price equivalent to the expenditure of kerosene. It has also been observed that the willingness to pay for electricity varies from one region to another and households where the electricity is supplied through diesel generator sets have high willingness to pay. The willingness to pay for electricity varies in the range of approximately Rs.30 – 120 a month in various rural areas. The table below presents the distributed generation systems presently in operation and corresponding load profile of the rural area.

Various renewable energy technology options are available which may cater to the load profile in the rural areas, however, it is essential to evaluate the financial viability of such options.

7.1 Financial Evaluation of Various RE Technology Options for Off-Grid Applications

A variety of technology options, including fossil fuel as well as non-conventional energy, are available for rural electrification. In most instances it has been observed that kerosene and diesel are the most prominent fossil fuels used for lighting, pumping and various other activities in rural areas. However, rural electrification may be more effective compared with conventional fuel option if it is through utilising renewable energy resources available in the 'host rural area'. Further, utilisation of renewable energy technology options may be more judicious for electrification of 'remotely located off grid rural areas'. However their viability should be determined in order to ensure large scale participation by the stakeholders. The typical characteristics of the renewable energy options are elaborated in the table below,

Table 7.1: RET Options and its Characteristics

Parameter	Solar PV	Gasifier	Micro Hydro	Solar Wind Hybrid
Maturity Level	High	Medium	High	High
Penetration Level	High	Low	Medium	Low
Advantages	Low O&M, Easy Installation & Maintenance	Easy Installation, Indigenous Tech.	Low O&M, Easy Installation & Maintenance	Low Installation Cost
Dis-advantages	High capital cost Battery replacement (5yr)	Capacity building needed. Difficulty in sustained biomass supply	Mostly inaccessible Reduced output during lean period	High investment
Minimal requirement	~4-5kWh/d/m2 solar insolation	1.5-2 kg biomass per kWh	For 1kW: 30m head 4L/s flow	Start-up wind speed 2.5m/s
Cost (Rs/kW)	150-180,000	40-50,000	90-100,000	~250,000
Typical unit size	1-10kWp	10,20,50,100kW		1-10kW
Application	Lighting alone	Lighting plus productive loads		Lighting

(Source: ABPS Infra analysis)

The following sections discuss the suitability and financial feasibility of various renewable energy technology options available for off grid rural electrification. The parameters considered for determination of financial viability of various renewable energy technologies for rural electrification are elaborated in the table below.

The determination of cost of supply is based on the following assumptions.

- Developer designs, builds, finances, constructs and operates the renewable energy based off-grid generation plant
- Developer also builds and operates the network for distribution of electricity to rural consumers
- Network loss shall be around 20 per cent
- Consumption by Domestic and Commercial Consumers shall be in the ratio of 80:20
- Tariff rate for supply of electricity to domestic consumers shall be same as that approved by the respective State Electricity Regulatory Commission
- Floor & Forbearance price of the renewable energy certificate under Solar and Non Solar category has been adopted as specified by CERC in its order dated August 23, 2011
- Tariff rates as specified by Uttarakhand Electricity Regulatory Commission have been considered.

Table 7.2: Assumption Parameters for Computation of Cost of Supply

Parameter Head	Sub-Head (1)	Sub-Head (2)	Unit	Biomass Gasifier	Solar PV	Micro Hydro	Wind PV Hybrid
Power Generation	Capacity	Installed Capacity	kW	10	10	10	10
		PLF/CUF	%	80.00%	19.00%	45.00%	18.00%
		Auxiliary Consumption	%	10.00%	0.00%	1.00%	1.00%
		T&D Loss in the Mini Grid	%	20.00%	20.00%	20.00%	20.00%
		Life of Power Plant	Years	20	20	20	20
Project Cost	Capital Cost	Power Plant Cost	Rs/kW	50000	150000	100000	250000
Sources of Fund	Debt : Equity	Debt	%	70%	70%	70%	70%
		Repayment Period	years	10	10	10	10
		Interest Rate	%	12.50%	12.00%	11.75%	11.50%
		Return on Equity	% p.a	19.36%	19.36%	19.36%	19.36%
		RoE Period	Year	10.00	10.00	10.00	10.00
		Return on Equity after 10 years		19.36%	19.36%	19.36%	19.36%
		Weighted average of ROE		19.36%	19.36%	19.36%	19.36%
		Discount Rate (equiv. to WACC)		14.6%	14.2%	14.0%	13.9%
		Depreciation Rate	%	5.28%	5.28%	5.28%	5.28%
Financial Assumption	Depreciation	Depreciation from 11th yr	%	3.72%	3.72%	3.72%	3.72%
Fuel related	Biomass	Biomass Requirement	kg/kWh	1.50			
		Fuel Price	Rs/MT	1200.00			
		Escalation	%	5%			
Working capital	For Fixed Charges	O&M Charges	Months	1	1	1	1
		Maintenance Spare		15%	15%	15%	15%
		Receivables for Debtors	Months	2	2	2	2
		Fuel Cost	Months	4	-	-	-
		Interest On Working Capital	%	12.50%	12.00%	11.75%	11.50%
Operation & Maintenance		Power Plant	Rs Lakh	0.15	0.30	0.20	0.32
		Total O & M Expenses Escalation	%	5.72%	5.72%	5.72%	5.72%

7.2 Analysis of Financial Viability of 'Biomass Gasifier Systems'

The biomass gasifier systems are available in different capacities to meet the requirement of electrical load of any rural area. The biomass gasifier systems have advantage over other renewable energy options for rural electrification as these systems can be operated from one hour in a day to round the clock depending upon the electrical load they are required to serve. However, in order to make rural electrification utilising such technology more effective and to encourage participation, it is essential to demonstrate financial feasibility of such systems and suitable mechanisms to address the gap in the revenue stream, which may make such installations unviable.

Determination of Cost of Supply under Base Case

It has been observed that gasifier systems of small capacities shall be desirable for rural electrification taking into consideration the load requirements. Accordingly, while carrying out the financial analysis, the size of the gasifier system has been assumed as 10kW. The cost of supply has been computed for two scenarios i.e. with government subsidy and without government subsidy.

The analysis assumes the useful life of such systems to be twenty (20) years, which shall be operating at a plant load factor of around 80% per annum. The analysis suggests that such systems do not operate round the clock and generate electricity for fixed number of hours depending upon the electricity requirement. Accordingly, it has been considered that the system shall be operating for twelve (12) hours per day to meet the electricity requirement of the rural area. The analysis also assumes that the developer distributes the electricity through building distribution network/grid. The network distribution losses have been considered as twenty per cent (20%) for determining the 'Cost of Supply' from such systems to the rural area.

For fuel related parameters, experience suggests that the specific fuel consumption by such systems varies from around 1kg/kWh to 1.5kg/kWh depending upon the type, quality of fuel and system design. While assessing the biomass requirement, it has been assumed that 1.5kg of fuel shall be required to generate one unit of electricity. The gasifier system shall be utilising the biomass fuel available in the local region. However, operating experience of the gasifier systems suggests that the price of the fuel varies from Rs.800 per metric ton to Rs.1500 per metric ton. Accordingly, the price of biomass fuel has been assumed to be Rs.1200 per metric ton while determining the variable cost of the electricity generated from the biomass gasifier system. Further, it has been envisaged that such system, because of size and investment requirement, shall be part of the balance sheet of the organisation and shall not be developed by forming separate special purpose vehicle for individual generating system.

Keeping into consideration the aforesaid facts and parameters discussed above, the table below presents the levelised cost of supply over useful life of the plant i.e. twenty (20) years under two options i.e. with and without government support or subsidy.

Table 7.3: Investment Requirement and Cost of Supply for Biomass Gasifier

Technology	CASE I: With Government Support		CASE II: Without any Support	
	Investment Cost Requirement (RsLakh)	Cost of Supply (Rs/kWh)	Investment Cost Requirement (RsLakh)	Cost of Supply (Rs/kWh)
Biomass Gasifier	2.0	6.06	5.0	8.00

(Source: ABPS Infra analysis)

Considering twelve (12) hours generation of the electricity from the gasifier system, thirty five thousand (35000) units shall be generated per annum and after considering the technical and network losses of around twenty five (25) thousand units shall be available for distribution to rural consumers. The electricity so generated shall be utilised by the domestic and commercial purposes by the rural community.

Source of Revenue

Under the 'Base Case' scenario it has been assumed that the majority of electricity, around 80 per cent, shall be consumed for domestic purposes such as lighting, entertainment etc. and remaining by the shops for the commercial activity. To assess the gap in the viability it has been assumed that the domestic consumers shall be paying Rs.1.50/kWh and the commercial consumers Rs.3.20/kWh[2] for the electricity usage. The weighted average rate of supply is determined at Rs.1.85/kWh. With the aforesaid analysis, the gap in the viability of the project is determined as Rs.4.21/kWh and Rs.6.15/kWh under Case I and Case II respectively (Difference between the cost of supply and the revenue from distribution of electricity (Rs.1.85/kWh).

[2] *Rates as specified by Uttarakhand Electricity Regulatory Commission for respective consumer category*

7.3 Analysis of Financial Viability of 'Micro Hydro Power Generation'

The micro hydro systems may be developed taking into consideration the requirements of meeting the electrical load of any rural area. The hydro systems may be operated as and when required. However, in order to make rural electrification utilising such technology more effective and to encourage participation, it is essential to demonstrate financial feasibility of such systems and suitable mechanisms to address the gap in the revenue stream, which may make such installation of systems unviable.

Determination of Cost of Supply under Base Case

It has been observed that micro hydro systems of small capacities shall be desirable for rural electrification taking into consideration the load requirements. Accordingly, while carrying out the financial due diligence the size of the system has been assumed as 10kW. The cost of supply has been carried out for options where support or subsidy is available under the Government scheme as well as where no support is available under any scheme.

The analysis assumes the useful life of such systems around twenty (20) years which shall be operating at a capacity utilisation factor of around 45%. The analysis also assumes that the developer distributes the electricity through building distribution network/grid. The network distribution losses have been considered as twenty (20) per cent and are considered while determine the 'Cost of Supply' from such systems to the rural area.

It has been observed that under specific schemes, the Ministry of New and Renewable Energy provides subsidy for the development of such facilities to the extent of 90 per cent of the capital cost. Accordingly, while carrying out the feasibility of such systems has been carried out for options where support or subsidy is available under the Government scheme as well as where no support is available. The capital cost has been considered as Rs.1Lakh/kW. The Capacity Utilisation Factor of systems as specified by State Electricity Regulatory Commissions of Himachal Pradesh and Uttaranchal. Keeping into consideration the aforesaid facts and parameters discussed in the table above, the table below presents the levelised cost of supply over useful life of the plant i.e. twenty (20) years under two options i.e. when government support or subsidy is available and when no support is available in any scheme,

Table 7.4: Investment Requirement and Cost of Supply for Micro Hydro Facility

Technology	CASE I: With Government Support		CASE II: Without any Support	
	Investment Cost Requirement (RsLakh)	Cost of Supply (Rs/kWh)	Investment Cost Requirement (RsLakh)	Cost of Supply (Rs/kWh)
Micro Hydro	6.0	3.51	10.0	5.21

(Source: ABPS Infra analysis)

Considering the aforesaid facts, around thirty nine (39) thousand units shall be generated per annum and after considering the technical and network losses around thirty one (31) thousand units shall be available for distribution to rural consumers. The electricity so generated shall be utilised by the domestic and commercial purposes by the rural community.

Source of Revenue

Under the 'Base Case' scenario it has been assumed that the majority of electricity, around 80 per cent, shall be consumed for domestic purpose such as lighting, entertainment etc. and remaining to the shops for the commercial activity. To assess the gap in the viability it has been assumed that the domestic consumers shall be paying Rs.1.50/kWh and the commercial consumers Rs.3.20/kWh for the electricity usage. The weighted average rate of supply is determined at Rs.1.85/kWh. With the aforesaid analysis the gap in the viability of the project is determined as Rs.1.66/kWh and Rs.3.36/kWh under Case I and Case II respectively (Difference between the cost of supply and the revenue from distribution of electricity (Rs.1.85/kWh).

7.4 Analysis of Financial Viability of 'Solar Photovoltaic Power Generation Systems'

Solar Photovoltaic may be another suitable option for rural electrification. The facilities based on solar photovoltaic technology may be established in small sizes. However, such technology is still in evolving phase and perceived costly proposition compared to other technologies. And thus the financial viability of such projects may be necessary considering the sources of revenue available the developers of such projects for rural electrification.

It has been assumed that approximately Rs.1.5Lakh/kW shall be required to install such system and supply of electricity generated from such systems for rural electrification. Further, in order to assess the likely generation the capacity utilisation factor (CUF) is considered as 19 per cent. However, it should be noticed that the CUF may vary from one site to another depending upon the incident solar irradiation. The analysis also assumes that the developer distributes the electricity through building distribution network/grid. The network distribution losses have been considered as twenty (20) per cent and are considered while determine the 'Cost of Supply' from such systems to the rural area.

It has been observed that under specific schemes, the Ministry of New and Renewable Energy provides subsidy for the development of such facilities. Accordingly, while carrying out the feasibility of such systems has been carried out for options where support or subsidy is available under the Government scheme as well as where no support is available.

Keeping into consideration the aforesaid facts and parameters discussed in the table above, the table below presents the levelised cost of supply over useful life of the plant i.e. twenty (20) years under two options i.e. when government support or subsidy is available and when no support is available in any scheme,

Table 7.5: Investment Requirement and Cost of Supply for Solar PV System

Technology	CASE I: With Government Support		CASE II: Without any Support	
	Investment Cost Requirement (Rs Lakh)	Cost of Supply (Rs/kWh)	Investment Cost Requirement (Rs Lakh)	Cost of Supply (Rs/kWh)
Solar PV	10.5	15.25	15.0	20.35

(Source: ABPS Infra analysis)

Considering the aforesaid facts, around sixteen (16) thousand units shall be generated per annum and after considering the technical and network losses around thirteen (13) thousand units shall be available for distribution to rural consumers. The electricity so generated shall be utilised by the domestic and commercial purposes by the rural community.

Source of Revenue

Under the 'Base Case' scenario it has been assumed that the majority of electricity, around 80 per cent, shall be consumed for domestic purpose such as lighting, entertainment etc. and remaining to the shops for the commercial activity. To assess the gap in the viability it has been assumed that the domestic consumers shall be paying Rs.1.50/kWh and the commercial consumers Rs.3.20/kWh for the electricity usage. The weighted average rate of supply is determined at Rs.1.85/kWh. With the aforesaid analysis the gap in the viability of the project is determined as Rs.13.39/kWh and Rs.18.49/kWh under Case I and Case II respectively (Difference between the cost of supply and the revenue from distribution of electricity (Rs.1.85/kWh).

7.5 Analysis of Financial Viability for "Wind Solar Hybrid Systems"

The Wind Solar Hybrid systems are combination of aero-generator and solar PV systems of suitable capacities. The Ministry of New and Renewable Energy supports such schemes. However, in order to avail the benefits under such scheme the maximum size of the system shall be 50kW and wind component shall be at least 60 per cent of the total capacity. According to the information available in the public domain it is noticed that such systems with 60 per cent wind component and 40 per cent solar photovoltaic component require investment of Rs.2.5Lakh/kW to Rs.2.7Lakh/kW[3]. Further, the analysis of a 10kW Wind Solar hybrid system suggests that the Capacity Utilisation Factor varies 13% to 18%. Accordingly, while carrying out the feasibility analysis a CUF of 18 per cent has been considered for such systems.

It has been observed that under specific schemes, the Ministry of New and Renewable Energy provides subsidy for the development of such facilities. Accordingly, while carrying out the feasibility of such systems has been carried out for options where support or subsidy is available under the Government scheme as well as where no support is available. While determining the 'Cost of Supply' from such systems, the support from the MNRE (Rs.1Lakh/kW) has been considered.

[3] *http://www.thehindubusinessline.com/features/investment-world/article1702043.ece*

Table 7.6: Support from MNRE to Wind Solar Hybrid Systems

Category	Institutions/Organisations	Available Support
I	Government, Public, Charitable, R&D, Academic, other Non Profit Organisation	Rs.1.5Lakh/kW
II	Other beneficiaries' (Individuals, Private/Corporate Sector)	Rs.1.0Lakh/kW

(Source: Ministry of New and Renewable Energy)

Keeping into consideration the aforesaid facts and parameters discussed in the table above, the table below presents the levelised cost of supply over useful life of the plant i.e. twenty (20) years under two options i.e. when government support or subsidy is available and when no support is available in any scheme,

Table 7.7: Investment Requirement & Cost of Supply for Wind Solar Hybrid System

Technology	CASE I: With Government Support		CASE II: Without any Support	
	Investment Cost Requirement (RsLakh)	Cost of Supply (Rs/kWh)	Investment Cost Requirement (RsLakh)	Cost of Supply (Rs/kWh)
Wind Solar Hybrid	15	23.47	25.0	35.35

(Source: ABPS Infra analysis)

The annual generation from the wind and solar hybrid systems shall be approximately 15768 units and taking the network losses into consideration approximately 12614 units shall be available for distribution to rural consumers.

<u>Source of Revenue</u>

Under the 'Base Case' scenario it has been assumed that the majority of electricity, around 80%, shall be consumed for domestic purpose such as lighting, entertainment etc. and remaining by the shops for commercial activity. To assess the gap in the viability it has been assumed that the domestic consumers shall pay Rs.1.50/kWh and the commercial consumers Rs.3.20/kWh for the electricity usage. The weighted average rate of supply is determined at Rs.1.85/kWh. With the aforesaid analysis the gap in the viability of the project varied from Rs.21.71/kWh to Rs.33.49/kWh under Case I and Case II respectively (Difference between the cost of supply and the revenue from distribution of electricity (Rs.1.85/kWh)

8 POTENTIAL BUSINESS MODELS FOR OFF-GRID PROJECTS

8.1 Status update on DDG scheme and need to propose business models

Guidelines for DDG scheme were released by Ministry of Power on January 12, 2009 with planned capital outlay of Rs 540 Crore during XIth Plan period. REC was identified as Nodal Agency to facilitate implementation of DDG scheme and to ensure release of capital subsidy to eligible projects under DDG scheme through REC.

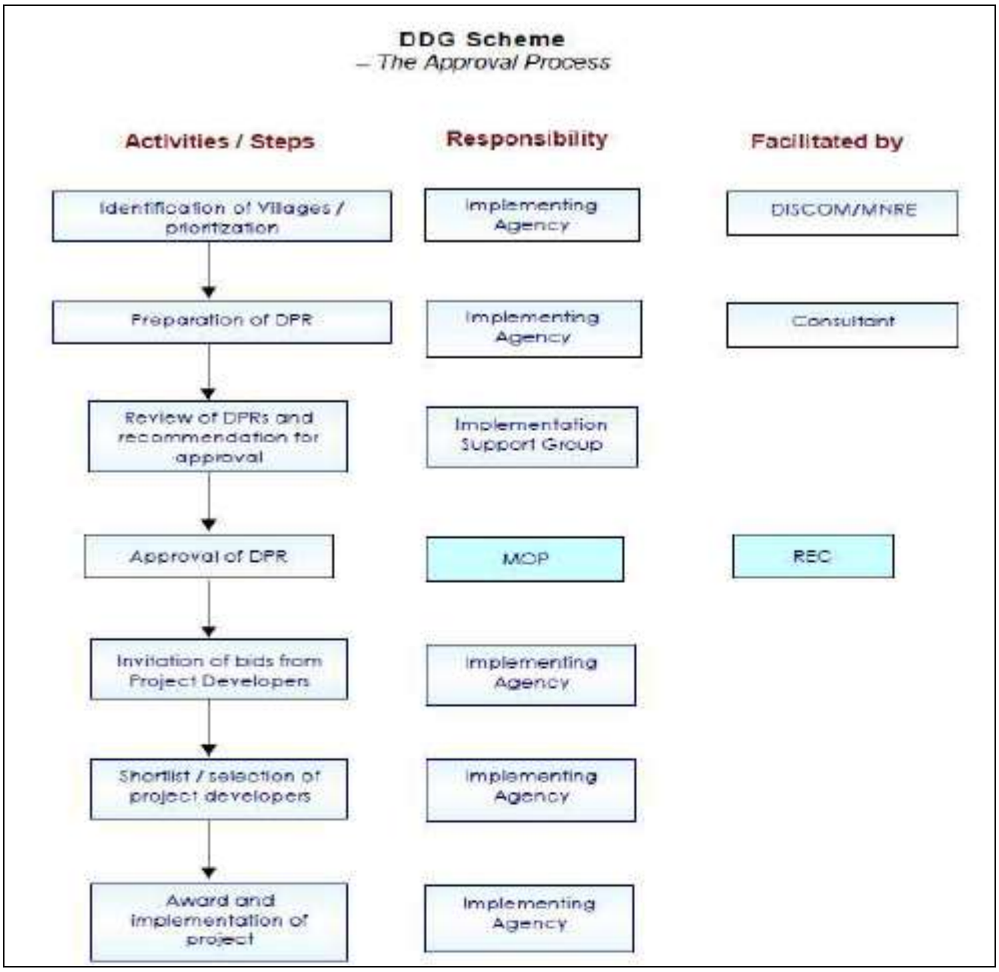
However, over past 2 years only 13 projects with capital outlay of Rs 109 Crore have been sanctioned. It is understood that eligible DDG projects comprise one project each in State of Chhattisgarh, Jharkhand and NE State with outlay of around Rs 3 Crore per project and 10 projects in West Bengal with total estimated capital outlay of Rs 100 Crore, mainly based on solar photovoltaic applications. Incidentally, all the projects are proposed by State Nodal Agencies in respective States and no project from private sector has been proposed under the scheme. It is further understood that Detailed Project Report (DPRs) for said projects are still under preparation and no disbursement has yet taken place.

Based on our interaction with the concerned officials in the Ministry, it is gathered that the Government has realised that there is urgent need to undertake critical review of DDG Scheme and Policy framework and a need to evolve some new and innovative business models. Further, DDG scheme is likely to be continued in the 12th Plan subject to development of suitable model for implementation under DDG scheme.

8.2 Limitations of the Existing DDG Scheme

A critical review of the existing DDG scheme is undertaken to identify key areas that created need to propose new Business Models for Off-Grid projects. Various activities involved from identification of project scheme to development of project as part of existing DDG scheme alongwith the role of various entities involved in the process is charted out in the following schematic.

Figure 8.1:Process Flow Schematic for Existing DDG Scheme



i. To implement the project on Build-Operate-Maintain-Transfer (BOMT) basis for a period of 5 years without any ownership stake in the project.

ii. To handover the project to the State Government at the end of 5 years of project operations without any consideration.

iii. Selection of Project Developer shall be based on tendering process by Implementing Agency in two parts (a) Capital Cost and (b) Cost of providing power for 5 years.

iv. Even the cost of operations for five years shall be reimbursed as difference between O&M cost and revenue recovery through tariff to be paid by Implementing Agency out of its Service charge compensation (which is 8% for State Govt. and 9% for CPSUs). Thus, there is hardly any motivation for State Utilities and State Implementing Agencies to support the continued/sustainable operation of the project scheme.

v. Besides, the second part, i.e. cost of providing power during operations phase cannot exceed service charge of 8% of capital cost; which may not be viable proposition for project schemes involving biomass or project schemes with higher operating costs.

vi. Further, Project Developer is obliged to provide quantum of power for 6-8 hours per day for at least 25 days per month, failing which contract performance guarantee (in the form of Bank Guarantee) to the extent of 10% of capital cost is required to be provided by Project Developer.

vii. DDG Scheme can be adopted in States provided the State Governments undertake to provide Service Charge compensation, so project developer perceives the availing funding support from Central Government (for Initial Capital Cost) and from State Government (for Operating Cost) as difficult proposition from practical implementation viewpoint.

There are several reasons for development of new Business models, which are presented below,

- Several schemes for electrification in the country, but still large number of households to be electrified;
- Grid has reached several parts of the country, but adequacy of supply is a concern;
- In rural areas of the country liquid fuels like kerosene, diesel, etc are used for basic applications such as lighting. These liquid fuels are expensive and hazardous to health;
- It has been observed in chapter 2, that there is a significant potential of renewable energy;
- Traditionally, rural energy models are based on either cherry picking of customers and charging high from customers or high level of subsidies. All these models are typically associated with poor quality of supply and low level of services.
- Obviously, existing business models are inadequate for large scale deployment of off-grid renewable energy projects;
- Renewable energy is cheaper than liquid fuels like kerosene and diesel but expensive than grid supply in rural areas.

Due to the large number of limitations in the existing schemes, private sector participation is still lacking and that creates a need to develop innovative off-grid business models.

8.3 Business Models

In order to address these concerns and to ensure the financial viability of the project, ABPS Infra has identified several business models for deployment of off-grid renewable energy generation projects. The table below presents the five proposed business models with their sources of revenue from different institutions.

Table 8.1: Business models with their sources of revenue

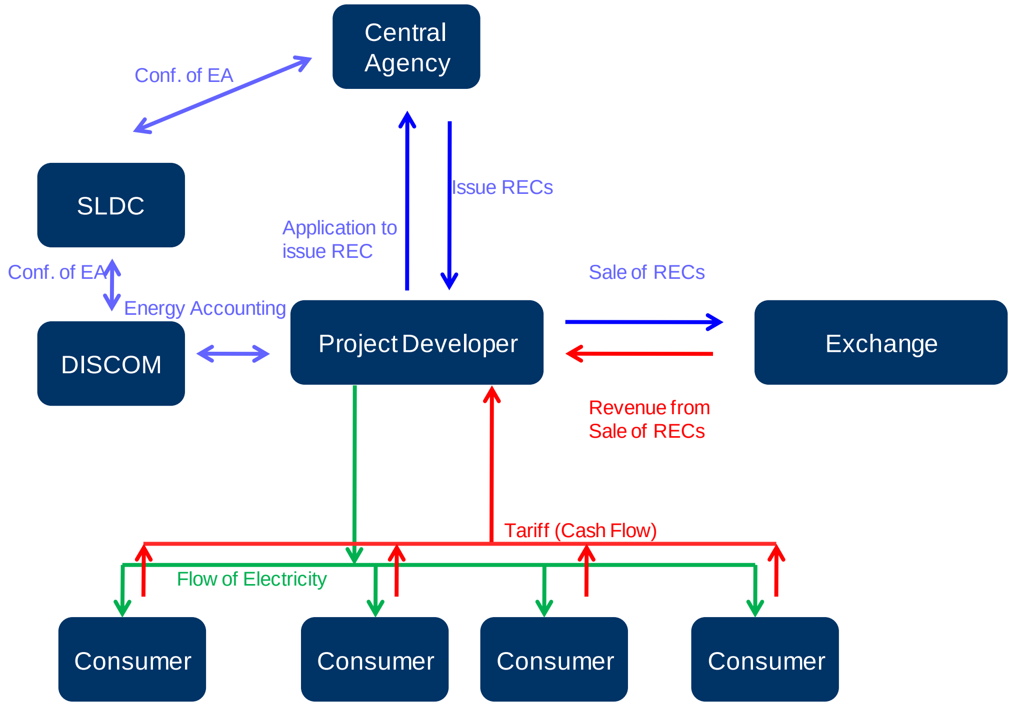
S. No	Business Models	Sources of Revenue				
		Consumer	DISCOM	MoP	CPA	Exchange
1	REC based Model	Tariff	-	-	-	REC
2	CPA based REC Model	Tariff	-	-	REC	-
3	GLS Model	Tariff	-	GLS	-	-
4	Combination of REC & GLS Model	Tariff	-	GLS	-	REC
5	Off-Grid Distributed Generation Based Distribution Franchisee	-	FIT	-	-	-

These business models have been discussed at length in the following sections.

8.3.1 REC BASED MODEL

The REC based Model is based on two sources of revenue for the project developer, one is the tariff to be received from the rural consumer and the other is revenue earned from the sale of REC on the Exchange. The project developer shall supply electricity to consumers and collects tariff from the consumers. The project developer shall submit application for issuance of RECs to the Central Agency (CA) and RECs will be issued in accordance with modified REC Regulations. The project developer to sell RECs in the open market and earn revenue to earn profit thereby making this business model viable. The figure below presents the operational structure of the REC based Model.

Figure 8.2: Operational structure of REC based Model



The key processes involved in the model can be elaborated us under:

- Project developer (PD) to identify the project scheme under which the project will be commissioned;
- PD to finalize the technology based on the availability of local fuel resources;
- PD to undertake the detailed prefeasibility study of the project;
- Detailed project report will be developed;
- PD to achieve Financial closure;
- PD to develop and commission the project;
- PD to supply electricity to the consumers and collect the mutually agreed tariff between the consumers and the PD;
- PD to submit application for accreditation of the RE generation project;
- State Nodal Agency (SNA) to verify the application and issue the "Accreditation certificate" to project developer;
- DISCOM to do energy accounting of the project and shall report the same to SLDC and SLDC in turn, after verification, shall submit the energy accounting report to CA;
- Application for registration shall be submitted by project developer to CA;
- CA shall issue "Registration Certificate" to project developer;
- Application for issuance of RECs shall be submitted to CA and CA in turn issue RECs to project developer;

- Project developer will sale RECs on Exchange and earn revenue.

Pre-requisites of the model,
- FOR to develop Off-Grid REC Regulations;
- DISCOM to be allowed to do energy accounting for Off-Grid Projects.

Financial Analysis of the REC based Model

Taking into consideration, the discussions carried out in the previous chapter on the financial analysis of four renewable energy technology options, the revenue flow from sale of electricity to consumer for different technologies is in the range of Rs 23,000 to Rs 47,000 as shown in the table below.

One of the possible solutions to meet the gap in the viability is allowing the project to participate in the REC Mechanism. The gap in the viability shall be met from the revenue generated from sale of RECs. CERC has determined the floor and forbearance price for Renewable Energy Certificates issued under Solar and Non Solar Category. In order to assess the viability gap, the floor and forbearance price have been adopted as determined by the CERC for Renewable Energy Certificates issued under Non Solar category. The table below represents the revenue flow from sale of electricity to consumer and revenue flow from sale of RECs.

Table 8.2: Revenue flows for REC based Model

Technology	Revenue flow (Rs Lakh)		Viability Gap (Rs Lakh)	
	Sale to consumer	Sale of RECs	Without support	With support
Biomass Gasifier	0.47	0.48 - 1.06	0.49-1.07	0.00-0.58
Micro Hydro	0.58	0.59 - 1.29	0.24-0.46	0.075-0.76
SPV	0.25	1.58 - 2.28	0.18-0.88	0.50-0.20
Wind + SPV Hybrid	0.23	0.69 - 1.10	3.13-3.54	1.64-2.05

(Source: ABPS Infra analysis)

Advantages
- There will be direct issuance of RECs by CA to the project developer;

- Project developer will get the better price of RECs in the Exchange as all the transactions will be done by self.

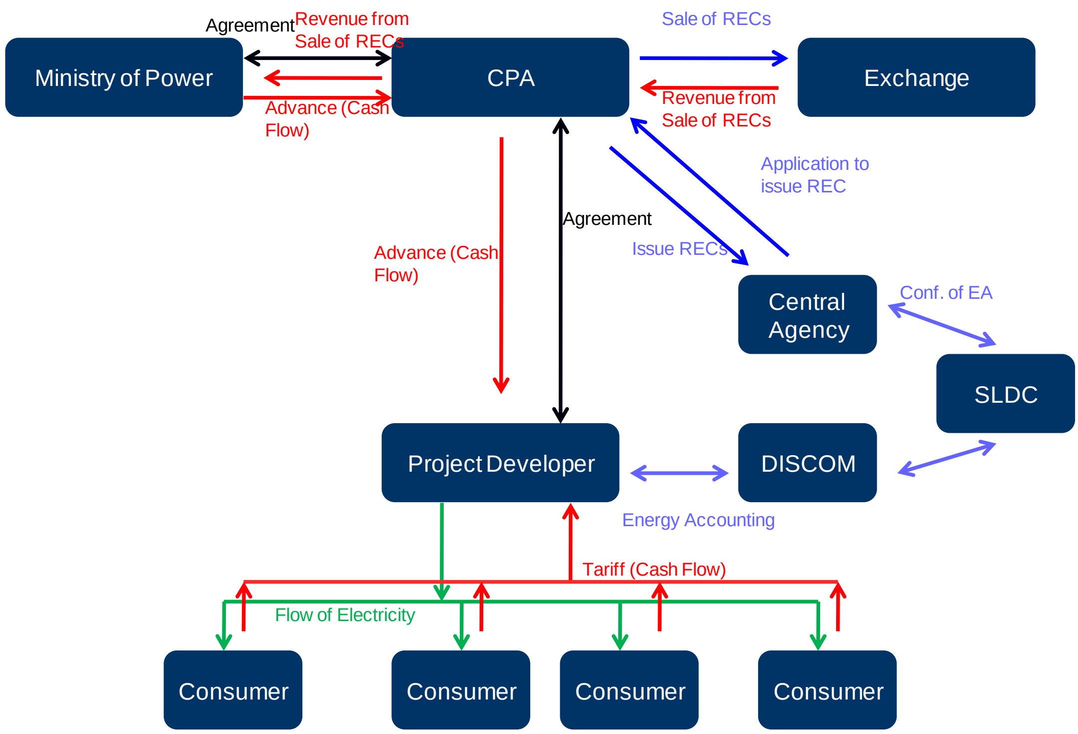
Disadvantages

- There will be limited resources available with the project developer in the rural area to reach to Exchange for the sale of RECs;
- There will be huge risks involved with the volume and prices of the RECs;
- As the project developer will be located in the remote areas, the transactions costs will be high.

8.3.2 CENTRAL PROCUREMENT AGENCY (CPA) BASED REC MODEL:

The model is based upon CPA, which shall be a procurement agency, to be developed by MoP. The model is dependent upon two sources of revenue, one is the tariff to be received from the consumers and the other is RECs. MoP shall provide grant to CPA and in turn CPA provide advance to project developer. CPA shall procure RECs and sale to Exchange and transfer the revenue from sale of RECs to MoP. The figure below presents the CPA based REC model.

Figure 8.3: Operational Structure of CPA based REC model



The steps involved in this model are explicated below:

- PD to identify the project scheme under which the project will be commissioned;
- PD to finalize the technology based on the availability of fuel resources;
- PD to undertake the detailed prefeasibility study of the project;
- Detailed project report will be developed;
- PD to achieve the financial closure;
- PD to develop and commission the project;
- PD to provide electricity to the consumers and collects the same tariff as paid by the consumers of the local DISCOM;
- There will be an agreement between MoP and CPA; CPA and project developer.
- Based on the agreements, MoP shall provide advance loan to CPA and CPA will provide advance to project developer.
- CPA to submit application for accreditation of the RE generation project;
- SNA to verify the application and issue the "Accreditation certificate" to CPA;
- DISCOM to do energy accounting of the project and report the same to SLDC and SLDC in turn, after verification, shall submit the energy accounting report to CA;
- DISCOM to provide the energy accounting report to CA;
- Application for registration shall be submitted by CPA to CA;
- CA to issue "Registration Certificate" to CPA;
- Application for issuance of RECs shall be submitted to CA and CA in turn issue RECs to CPA;
- CPA shall sale RECs to Exchange and earn revenue, and transfer the revenue to MoP in order to repay the loan amount.

Pre-requisites of the model,

- Establishment of CPA for RECs;
- FOR to develop Off-Grid REC Regulations;
- DISCOM to be allowed to do energy accounting for Off-Grid Projects

Financial Analysis of the CPA based REC Model

In order to assess the financial viability of the model, we have considered the assumption parameters as discussed in the previous chapter. The revenue from sale of electricity to consumer for different technologies is in the range of Rs 23,000 to Rs 47,000.

It has been observed that the 'Gap' may be met if such Off Grid rural electrification schemes are allowed to participate in the REC Mechanism. The REC issued to the CPA corresponding to the energy generation shall be an effective measure to meet the viability gap. The table below summarises the revenue flow for different technologies from sale of electricity to consumer by the project developer and from sale of RECs by the CPA.

Table 8.3: Revenue flows for project in the CPA based REC Model

Technology	Revenue flow (Rs Lakh)		Viability gap (Rs Lakh)	
	Sale to consumer	Sale of RECs	Without support	With support
Biomass Gasifier	0.47	0.77	0.78	0.29
Micro Hydro	0.58	0.94	0.11	0.43
SPV	0.25	1.93	0.53	0.15
Wind + SPV Hybrid	0.23	0.89	3.34	1.85

(Source: ABPS Infra analysis)

Advantages

- Project developer will get assured centralized assistance from MoP;
- All the REC transactions will be carried out by CPA, so there will not be any hassle for project developer to sale RECs in Exchange

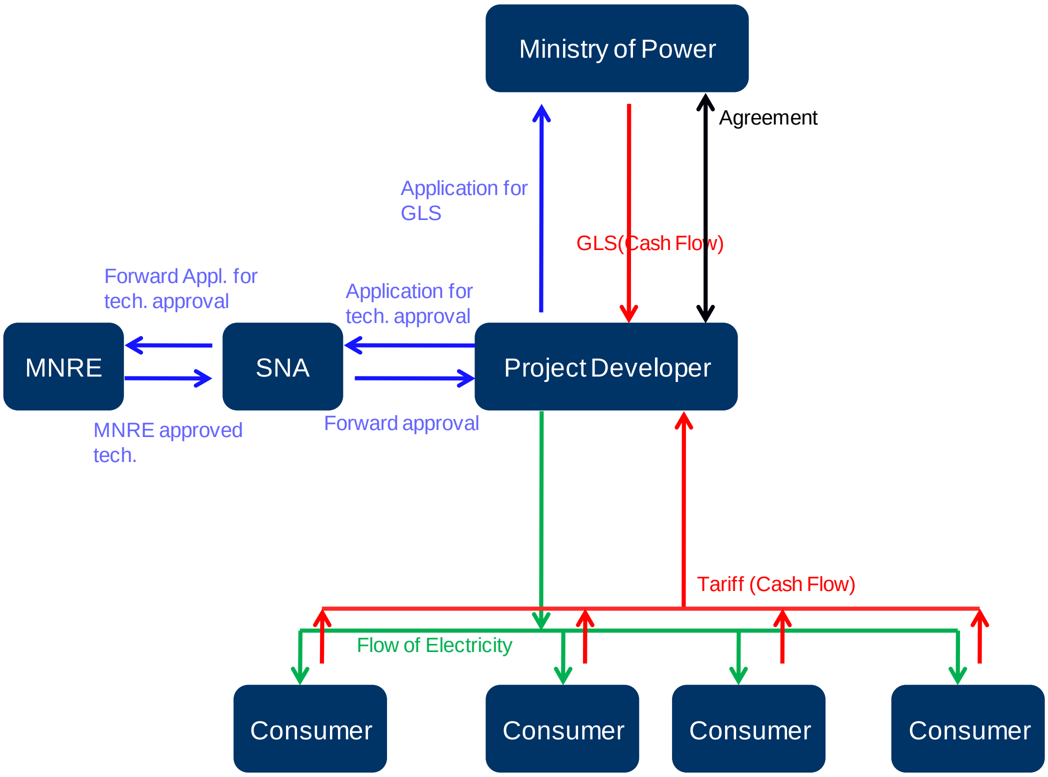
Disadvantages

- There will be a need to establish CPA at the central level, that will be a complicated process;
- Project developer may get low REC pricing in advance;
- There will be a huge risk on CPA for the sale of RECs in Exchange, as the price of REC varies and CPA has to repay the loan to MoP;
- CPA will become dependent on DISCOM for energy accounting of the project.

8.3.3 GENERATION LINKED SUBSIDY (GLS) MODEL

This Model assumes that the Central Government will come out with Generation Linked Subsidy mechanism for promotion of renewable energy based off-grid rural electrification projects. In this model, the project developer will provide electricity to the consumer and will receive tariff from consumers. in addition, Central Government through Ministry of Power shall provide GLS to the project developer at a predetermined rate. The operational structure of GLS model is shown in figure below.

Figure 8.4: Operational Structure of GLS Model



The key steps involved in the model are illustrated below:

- PD to identify the project scheme under which the project will be commissioned;
- PD to shall finalize the technology based on the availability of fuel resources;
- PD to undertake the detailed prefeasibility study of the project;
- Detailed project report will be developed;
- PD to achieve the financial closure;
- PD to develop and commission the project;
- Project developer to provide electricity to the consumers and collects the same tariff as paid by the consumers of the local DISCOM;
- Project developer to submit application for technology approval to SNA;
- SNA forward the application to MNRE;
- MNRE shall approve the technology and SNA forward the same to project developer;
- GLS application shall be submitted by project developer to MoP;

- There will be an agreement between MoP and project developer, and MoP shall provide GLS.

Pre-requisites of the model,

- Allocation of fund by MoP for Off-Grid Projects.

Financial Analysis of the GLS Model

Taking into consideration the parameters discussed for carrying out the commercial viability of the renewable energy technology options, the revenue flow from the sale of electricity to consumers has come out to in the range of Rs 23,000 to Rs 47,000.

Table 8.4: Revenue flow from sale to consumers in the GLS Model

Technology	Revenue flow (Rs Lakh)	Viability Gap (Rs Lakh)	
	Sale to consumer	Without support	With support
Biomass Gasifier	0.47	1.55	1.06
Micro Hydro	0.58	1.05	0.51
SPV	0.25	2.46	1.78
Wind + SPV Hybrid	0.23	4.23	2.74

(Source: ABPS Infra analysis)

Advantages

- Assured return to the project developer as the GLS will be provided by MoP;
- No risk involved in this business model due to the absence of RECs.

Disadvantages

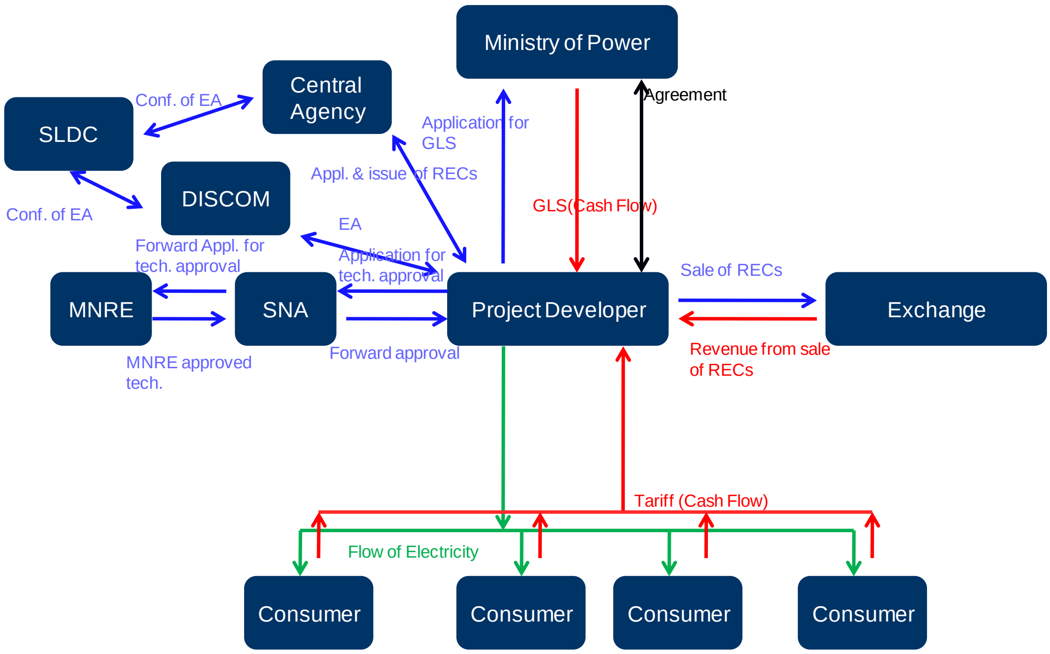
- It will be lengthy process to reach GLS to project developer which will be located at remote area;
- Requirement of an intermediary at the State level will be there.

8.3.4 COMBINATION OF REC AND GLS MODEL

This model is based on three sources of revenue for the project developer, one is the tariff received from consumers, the second is the sale of RECs to exchange and the third is the GLS from the Government. The project developer shall provide electricity to consumers and in turn receive tariff. The project developer shall submit an application and RECs will be issued. Further, project developer shall sale RECs to the

Exchange. An agreement between the project developer and MoP will be signed and MoP shall provide GLS.

Figure 8.5: Operational Structure of Combination of REC and GLS Model



The key processes of this business model are described below:

- PD to identify the project scheme under which the project will be commissioned;
- PD to finalize the technology based on the availability of the local renewable resources;
- PD to undertake the detailed prefeasibility study of the project;
- Detailed project report will be developed;
- PD to achieve the financial closure;
- PD to develop and commission the project;
- PD to provide electricity to the consumers and collects the same tariff as paid by the consumers of the local DISCOM;
- PD to submit applications for accreditation of the RE generation project and technology approval to SNA;
- SNA to verify the application, issue the "Accreditation certificate" to project developer and forward the technology approval application to MNRE;
- MNRE shall approve the technology and SNA forward the same to project developer;
- GLS application shall be submitted by project developer to MoP;

- There will be an agreement between MoP and project developer, and MoP shall provide GLS.
- DISCOM to do energy accounting of the project and report the same to SLDC and SLDC in turn, after verification, shall submit the energy accounting report to CA;
- Application for registration shall be submitted by project developer to CA;
- CA to issue "Registration Certificate" to project developer;
- Application for issuance of RECs shall be submitted to CA and CA in turn issue RECs to project developer;
- Project developer shall sale RECs on Exchange and earns revenue.

Pre-requisites of the model,

- FOR to develop Off-Grid REC Regulations;
- DISCOM to be allowed to do energy accounting for Off-Grid Projects;
- Allocation of fund by MoP for Off-Grid Projects.

Financial Analysis of the Combination of REC and GLS Model

In order to assess the financial viability of the model, we have considered the parameters assumed for assessing the commercial viability of the renewable energy technologies, and the revenue flow from sale of electricity to consumer has come out in the range of Rs 23,000 to R 47,000 and revenue flow from sale of RECs has come out in the range of Rs 45,000 to Rs 1,68,000 which has been represented in the table below,

Table 8.5: Revenue flows in the Combination of REC and GLS Model

Technology	Revenue flow (Rs Lakh)		Viability Gap (Rs Lakh)	
	Sale to consumer	Sale of RECs	Without support	With support
Biomass Gasifier	0.47	0.48	1.07	0.58
Micro Hydro	0.58	0.59	0.46	0.075
SPV	0.25	1.58	0.88	0.20
Wind + SPV Hybrid	0.23	0.69	3.54	2.05

(Source: ABPS Infra analysis)

Advantages

- REC transactions will be carried out directly by project developer, which will result in better pricing of RECs;
- There will be assured return due to GLS available from MoP.

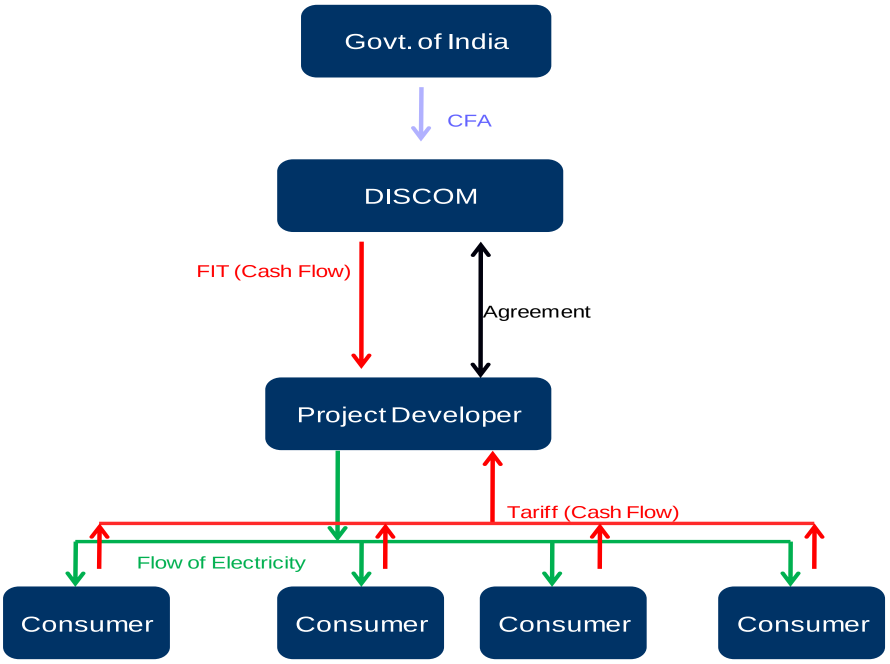
Disadvantages

- Limited resources of project developer to reach to Exchange, as the project being situated at a remote location;
- There will be huge risk of volume and price of RECs;
- Long process involved in reaching GLS from MoP to project developer.

8.3.5 OFF-GRID DISTRIBUTED GENERATION BASED DISTRIBUTION FRANCHISEE (ODGBDF) MODEL

The model is based mainly dependent upon the FIT provided by DISCOM and the CFA provided by GoI to DISCOM. The project developer shall form a franchisee agreement with DISCOM. Project developer shall provide electricity to consumer and receive tariff. DISCOM will provide FIT to project developer and receive CFA from GoI. The figure below presents the structure of ODGBDF model.

Figure 8.6: Operational Structure of ODGBDF Model



The key steps involved in the model are explicated below:

- PD to identify the project scheme under which the project will be commissioned;
- PD to finalize the technology based on the availability of fuel resources;
- PD to undertake the detailed prefeasibility study of the project;
- Detailed project report will be developed;
- PD to form a franchisee agreement and PPA at FIT with DISCOM;
- PD to achieve the financial closure;
- PD to develop and commission the project;
- PD to provide electricity to consumer and receive tariff as paid by the consumer of the local DISCOM;
- PD to receive FIT from DISCOM (however, as per the Franchisee Agreement, PD to collect the due tariff from the consumer for supply of electricity on behalf of DISCOM);
- GoI may provide central financial assistance to the DISCOM. However, CFA is not mandatory for implementation of this model.

Pre-requisites of the model,

i) FOR to develop Model Regulations for Off-grid Rural Electrification.
ii) Government of India to modify Rural Electrification Policy and announce central financial assistance. This step is optional.
iii) Central Electricity Authority to develop technical guidelines for interconnection of small generating systems with the distribution system
iv) SERC to adopt the Model Regulations with suitable adjustments to take into consideration state specific factors. This is one time activity.
v) DISCOM to submit petition to SERC for determination of FIT. This step is generic and shall be performed for each technology in each state & not for particular project.

Financial Analysis of ODGBDF Model

Taking into consideration, the discussions carried out in the previous chapter on the financial analysis of available renewable energy technology options, the revenue flow from sale to consumer for different technologies is in the range of Rs 23,000 to Rs 47,000 as shown in the table below. In order to achieve the financial viability of the model, the revenue flow from the sale of electricity to DISCOM or the feed in tariff to be provided by the DISCOM to the project developer has come out in the range of Rs 1,63,000 to Rs 4,46,000.

Table 8.6: Revenue flows for ODGBDF Model

Technology	Revenue flow (Rs Lakh)	
	Sale to DISCOM (without support)	Sale to DISCOM (with support)
Biomass Gasifier	2.02	1.53
Micro Hydro	1.63	1.09
SPV	2.71	2.03
Wind + SPV Hybrid	4.46	2.97

(Source: ABPS Infra Analysis)

Advantages

- Simplicity of cash flow, as there will be direct cash flow from DISCOM;
- Assured return, as GoI will provide CFA and DISCOM will pay FIT, which will be recovered through Aggregate Revenue Requirement (ARR);
- Stability of cash flow due to longer tenure period of FIT, as it will be approved for around 10-20 years;
- No need of creation of CPA by MoP

Disadvantages

- There will be too much dependence of project developer on DISCOM.

8.4 Summary of Business Models

From the discussion in this chapter, and for better understanding of these five proposed business models, the comparative summary is shown in the table below:

Table 8.7: Summary of business models

S.No	Business Models	Advantages	Disadvantages
1	REC based Model	Direct Issuance of RECs to PD; Better price of RECs to PD	Limited resources of PD to reach to Exchange; Risks associated with volume & price, High transaction costs
2	CPA based REC Model	Assured Centralized assistance from MoP; Centralized procurement of RECs; No hassle of REC in Exchange by PD;	Need to establish CPA; PD may get low REC pricing in advance; Risk to CPA for sale of RECs to Exchange; CPA dependent for Energy accounting
3	GLS Model	Assured return due to GLS from MoP; No risk involved due to absence of RECs	Long process in reaching GLS to PD, Intermediary required at State level
4	Comb. of REC & GLS Model	Direct Issuance of RECs to PD; Better price of RECs to PD; Assured return due to GLS from MoP	Limited resources of PD to reach to Exchange; Long process in reaching GLS to PD Price and Volume Risk
5	ODGBDF Model	Direct cash flow to PD; Assured Return Stability of cash flow due to long tenure period of FIT; No need for creation of CPA Assured Centralized Assistance	Too much dependence on DISCOM,

8.5 Analysis of Business Models

In order to assess the financial viability of the potential business models for the community based off-grid rural electrification, revenue from all sources was calculated for each model. In the following, wherever annualized revenue has been sufficient to meet annualized project costs, it has been shown as surplus (black) while wherever revenue is insufficient to meet the costs, it has been depicted as deficit (red). While calculating revenue, all sources such as consumer tariff, sale of RECs, capital subsidy, generation linked subsidy, etc, as the case may be, has been considered. Similarly, while calculating costs, both capital as well as operating costs have been considered. The following table presents the analysis.

Table 8.8: Summary of Financial Analysis of the proposed business models

Business Models	CASE I: With Govt. Support (Surplus/deficit) (Rs Lakh)				CASE II: Without any support (Surplus/deficit) (Rs Lakh)			
	Gasifier	Hydro	SPV	SPV+Wind	Gasifier	Hydro	SPV	SPV+Wind
REC based model	0.00 - 0.58	0.075-0.76	0.50-0.20	1.64 - 2.05	0.49 - 1.07	0.24 - 0.46	0.18 - 0.88	3.13 - 3.54
CPA based REC model	0.29	0.43	0.15	1.85	0.78	0.11	0.53	3.34
GLS Model	1.06	0.51	1.78	2.74	1.55	1.05	2.46	4.23
Comb. Of REC & GLS model	0.58	0.075	0.20	2.05	1.07	0.46	0.88	3.54
ODGBDF model	Recovered from DISCOMs							

The table above depicts that except ODGBDF model, all the business models show deficit even with the support or subsidy available from the Government and also without any support or Govt. scheme. Apart from the financial analysis, these models have been compared on several other parameters.The table below provides the comparative analysis of the proposed business models for off-grid rural electrification.

Table 8.9: Comparative Analysis of proposed business models

S. No	Parameters	REC based Model	CPA based Model	GLS Model	Comb. Of REC & GLS	ODGBDF Model
1	Compliance with EA 03	High	High	High	High	High
2	Assured CFA	NA	NA	Highest	High	High
3	Stability of cash flow	Lowest	Low	High	Low	Highest
4	Simplicity of model	Low	Low	High	Low	High
5	Necessity of new Institution	NA	High	NA	NA	NA
6	REC related Risks	**Highest**	**High**	NA	Medium	NA
7	REC transaction issues	Highest	High	NA	High	NA
8	Centralized REC procurement	NA	Highest	NA	NA	NA
9	Dependence of DISCOM	Low	Low	Low	Medium	Highest

8.6 Recommendations

On the basis of the detailed analysis presented above, ABPS Infra has recommended ODGBDF Model for the deployment of off-grid community based renewable energy projects. The reasons for the same are as given below:

- Maximum certainty of revenue to the project developer as the DISCOM shall pay FIT, recoverable from ARR, and also CFA, if any from GoI;
- 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 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.

In certain cases, where REC revenue and consumer tariffs are sufficient to meet revenue requirement of the project developer, REC based model may also be considered.

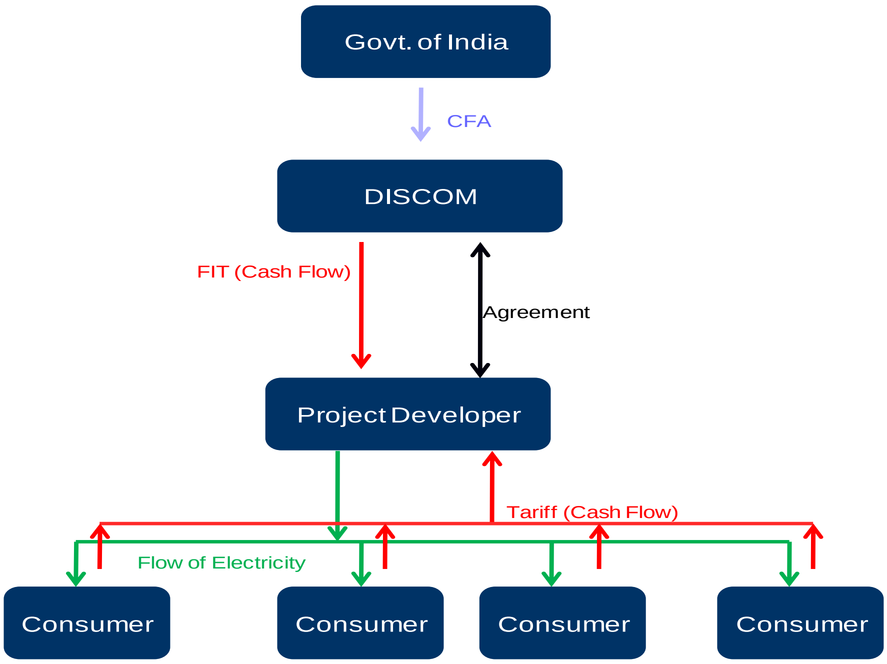
9 PROPOSED BUSINESS MODELS

As discussed in the previous chapter, ABPS Infra has recommended "Off-grid Distributed Generation Based Distribution Franchisee" or ODGBDF model. However, where REC revenue and consumer tariffs are sufficient to meet revenue requirement of the project developer, REC based model may also be considered. This chapter details out the operational structure, institutional and contractual structure, and implementation plan for the proposed models.

9.1 ODGBDF Model

9.1.1 Operational Structure of ODGBDF

This section discusses about the detailed workings of the model. The figure below represents the operational structure of the model.



Step wise description of the model is as follows:

i) Project developer to identify the project scheme for electrification of rural off-grid community;

ii) Project developer to finalize the technology based on the availability of local renewable resources;

iii) Project developer to verify the State Government notification of rural area from the Rural Local Body (RLB).

iv) RLB shall provide the necessary details to project developer such as number of households in the village, un-electrified status of village / hamlet / padas, and consumers' willingness to pay etc. and also provide consent to developer for generating and distributing electricity in the particular area.
v) Project developer to undertake the detailed prefeasibility study of the project;
vi) Detailed project report to be developed by the project developer;
vii) Project developer to enter into a franchisee agreement and PPA at FIT with DISCOM,
viii) Project developer to achieve Financial closure;
ix) Project developer to develop and commission the project;
x) Project developer to provide electricity to consumer and receive tariff as paid by the consumer of the local DISCOM;
xi) Project developer to receive FIT from the DISCOM (however, as per the Franchisee Agreement, project developer to collect the due tariff from the consumer for supply of electricity on behalf of DISCOM);;

Pre-requisites of the model,

vi) FOR to develop Model Regulations for Off-grid Rural Electrification.
vii) Government of India to modify Rural Electrification Policy and announce central financial assistance. This step is optional.
viii) Central Electricity Authority to develop technical guidelines for interconnection of small generating systems with the distribution system
ix) SERC to adopt the Model Regulations with suitable adjustments to take into consideration state specific factors. This is one time activity.
x) DISCOM to submit petition to SERC for determination of FIT. This step is generic and shall be performed for each technology in each state & not for particular project.

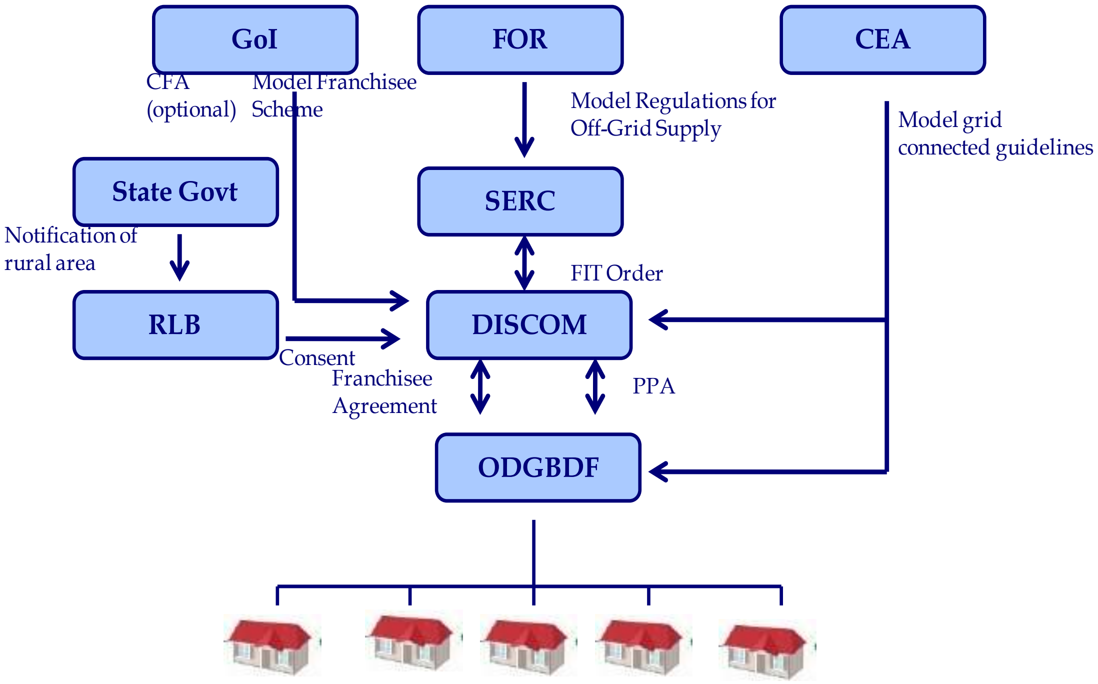
If the Central Government decides to offer Central Financial Assistance to the Distribution Companies, following activities would be involved.

xi) DISCOM to submit an application to GoI seeking CFA, if / as available;
xii) GoI to provide CFA to DISCOM.

9.1.2 Institutional & Contractual Structure of ODGBDF

The institutional and contractual structure of ODGBDF model is presented in the figure below:

Figure 9.1: Institutional and contractual structure of ODGBDF model



The figure above envisages that model franchisee scheme adopted by the Government of India as a part of RGGVY shall be adopted in this business model. The GoI may modify its Rural Electrification Policy to provide central financial assistance to DISCOM so as to compensate it for provision of electricity to off-grid areas. However, it may be noted that such policy is not mandatory for development of ODGBDF model.

It is envisaged that FOR will develop "***Model Regulations for Off-grid Renewable Energy Generation and Supply***". Each SERC will notify its own State Regulations by modifying model regulations to take into account local requirements. SERC will also issue Tariff order for Off-grid renewable energy generation. CEA shall develop grid connection guidelines for small scale renewable energy based plants. State Government shall notify the rural areas in accordance with the Seventy-Third Amendment to the Constitution of India (rural areas would mean all rural areas as defined / specified pursuant to the Seventy-Third Amendment to the Constitution of India). Rural Local Body (RLB) shall provide consent of rural area, number of households, un-electrified status of village / hamlet / padas etc. to ODGBDF. Further, it is envisaged that ODGBDF shall sign PPA and Franchisee Agreement with DISCOM. ODGBDF will provide electricity to consumers and receive tariff as paid by the consumer of the local DISCOM.

9.1.3 Roles and Responsibilities of key stakeholders

The roles and responsibilities of entities involved is elaborated in the following paragraphs:

Government of India

- GoI shall approve model franchisee scheme for off-grid renewable energy projects;
- GoI may modify DDG scheme to provide CFA to DISCOM for promoting off-grid projects as suggested in the Report;
- In case of CFA Scheme, GOI to verify DISCOM applications for CFA;
- Disburse CFA to DISCOM subject to verification rules.

Forum of Regulators

- FOR shall develop "*Model Regulations for Off-grid Renewable Energy Generation and Supply*";
- FOR may also give guidelines for development of fee-in tariff for small scale renewable energy generators used for off-grid supply.

Central Electricity Authority

- CEA shall develop technical guidelines for interconnection of small generating systems with the distribution system.

State Electricity Regulatory Commission

- SERC to notify State Regulations for *Regulations for Off-grid Renewable Energy Generation and Supply*;
- SERC to adopt the Model Regulations with suitable adjustments to take into consideration state specific factors;
- SERC to publish Tariff Order for Off-grid renewable energy generation
- Shall all costs incurred on off-grid supply in ARR of DISCOM.

DISCOM

- In order to make the process simple and convenient, DISCOM shall allow each project on "first come first serve" basis;
- DISCOM to submit tariff petition to SERC for determination of feed-in-tariff;

- Enter into Franchisee Agreement and PPA with PD
- Make payment at FIT for energy generated to the project developer;
- DISCOM to submit an application to GoI seeking CFA if / as available (optional);
- While planning grid expansion, DISCOM shall consider off-grid schemes

Rural Local Body (RLB)

- RLB to confirm un-electrified status of village / hamlet / padas and consumers' willingness to pay DISCOM tariffs, etc. to project developer;
- RLB to confirm the number of households and establishments;
- And shall also provide consent to the project developer for generating and distributing electricity in the particular area.

Project Developer

- PD to identify the project scheme for electrification of rural off grid community;
- PD to finalize the technology based on the locally availability renewable resources;
- Project developer to confirm the State Government's notification of rural area from RLB;
- RLB to confirm the number of households and establishments, un-electrified status of village / hamlet / padas from RLB;
- Project developer to undertake the detailed prefeasibility study of the project;
- Detailed project report to be developed by the project developer;
- PD to enter into franchisee agreement and PPA at FIT with DISCOM;
- Project developer to achieve financial closure;
- PD to develop and commission the project;
- PD to enter into franchisee agreement with DISCOM;
- PD to provide electricity to consumers and receive tariff as paid by the consumer of the local DISCOM;
- PD to receive FIT minus consumer tariff from DISCOM.

Consumers

- Consumers shall pay charges to ODGBDF

9.1.4 Regulations for Off-grid Renewable Energy Generation and Supply

The section above envisages that, SERC shall issue *Regulations for Off-grid Renewable Energy Generation and Supply (ROREGAS)*. The Regulations are required to operationalize following provisions within the Electricity Act 2003.

Eight proviso to Section 14 exempts generation and distribution in rural areas from licensing requirement. The relevant extract of provision of EA 2003 is as under;

> *"person intends to generate and distribute electricity in a rural area to be notified by the State Government, such person shall not require any license for such generation and distribution of electricity….."*

However, no institutional/ regulatory framework is prescribed either in Act or Rural Electrification Policy for implementation of this proviso.

It is possible to make use of provisions related to generation of electricity (S9), Tariff (S61h), Renewable (S86-1e), franchisee (S14) & put cogent framework. The extracts of relevant provisions of EA 2003 are as under:

Section 9: It mandated that a person may construct captive generating plant and dedicated transmission line, the supply of electricity of the same plant through grid shall be regulated in the same manner as the generating station of the generation company.

> *"Notwithstanding anything contained in this Act, a person may construct, maintain or operate a captive generating plant and dedicated transmission lines:*
> *Provided that the supply of electricity from the captive generating plant through the grid shall be regulated in the same manner as the generating station of a generating company"*

Section 61(h): It prescribed the philosophy to be followed by SERCs while determining tariffs. It stated that the Commission shall be guided by promotional aspect as regards renewable energy sources. The relevant extract of provision of EA 2003 is as under:

> *"61. The Appropriate Commission shall, subject to the provisions of this Act, specify the terms and conditions for the determination of tariff, and in doing so, shall be guided by the following, namely:-*
> …

(h) the promotion of co-generation and generation of electricity from renewable sources of energy;…"

Section 86(1)(e): Under Section 86 of EA 2003, the Regulatory Commissions are required to specify obligations of various entities to procure specific percentage of renewable energy out of total consumption of electricity in the area of distribution licensee. The relevant extract of EA 2003 is as under:

"86. The State Commission shall discharge following functions, namely –

(1)

(e) promote cogeneration and generation of electricity from renewable sources of energy by providing suitable measures for connectivity with grid and sale of electricity to any person, and also specify, for purchase of electricity from such sources, a percentage of total consumption of electricity in the area of distribution licensee".

As the projects being small, there is a need to determine tariffs by the appropriate Regulatory Commissions and shall not follow the competitive bidding route for the selection of projects. This kind of framework would be established using these Regulations.

Contents of Regulations

The Proposed Regulations for Off-grid Renewable Energy Generation and Supply (OREGAS) would broadly cover the following the following:

- ***Supporting Provisions of the Act***

Section 181 of the Act empowers the State Electricity Regulatory Commission to develop Regulations. It is suggested that the SERCs notify the Proposed Regulations using these powers. Further, other supporting provisions of the Act namely 8th Proviso to Section 14, Section 86(1)(e), Section 61 (h) and Section 9 may be cited.

- ***Concept of ODGBDF***

Definition of ODGBDF should be given in the Regulations. Further, roles and responsibilities of the ODGBDF should be clarified. The roles and responsibilities may include the generation and supply of electricity to consumers, availability of fuel, hours of supply, development of distribution network, tariff collection as paid by the consumers of the local DISCOM etc.

- ***Nature of PPA and Franchisee Agreement***

These Regulations shall require Distribution Company to enter into PPA and Franchisee Agreement with the project developer. The basic minimum requirements under these agreements shall form part of the Regulations.

- ***Eligibility Criteria for village / hamlet***

The Regulations shall specify the eligibility criteria for the village / hamlet. The eligibility criteria may include the number of households, the un-electrified status of the village and establishments etc. It may also look at the issues such as consumers' willingness to pay DISCOM tariffs.

- ***Eligibility Criteria for ODGBDF Operator***

The Regulations shall also delineate the eligibility criteria for ODGBDF operator. This may include financial strength, ability to achieve financial closure, technical capability, process for demonstration, etc.

- ***Eligibility Criteria for Technology and Sizing of the Plant***

The Eligibility criteria for technology to be used by the project developer and the sizing of the plant shall be defined in the Regulations. The eligibility for technology and sizing of the plant depend upon the availability of the fuel, environmental conditions / clearances for the particular technologies.

- ***DISCOM to create supporting Institutional Structure***

DISCOM shall create the supporting Institutional Structure to enable implementation of ODGBDF model. DISCOM shall submit tariff petition to appropriate Regulatory Commission for FIT, and also submit request application for grant of CFA to GoI. These Regulations shall cover such supporting Institutional Structure required from DISCOM.

- ***Responsibility of DISCOM to enter into Agreement***

The Regulations shall specify the responsibilities of the DISCOM. The DISCOM shall sign the PPA and Franchisee Agreement with the project developer. The DISCOM, before signing of agreements, shall undertake necessary verification of the project developer, the status of un-electrified village, the consent of RLB etc.

- ***Modes of Payment for Generation and Franchisee***

Modes of payment for generation of electricity by the project developer and the franchisee payment to be settled with DISCOM shall be specified in the Regulations. The payment to be provided to the project developer by the DISCOM shall be the FIT and the DISCOM may pay franchisee fees or any sort of payment to the project developer. The modes of payment may be monthly or after collection of tariffs from the consumers.

- ***Grid Interconnection Requirement***

The Regulations shall also include with the grid interconnection requirements so that the project is able to integrate with grid as and when network reaches area of supply.

9.1.5 Model Franchisee Framework

While SERC Regulations would require the DISCOM to enter into Franchisee Agreement with ODBDF operator, the Regulations won't define the contents of the Agreement. Possible contours of the proposed Franchisee agreement have been discussed in this Section of the Report. The Model Franchisee Framework shall be developed by MoP under RGGVY, which has identified six models for franchisee arrangement. These are as follows:

Model I – Revenue Franchisee – collection based

This model entrusts franchisee with limited role of billing, revenue collection, complaints redressal, facilitating release of new service connection and keeping vigil on the status of distribution network in the franchised area for providing appropriate feedback to the utility. Such Collection Franchisee would be appointed for an area and be given a target for revenue collection every month.

Model II - Revenue Franchisee – Input based

In this model, the input energy into the area covered by the franchisee is measured by the utility and the target for revenue collection is set based on the collections made as a percentage of the input energy supplied to the consumers beyond the point of metering by the utility. The operations and remuneration methodology of the input based franchisee is similar to that of the collection franchisee. The basic difference is in the target setting mechanism by the utility.

Model III - Input based Franchisee

This model is similar to the Revenue Based Model, with one significant difference that the franchisee will also buy the electricity from the utility and shall pay the energy charges to the utility at a pre-determined rate. The franchisee will have to collect revenues from the consumers through raising bills so as to have sustainable commercial operation.

Model IV - Operation & maintenance franchisee

In this model, in addition to the model III, the Utility may also hand over the operation and maintenance of 11 kV & LT feeders including distribution transformers to the franchisee based on monthly retainer basis or at an adjusted energy purchase price (of the utility), factored appropriately considering O & M cost of the franchisee.

Model V - Rural Electric Co-operative Societies

In this model, the State to authorize the creation of traditional electric cooperative society that is organized, owned and operated by its members. The society owns the distribution utility assets, purchases power from State Utility and is responsible for all utility functions including operations and maintenance, metering, billing and collections, accounting and finance, procurement, stores and system planning and expansion.

Model VI - Electric cooperative society – operations management through contracting

Keeping the formation procedure of the society unaltered as in Model V. The Board of Directors of the society may decide to run the operations of the society through an external experienced agency / organization with suitable fee structure. This can be achieved through an appropriate "operations contract" with built-in performance criteria.

It is suggested that 'Revenue Franchisee – Input Based' as defined under Model II is modified for off-grid supply.

- During off-grid operations, input shall be quantum of generation from renewable energy project,
- And when connected to grid, input shall be quantum of energy supplied plus the energy generated from the off grid renewable energy project;
- Fixed loss equal to loss level in the adjoining area should be allowed to ODGBDF Operator;
- Loss levels may be fixed for tenure of the contract or for a year at the beginning of the year.

Franchisee Agreement

There shall be a franchisee agreement between the project developer and the DISCOM. The agreement shall follow Model Draft Franchisee Agreement approved by the Government of India as a part of Rajiv Gandhi Grameen Vidyutikaran Yojana and would contain the following:

- Date Agreement
- Contracting Parties
- Definitions and Interpretations
- Definition of Area
- Period of the Contract
- Billing and Payment Cycle
- Agreed Power Price
- MRV Process
- Force Majeure Conditions

9.1.6 Power Purchase Agreement

There shall be a PPA between the project developer and the DISCOM. The PPA shall contain the following information:

- Date of Agreement
- Contracting Parties
- Definitions and Interpretations
- Capacity of the project in kW and also in kWh.
- Complete details of the distribution network, declare the voltage levels, etc.
- Measurement, Reporting and Verification (MRV) process
- Grid Synchronization
- Tariff
- Period of Contract
- Billing and Payment Cycle
- Delayed Payment Charge
- Force Majeure Conditions

Model Draft Power Purchase Agreement for small renewable systems shall be approved by the respective State Electricity Regulatory Commission.

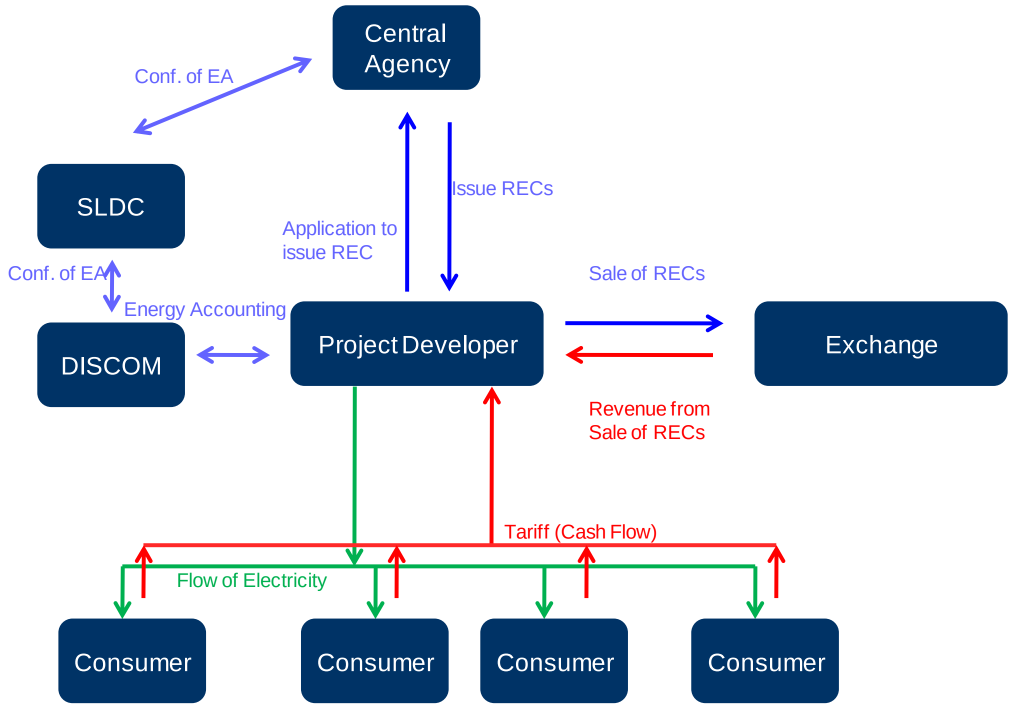
9.1.7 Implementation Plan

This section presents the list of important events that will constitute the implementation plan for projects under the proposed "Policy and Regulatory Intervention for Promotion of community level off grid renewable energy projects".

- FOR to adopt proposed approach for Off-grid Community based RE Projects
- FOR to develop Model Regulations for Off-Grid Supply
- SERC to adopt Model Regulations after suitably accounting for State requirements
- FOR to adopt Guidelines for Determination of Tariffs for Off-Grid RE Technologies
- SERC to adopt Model Tariff Regulations for Off-Grid RE Technologies
- SERC to issue tariff order for Off-grid renewable energy
- PD to identify the Project Scheme and submit DPR to DISCOM
- PD to sign PPA & Franchisee Agreement with DISCOM
- PD to accomplish Financial Closure & commissioning of project
- DISCOM to account costs in tariff petition to SERC
- SERC to scrutinize the project & approves FIT
- PD to supply electricity to consumers & claim FIT from DISCOM
- DISCOM to provide FIT
- DISCOM to request CFA from GoI, if / as required (optional)
- GoI to provide CFA to DISCOM

9.2 REC based Model

In case, REC revenue and revenue from consumer tariffs are sufficient to make community based project financially viable, simple REC based model as described in this section may be implemented. The figure below represents the operational structure of the model.



The key processes involved in the model are elaborated us under:

- PD to identify the project scheme under which the project will be commissioned;
- PD to finalize the technology based on the availability of fuel resources;
- PD to undertake the detailed prefeasibility study of the project;
- Detailed project report will be developed;
- PD to achieve the financial closure;
- PD to develop and commission the project;
- PD to supply electricity to the consumers and collect the mutually agreed tariff between the consumers and the PD;
- PD to submit application for accreditation of the RE generation project;
- State Nodal Agency (SNA) to verify the application and issue the "Accreditation certificate" to project developer;
- DISCOM to do energy accounting of the project and shall report the same to SLDC and SLDC in turn, after verification, shall submit the energy accounting report to CA;
- Application for registration shall be submitted by project developer to CA;
- CA shall issue "Registration Certificate" to project developer;
- Application for issuance of RECs shall be submitted to CA and CA in turn issue RECs to project developer;
- Project developer will sale RECs on Exchange and earn revenue.

In a typical REC project, the energy accounting is done by the appropriate SLDC. However, these projects are very small in size, located at far off places connected at distribution voltage levels. It will be difficult for SLDC to do energy accounting at this level. Therefore, it is suggested that energy accounting is carried out by the local distribution company.

It should be noted that the REC based business model can be a viable business model only if the project developer could get sufficient benefit from sale of electricity to the consumer and sale of RECs on the Exchange to recover all his costs. Earlier analysis shows that these revenues are insufficient in case of many technologies. Hence, sufficiency of revenues should be ascertained before directing REC based model.

In this case, there will be a need to develop Off grid REC regulations, as presently REC regulations allow for issuance of RECs to grid connected plants. These new regulations should allow off-grid RE generators to receive RECs and sell those on the Exchange. Further, purchase of RECs by obligated entities should be allowed to meet compliance of RPO target.

10 CONCLUSIONS

In this chapter, ABPS Infra presents the conclusion of the study "To support community level off-grid projects through policy and regulatory interventions". In India, there are around 6 lakh villages, out of which approx. 14000 are yet to be electrified. The mission to bring electricity services to ALL by 2012 is still on. However, around 55% of rural & 12% of urban households are yet to be electrified. Several of these households are in un-electrified villages, padas, bastis. Typically these habitations have less than 100 households. Even electrified villages are witnessing shortages in power supply. At the same time, local renewable resources are not being tapped. Costs of renewable technologies are reducing with time. It has become imperative to develop decentralized RE generation options for supply of electricity to these un-electrified households. For this purpose, ABPS Infra has carried out this work with support from Shakti Sustainable Energy Foundation to provide inputs to CERC & FOR.

As a part of the study, ABPS Infra carried out review of existing policy framework and schemes at national and international level for rural electrification and distributed RE generation. At the national level, schemes such as MNRE VESP, MNRE off-grid solar guidelines, MoP off-grid and DDG Scheme were reviewed. In order to understand the real situation on ground, several field visits were undertaken. The purpose of the visits was to understand operations of a particular technology, billing & payment practices, social issues in supplying electricity etc. At international level, several rural electrification schemes of Brazil, China, and South Africa were studied. Identification of challenges for commercialization – financial viability issues of the technologies, evaluation of regulatory intervention measures and strategies has been carried out. Assessment of distribution management issues, institutional issues and governance issues has been done. And based on the above analysis, we proposed following five business models namely,

- REC based Model
- CPA based REC Model
- GLS Model
- Combination of REC and GLS Model
- ODGBDF Model

Detailed operational structure of each model has been discussed. Further, analysis of the business models was carried out, and based on that, we recommended ODGBDF model. In certain cases, where REC revenue and consumer tariffs are sufficient to meet revenue requirement of the project developer, REC based model may also be considered.

In ODGBDF model, the project developer will provide electricity to the consumers and collect the tariff as paid by the consumers of the local DISCOM. The DISCOM shall provide FIT to project developer. GoI may consider development of policy under which it may provide central financial assistance to DISCOM for promoting off-grid rural electrification. This model provides the maximum certainty of revenue to the developer, proper integration of off-grid projects with grid as and when it is feasible. This would enable large scale deployment of off-grid projects. The model will also ensure internalisation of costs of rural electrification. It will be possible to customise model according to local requirements and there shall be optimum utilisation of the government subsidy, if offered. The institutional and contractual structure for the model has been developed and presented in the chapter. It is proposed that FOR develops Model Regulations for Off-grid Renewable Energy Generation and Supply (OREGAS) which would be suitably modified and adopted by the SERCs.

It may be noted that the REC based business model could also be a viable business model if the Project Developer is able to recover all costs through revenue from sale of electricity to the consumer and sale of RECs on the Exchange. Earlier analysis shows that these revenues are insufficient in case of many technologies. Hence, sufficiency of revenues should be ascertained before directing REC based model.

In case REC based Model, there will be need to develop Off grid REC regulations, as presently REC regulations allow for issuance of RECs to grid connected plants. These new regulations should allow off-grid RE generators to receive RECs and sell those on the Exchange. Further, purchase of RECs by obligated entities should be allowed to meet compliance of RPO target.

11 ANNEXURE

This annexure contains the following case studies on various renewable energy technologies covered under the assignment.

- Husk Power Systems for Rural Electrification in Bihar
- Bio-oil based power generation at Mokhayachapada, Maharashtra
- Biogas based power generation at Jawhar, Maharashtra
- Solar Village Lighting at Chondipada, Maharashtra
- Micro Hydel Project for Rural Electrification in Orissa

11.1 Husk Power Systems for Rural Electrification

Most of the villages in Bihar are far away from electricity. In order to light up these villages, Husk Power System (HPS) is trying to explore the ways to convert farm waste into electricity. In 2007, under the guidance of Ministry of New and Renewable Energy (MNRE), they took their first step towards the green energy revolution. They got their gasifier fabricated at a local workshop and procured a cheap CNG engine modified to suit their purpose from a small supplier. Rice husk is a waste product of rice mills and is found in plenty in vast rural India, it is not often used for generating electricity. The added advantage of these generators is its by-product-silica, which is a valuable ingredient in making cement.

HPS Business Model

HPS has adopted a demand driven approach and quantifies the potential demand in watt-hours, minimum to be around 500 – 650 households would be there. Households are required to pay installation charge of Rs 100. This money ensures compliance by the users, and also covers a substantial portion of grid distribution expenditure, which in totality brings down the fixed investment in infrastructure like power plant shed and storage space, which is almost around 5%of the total investment. HPS on one hand ensures that the power plant machinery meets the requirement of the power plant and on the other hand makes it cost effective by procuring gasifiers from local manufacturers and coupling it to modified gas engine enabling to operate on 100% producer gas obtained through gasification of biomass (rice husk) using gasifier.

HPS has mainly 3 business Models

- BOOM (Build, Own, Operate and Maintain)
- BOM (Build, Own and Maintain)
- BM (Build and Maintain)

BOOM – Under this first starting model, all the activities of the gasifier power plant is carried out by HPS. HPS has 100% ownership of the plant. HPS installs (builts) the plant, owns and operates as well as maintains it regularly.

BOM – Under this modified model, HPS still has 100% ownership of the plant, HPS installs the plant and provide regular maintenance for the contract period of six (6) years. The plant is operated by the local entrepreneur and has to pay the maintenance fee of Rs 15,000 per month for six years and after completion of the contract period, the plant will be owned by the local entrepreneur. In order to start this plant, the local entrepreneur has to deposit a non refundable fee of Rs 2 Lacs.

BM – Under this latest business model for rapid scaling up, HPS install/builds the plant and provide maintenance service of the plant. The plant is fully owned and operated by the local entrepreneur who invests all the capital cost. Any financial assistance/subsidy on plant gets transferred to the local entrepreneur.

Following four HPS plants were visited at different villages in district Muzaffarpur located at around 75 km in the north from Patna in Bihar to gather the information

- Village Jhaphan, Dist Muzaffarpur, BOM just commissioned in April 2011
- Village Turki, Dist Muzaffarpur, BOM commissioned in January 2011
- Village Hathodi, Dist Muzaffarpur, BOM to commission in next 2-3 days (April 2011)
- Village Bhadhai, Dist Muzaffarpur , BOOM is commissioned in 2010

Plant at Jhaphan, Muzaffarpur District, Bihar (BOM Model)

Plant Operations

HPS manages most of the decentralized power generating units with the help of four personnel assigned to each plant. For the day-to-day management, every power plant has one operator and one husk loader, where in the operator carries out the routine maintenance. The operators are trained by HPS in Patna (Bihar), for two months and then sent for on the job training in one of the operational plants. In addition, two more people are associated with each plant - one of them handles husk buying and ensures a regular supply of raw material and also involved in the revenue collection activities, where as another one is an electrician for the cluster of villages. In addition HPS has cluster level manager who looked after the plants in the range of 20-25km or about 5-7 plants. Besides trained manpower, HPS has also taken due care to ensure smooth supply of low cost raw material. At the market end, the promoters have evolved strong relationship with the rice husk suppliers. This husk is transported by tractors simultaneously to about 7-8 plants in one cluster. HPS has plans to have one rice mill in each operational region to ensure sustained fuel supply at reasonable price.

Plant Economics

HPS is based on a proven biomass gasification technology of standard fixed bed, down draft type, which is suitable for rice husk based power generation of a capacity range below 200 kW. The capacity of the systems varies from 25 kW to 80 kW. A 32 kW system costs Rs 16 Lacs. (Project cost = Rs 50 per W). MNRE subsidy works out to around 50% of the total project cost that comes to nearly Rs 8 Lacs. The subsidy amount from MNRE is directly transferred to the local entrepreneur in case of BOM and BM business models and is kept by HPS in case of BOOM model.

The rated capacity of the typical HPS systems installed in Bihar is around 32 kVA that generates nearly 25 kW of electricity. Out of this, 1-1.5 kW goes as the lines losses; average theft amounts to around 1kW; and approximately 18-19 kW is available for consumption, usage or saleable purpose.

Villagers use kerosene as a fuel for lighting purpose. In case of unavailability of electricity the common means used by the local people is by using diesel generators. Approximately Rs 85-90 per month per household is charged for 3 hours of electricity with which user gets lighting using 8-10W CFL bulb. Consumers are willing to pay this amount for lighting their houses, television, commercial and social services like Xerox machines, fax, printing machines, education, etc.

A differential pricing method is adopted by HPS to calculate the electricity charges. Accordingly, every household has to pay a fixed monthly charge of Rs 45 per CFL of 15 W, whereas shops pay a per month charge of Rs 80 per CFL. For households seeking connection to operate fan and television etc. charges are calculated on similar wattage basis.

1 unit of HPS (HPSU)= 15W * 6hrs * 30days = approx. 2.7 kWh equivalent

On an average, the monthly revenue collection of a typical 32kVA HPS plant is the plant is around Rs 60,000. A plant consumes around 50kg of husk per hour, and cost of rice husk is nearly Rs 1.10-1.30 per kg. The plant operates for six hours a day. Thus fuel (husk) cost works out to around Rs 11,500 per month. The total monthly plant operating cost including the cost of manpower works out to Rs 25,000. This insures profit margin of approximately Rs 35,000, out of which the local entrepreneur has to pay a sum of Rs 15,000 to HPS per month making the project financially sustainable.

Plant at Village Bhadai, BOOM

Strength of HPS

Enthused by the response received from people, HPS is growing from strength to strength. Currently HPS has approximately 50 plants under BOOM model, 25 under BOM model, and 3 under BM model. The organization is expecting to meet the target of operating 2,016 plants by the year 2016. Though it is an acceptable fact that till date, renewable energy projects in general, and biomass based projects, in particular, are not cost competitive as compared to fossil fuel based projects. However, considering the remoteness of the project location chosen by the HPS, future is extremely bright for the people living in the off-grid villages.

11.2 Bio-oil based power generation at Mokhayacha Pada

The village '*Mokhyachapada*' is located in Jawhar Tehsil of District Thane in the State of Maharashtra. The village has around 52 households and a population of around 320 as per the census 2001. The village is located in the belt Sahyadri mountain range of Western Ghats. The village does not have basic infrastructure such as proper road, availability of electricity for longer duration, schools for higher education, health centres etc. During the monsoon season the village remain un-approachable even by vehicles. The education facility in the village is up to fourth standard and after which the children are engaged in providing assistance in farming or other home business. The school for higher education is located at around 10km from the village at Jawhar

Taluka. In terms of medical facilities, the village has one sub – centre for primary treatment.

In spite of blessed fertile land, the farmers face many challenges, such as adopting traditional methods of farming, availability of water during monsoon season only etc.. During the *Kharif* Season the farmers cultivate paddy crop. However, during non–monsoon period, being located at the hilly terrain, no water is available for cultivation and hence the farmers are able to grow only one crop. During the off season they undertake labour activity to earn their living.

For the purpose of cooking food, the villagers primarily depend upon woods from nearby forests. This is also leading to deforestation. It has also been observed that during the monsoon season, though the wood is available in abundance, the calorific value of the wood deteriorates because of getting wet leading to generation of smoke while burning. Further, each household in the village receives 5 litre of kerosene at a cost of Rs 12per litre which is essentially utilised for illumination during evening and night hours.

'Pragati Pratisthan', a local Non Government Organisation (NGO), is active in Jawhar Tehsil with the mission of overall sustainable rural development. With the assistance from Ministry of New and Renewable Energy (MNRE) the NGO, during January 2006, had established a Bio-Oil (SVO – Straight Vegetable Oil) based decentralized power generation plant to meet the local electricity needs. The project is implemented under the "Village Energy Security Project Scheme" (VESP) initiated by the MNRE. The VESP was launched, by the MNRE, with the objective of providing energy security in villages which do not have access to grid electricity. The programme aims meeting total energy needs for cooking, electricity and motive power through various forms of locally available biomass material.

Under this project, a 10 HP/7.5 kW engine alternator operating on SVO (Make-Field Marshal) was commissioned on March 2008. Also the necessary power distribution network was laid down and each household was provided with two 60W incandescent bulbs and a socket point for charging mobile or using other electrical/electronic gadgets.

Though SVO engine was procured in 2008, the oil expeller was commissioned earlier during 2007. The NGO engaged a local entrepreneur who was running a flourmill in the village as operator of the oil expelling system and also allowed the entrepreneur to expel oil from edible oilseeds. The entrepreneur expels edible oilseeds that are brought to him from the village as well as its neighbouring villages. After the SVO based engine was installed, the same entrepreneur was involved as operator for the SVO engine and for expelling non-edible oilseeds (mainly jatropha, Karanj and Mahua) for use in the SVO engine.

The model followed is that the entrepreneur operates and maintains both the oil expeller and SVO engine and keeps the earning from the sale of oil cakes. Annually about 15-17 ton of oil cakes are generated from expelling of edible oils and these are sold @ Rs 4-6 per kg in the nearby markets as cattle feed. The oil cakes from the non-edible oils (about 7-8 ton annually) are purchased by the NGO @ Rs 2-4 for generating power from biogas at their school located at the Jawhar. The entrepreneur spends about Rs 30,000/- on fuel and maintenance to run a diesel engine coupled to the oil expeller. The entrepreneur keeps the difference between his earning from sale of oil cakes and fuel for the diesel engine, which is about Rs 4,000/- per month.

An 11 member Village Energy Committee (VEC) was formed for implementation and management of power plant. VEC in consultation with PIA has set monthly tariff of Rs 25 for lighting which villagers are paying regularly. This collected money is deposited in a bank account (opened specially for this purpose) of VEC and is used for procuring oil seeds for producing fuel for the SVO engine and for taking care of other operational expenses.

The average load is about 5-6 kW based on 2 bulb and one socket for each of the connected 52 households. The SVO genset consumes about 300ml/kWh and consumption may be on a higher side due to very low PLF, adversely affecting the expenses on input fuel cost.

Presently the SVO cost works out costly like diesel (@Rs 40/lit) since seeds are procured from the local market. In order to ensure sustainable fuel supply and reduced fuel cost about 25,000 jatropa plants had been planted in 10-hectare non-cultivable land within the village boundary. Once seeds starts coming from the captive plantation, it is expected that cost of generation will get reduced.

The system has been working smoothly with minor maintenance requirement of soot cleaning and monthly oil filter cleaning. However, it was seen that no pre-treatment of oil is being carried out and filter press is also not being used. Though this has not caused major breakdown but in long run can affect engine performance.

Recently, grid electricity has reached Mokhachapada village, though there is no three phase connection to the village. Approximately 30 households have taken single phase electricity connection at a per unit rate of 30 paise (BPL Category). Therefore, now the bio-oil based genset is no more in regular use and is used as back up option for meeting the specific requirement during the festivals and other social events.

11.3 Biogas based power generation at Jawhar

Jawhar is a Tehsil of Thane district in Maharashtra, which is also a headquarter of local NGO '*Pragati Pratisthan*'. The NGO is working in the region for the development of several tribal villages of this remote underdeveloped region and also running a school for deaf and dumb near their head quarter at Jawhar.

Oil expeller operating at Mokhayachapada

Floating dome biogas plant operating with de-oiled cake as feed material

With the assistance from Ministry of New and Renewable Energy (MNRE) the NGO has implemented "Village Energy Security Project Scheme (VESP)" of MNRE and commissioned jatropha oil seed extraction plant and SVO based electricity production unit at village Mokhyachyapada and also successfully operated several biogas plants for cooking using de-oiled cake as a feed material instead of commonly used cow dung with technical assistance from Brito Bio Industries, Virar.

In order to overcome the problem of unreliable power supply, frequent power cunt power cuts and increasing load shedding, the NGO has installed a small biogas based power generating unit at deaf and dumb school located at Jawhar. For this purpose two biogas plants have been installed using with the help of the help of Britto Industries and these biogas plants are being operated using deoiled cake as feed material instead of conventional cow dung. This biogas plants are used to fill 2 huge balloons of 2m^3 capacity, and stored biogas is used to operate a small portable genset engine for 3-4 hours during power cut. The plant is in operation on regular basis without any operational problems at the school for several years now.

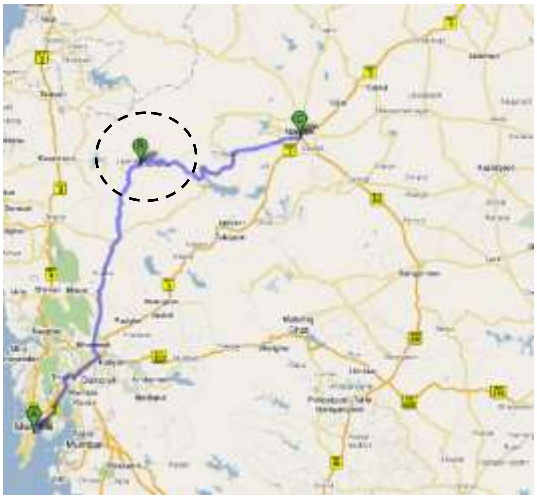
Rubber Balloon for biogas storage at Jawhar school

Biogas operated portable genset at Jawhar school

The required de-oiled cake is procured at the price @Rs 2-4 per kg from Mokhyachyapada where it is produced as by product from oil expeller installed to obtain jatropha oil for running genset. On an average gas production of 0.5m^3 per kg de-oiled cake and production of about 1kWh per m^3 has been observed. Therefore approximate fuel cost for this biogas based power generation works out to about Rs 1-2 per unit.

11.4 Solar Village Lighting at Chondipada

The village 'Chondipada' is located in Jawhar Tehsil of Thane District in the State of Maharashtra. The village has around 64 households and a population of around 300 as per the census 2001. The village is located in the belt of Sahyadri mountain range of Western Ghats, and receives approximately upside of 2000mm of rainfall annually. The village does not have basic infrastructure such as proper road, availability of electricity for longer duration, schools for higher education, health centres etc. During the monsoon season the village remain unapproachable for vehicles. The education facility in the village is up to fourth standard and after which the children are engaged in providing assistance in farming or other home business. The school for higher education is located at around 10km from the village at Jawhar Taluka. In terms of medical facilities, the village has one sub – centre for primary treatment.



In spite of blessed fertile land, the farmers face many challenges, such as adopting traditional methods of farming, availability of water during monsoon season only etc.. During the *kharif* season the farmers cultivate paddy crop. However, during non – monsoon period, being located at the hilly terrain, no water is available for cultivation and hence the farmers are able to grow only one crop. During the off season they undertake labour activity to earn their living.

For the purpose of cooking food, the villagers primarily depend upon woods from nearby forests. This is also leading to deforestation. It has also been observed that during the monsoon season, though the wood is available in abundance, the calorific value of the wood deteriorates because of getting wet leading to generation of smoke while burning. Further, in a month each household in the village receives 2.5 litre of kerosene at a cost of Rs 9 per litre which was utilised essentially utilised for illumination during evening and night hours.

A local Non Government Organisation 'Pragati Pratisthan', is active in Jawhar Tehsil with the motive of rural development. With the assistance from Rotary Club the NGO, during December 2010, had executed a solar energy project to meet the electricity needs. Under this project a total number of 64 Solar panel-Light sets were installed on the roofs of all the 64 households in the village. Each solar panel light costs Rs 4150/-. Each house hold contributes up to Rs 500/- for this project and a remaining amount was borne by Rotary Club-Jawhar.

LED Solar Home Lights

Solar Lantern

Apart from the household lights each house hold were also distributed one solar lantern and one solar street light is installed at the centre of the village to illuminate the roads during night.As per the villagers, the rooftop solar cells are capable of providing the necessary backup to keep the lights on throughout the night.

Solar Streetlight at Chondipada

The "Pragati Pratisthan" is solely responsible for the technology transfer and for providing the necessary technical know how to operate the sophisticated electronic devices .The study team of ABPS Infra was very pleased to know that the "Pragati Pratistahan" is taking due care to provide technical training to the youngsters of the village regarding assembling of the solar cell units in the rotary club office at Jawhar.

11.5 Mirco Hydel Project for Rural Electrification

The village of Putsil lies at the intersection of 82° 59"37' longitude and 18° 42" 08' latitude. Putsil village has a cross section area of 5 sq. km. The village is situated near the Deomali Hills. Geographically, it is located approximately 20 km north-east of Semiliguda block, Koraput district, Orissa state. The population of the village is around 369 and about 79 households. The primary source of economic livelihood is from agricultural activities and around half of the population of the village is available for labour. The main source of drinking water for villagers is through natural spring water. Stream water is used for irrigation requirements and other domestic purposes. The village has abundant water supply round the year.

The micro hydro scheme uses water from the stream Kodramb that runs close to the village. Kodramb, which is a tributary of the Karandi river, is a perennial stream which drains an area of approximately 3 sq. km. The rain climate in the region is mainly characterised by the southwest monsoon, which accounts for 1158 mm of the total annual average rainfall of 1366 mm or nearly 85% of the annual rainfall.

Power House

Community Television

Benefits of Micro Hydro to Putsil

The Micro Hydro Plant has accelerated visible changes in village Putsil, that leads to increase in income, work sharing, leisure time, community initiatives; sanitation and cleanliness; awareness and empowerment; management of local natural resources, forest protection, etc. Villagers have also sufficient time to watch TV, and families can also generate additional income of Rs 2000 a year. The Micro Hydro also benefits the neighbouring villages. They charge batteries and use the Mill. The Mill helps in community income – out of each rupee; 0.50 paisa goes to the community fund. Four young men get direct employment 2 in the Mill, 2 in the Plant. As trained electricians, the plant operators now earn about Rs 4000 per annum out of wiring and allied activities in and outside their village. Around 300 hectares of the forests have been protected to reduce the silt as well as restore the bio diversity to sustain the water flow in the streams. About 10 acres of land has been used to learn nursery management, raising saplings for regeneration of endangered or lost species.

Community Participation

The Putsil Micro Hydro Committee comprising of 21 members (includes six women) manages the power generation and distribution. Each of the 80 families in the village is a consumer. The consumers are divided in to six groups and each group is assigned with specific tasks such as repair, catchment area management, etc. One incredible aspect about the Putsil Micro Hydro is the depth of Community participation. The approach employed by the community to manage the plant has effective combination of traditional values of concern and flexibility. This is reflected in timing of power supply, collection of fees, compensation for services to operate the plant and other end use machineries.

Since 1998, each family has been paying average Rs 20 towards electricity fund, but they are free to give less during lean season and more when they have opportunity for cash income. For the family use, electricity is supplied from 6pm in the evening to 10pm; again from 3am to 6am, and then from 6am to 8am to run the Mill. The early morning power supply was initiated as per the demand of women to complete household chores before leaving for the field. During marriage, childbirth, serious illness, festivities and other such occasions power supply is given as per the need. Initially, two youth from Putsil were trained to run the plant – they in turn train other incumbents. The plant is located about 1 km away from the habitation.

Operation and Maintenance

Village community select the persons and training is provided for the operation and maintenance of the plant, putting electrical fixtures at the household level and operation and maintenance of end use machineries. Prior to the commissioning of the plant the village community was also made aware regarding the overall aspects of the production and caution in the use of electricity, its maintenance, management and distribution of power. The project commissioned in August 1999 at present generates 10 kW, which is sufficient for all the 80 families to have lighting, run TV/Radio during the night and the mill and machines for grinding and oil extraction, lathe for woodcrafts during daytime. The plant has potential to generate 25kW. Annual maintenance comes around Rs 7,000/-.

Micro hydel plant has certain challenges that made it difficult to work. Some of the major variables of failure are unequal income distribution among the villagers; involvement of village politics; untrained / change of operators; some places there is inability of the plant to meet the demand of the village; no funds for repair and maintenance; difficulties in tariff collection and seasonal changes etc. Facing huge problems, the Micro Hydro Plant in Putsil has achieved cent percent integration to a sustainable development process.

11.6 Biomass Energy for Rural India (BERI) Project, Karnataka

BERI project at Tumkur district, Karnataka was initiated by GoI – UNDP/GEF in 2002, and is currently being implemented in a cluster of 29 villages of the district. The villages are divided into 5 clusters of between 5-7 villages and 1 outlying village, in 9 Gram Panchayats spreading over 5 Taluks. The project provides basic services such as lighting, pumping drinking water & cooking and economic activities such as pumping irrigation water & agro-processing to village households.

The Implementation agencies are Department of Rural Development & Panchayat Raj, Government of Karnataka (GoK) and Karnataka State Council for Science & Technology (KSCST). The project is owned and managed by GoK through a registered society called BERI Society.

500 kW gasifier plant installed in the Kabbigere village of Koratagere taluk and commissioned in January 2006. Power from grid is used to start up of the gasifier and then power generated from the gasifier takes care of the auxiliary consumption. There are no fixed hours of operation for the power plant and it runs based on the availability of biomass. Maintenance of the system is undertaken after every 100 hours of operation, thereby shutting down the plant. Average cost of generation excluding the capital cost is Rs 2.50/kWh. While the project envisaged selling electricity directly to the consumers, however, the net electricity generated is fed to the 11 kV grid of the Bangalore Electric Supply Company (BESCOM) for distribution in the area due to risk of lower collection efficiency.

Village Biomass Energy Management Committees (VBEMC) and Village Forestry Committees (VFC) engaged for managing forests and common land plantations and also for promoting biomass development on private land, formed in all project villages during the initial phase of the project for better involvement of the community. Water Users Associations (WUA) and Self-Help Groups (SHGs) (including women SHGs) formed for nursery raising and preparation of seedlings for the energy plantation.

Plant is managed by Village Samithi (committee), formed as a sub-committee of Village Panchayat. Samithi comprises of 21 members with representation from 5 beneficiary villages. Samithi has 3 sub-groups with specific functions of financial management, raw material supply and power generation and management. Daily operation and maintenance has been taken care of by staff engaged by BERI Society. Salary of the staff is paid by the Samithi.

The BERI society and BESCOM have entered into a PPA to evacuate the power generated. Electricity is recorded at the delivery point by electronic meters and BESCOM pays a feed in tariff @ Rs 2.85/kWh to the Samithi on the net electricity fed to the grid. The consumers pay directly to the BESCOM at the prevalent tariff for rural consumers. Power generation gets affected during the rainy season when biomass supply with appropriate moisture content is in short supply.

SHGs were involved in setting up of nurseries to provide plant material for the biomass energy plantations and saplings were distributed at a subsidized price and these were planted on the bunds of the farm. The Samithi has entered into informal agreements with project beneficiaries for supply of biomass from their farmland to the plant.

The project has resulted in a decentralized power generation and better rural energy services apart from several other community development activities. Samithi members perceive that the power purchase rate fixed by KERC is on the lower side and the lower feed in tariff is also limiting the rates for biomass supply as any increase in the price of biomass will make the operation of the plant financially unsustainable.

11.7 SELCO (Solar Lighting)

SELCO-India is a private business that supplies PV solar home systems to provide power for lighting and small appliances to low-income households and institutions in Karnataka and Gujarat. SELCO's business model is based on the provision of product and service and providing access to financing through partnerships with banking institutions. SELCO has supported a business model for PV-powered battery-charging, in which an entrepreneur takes out a loan to purchase a solar lantern charging system and then rents out the solar lanterns to street vendors.

Dharwad, is a town situated in central part of Karnataka. Hundreds of street vendors in various parts of town use smoky kerosene lamps, petromax lanterns, or rechargeable emergency lamps for lighting up their wares. They spend around Rs 15 to Rs 25 for an average of four hours of lighting. The expensive fuel, most of the times, does not provide good quality of light, and even also reduce their profit.

A solar lighting solution, which provides higher quality illumination, designed for an average of four hours can be financed at a daily rate which is lower than their current expenditure. The bank provides loan to the interested, eligible entrepreneur to purchase the solar lights and central solar charging station to be placed at his house from SELCO. Power charging station can vary from 100 W to 1.5 kW. Around 10-150 batteries can be charged. Charged batteries can be transported to the vendors in the evening. Vendors use solar charged batteries to run their lights. They pay a nominal rental fee of Rs 15-20 to the entrepreneur at the time of battery delivery. The entrepreneur retrieves the batteries once discharged and restarts the cycle.