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RETs theme
Renewable energy in South East Asia for improving access to energy
(With focus on India and Nepal)

Prepared for
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Acronyms

AC	Alternating Current
AEPC	Alternative Energy Promotion Centre
APL	Above Poverty Line
AREP	Accelerated Rural Electrification Programme
BPL	Below Poverty Line
BSP	Biogas Support Program
CFL	Compact Fluorescent Lamp
CFS	Continuous Facility Survey
CHC	Community Health Centre
CMIE	Centre for Monitoring India's Economy
C-WET	Centre for Wind Energy Technology
DC	Direct Current
DOE	Department Of Energy
DRUM	Distribution Reforms Upgrades and Management
EMT	Electronic Milk Testing
EPC	Engineering Procurement Construction
ERAP	Energy Resources for the Alleviation of Poverty
ESAP	Energy Sector Assistance Program
GNESD	Global Network on Energy For Sustainable Development
IREDA	Indian Renewable Energy Development Agency
IREF	Interim Rural Energy Fund
kWp	Kilo Watts Peak
LCPD	Litre per Capita Per Day
LT	Low Tension
MNES	Ministry of Non-conventional Energy Sources
MoA	Ministry of Agriculture
MoC	Ministry of Coal
MoEF	Ministry of Environment and Forest
MoP	Ministry of Power
MoU	Ministry of Urban Development
MPCE	Monthly Per Capita Expenditure
MW	Mega Watt
NE	North East
NEA	Nepal Electricity Authority
NGO	Non-Governmental Organisation
NIRE	National Institute of Renewable Energy
NSSO	National Statistical Survey Organisation
O&M	Operation & Maintenance
PEDA	Punjab Energy Development Agency
PHC	Primary Health Centre
REC	Rural Electrification Corporation
REST	Rural Electricity Supply Technologies
RET	Renewable Energy Technologies

RONAST	Royal Nepal Academy of Science & Technology
RVE	Remote Village Electrification
SEC	Solar Energy Centre
SHS	Solar Home Systems
SPV	Solar Photovoltaics
SSP	Solar Energy Support Program
SWERA	Solar & Wind Energy Resources Assessment
VESP	Village Energy Security Partnership
WBREDA	West Bengal Renewable Energy Development Agency

Executive Summary

The initial assessment report on India has a specific relevance because of following two reasons

1. Large number of population are without electricity: As per 2001 census in India, out of total 586000 villages, 140,000 villages are yet to be electrified and there is a national target of electrifying all these villages and households in next 5 years
2. India has a rich experience of utilizing renewable energy sources and thus renewable plays a crucial role for meeting the electrification target

The study also presents the case-study on Nepal that discusses some of the issues relevant for this assessment.

The data information in this report are updated as on February 2005 when the final draft was sent for review. Subsequent to this review, no updation has been incorporated.

Characterization of zone

Due to geographical vastness of the country and different categorization for poor, the study first characterizes the population and zone. Characterization of population has been done on the basis of Below Poverty Line (BPL)[1] and study focuses on BPL category only. (Here BPL category is considered as poor). Similarly the characterization of zone has been done keeping in mind the availability of renewable resources in different agro-climatic conditions. Two zones (i) Arid and Dry and (ii) Humid have been selected under this study and one representative state from each zone (i.e state Rajasthan from arid and dry zone and state Meghalaya from humid zone) is selected for in-depth analysis. In both the states a large percentage of poor are not connected to the grid.

Minimum energy requirement

Minimum energy requirement in different sectors such as residential, productive social/community services etc. have

[1] BPL is an absolute poverty line used by Government of India to define the poor. As per this definition expenditure capacity is the primary criteria for identifying poor

been assessed. In each energy sector, 2-3 critical requirement have been identified (which is given in table 3.3) based on previous adopted norms, primary survey, case studies etc. Minimum energy requirements for both states on the zones have been estimated and all the requirements have been prioritized. Supply options for meeting the energy requirement have also been identified. Several studies reveal that in residential sector biomass (traditional use) and kerosene are the major source of energy used for cooking and lighting purposes respectively. Impact of access to electricity in meeting the minimum energy requirement has also been assessed.
Several renewable energy technologies which are relevant for individual zone to meet the energy requirement have been identified and their compatibility with users have been categorized. (Shown in table 3.4a and 3.4b)

Assessment of different renewable energy technologies

Different renewable resources have been assessed on the basis of their potential and achievement. Resource assessment indicates that India is blessed with abundant renewable resources such as solar, wind, biomass, hydro etc. Resource assessment has also been carried out for two specific zones and shown in table 3.7.It is estimated that solar, wind and their hybridization could be the most suitable option for Rajasthan whereas there is an enormous scope for hydro and biomass resources in Meghalaya.

The report includes the assessment of different renewable energy technologies in terms of their technical and commercial maturity, reliability etc. (Shown in table 3.5). In this context each technological option such as solar, PV, biomass, mini and micro hydro, hybrid system etc has been discussed individually with level of maturity and reliability. In case of PV system, it is observed that though the technology is well established and field proven, the major drawback is its high initial cost (around $7335/kWp for solar PV mini-grid system) with replacement of battery in regular interval (around 5 years). In case of biomass gasification technology, it is noted that the current level of penetration is very less. Further, biomass gasifier based technology requires relatively stringent and specialized daily and seasonal O&M requirements. Yet another critical issue related to biomass technology is to ensure sustainable supply of biomass. Therefore community participation /mobilization and proper institutional arrangements etc. are the major concern. Similarly, in case of mini/micro hydro system, the level of penetration in India is not very high. Though hybrid system has the advantage of supplying reliable power for a relatively extended period, it is more in the pilot stage in India.

Case studies

This report uses case studies extensively in order to address the following issues

- Technology options and their techno-commercial viability
- Management and community involvement in planning and implementation
- Institutional requirements including the regulatory and policy framework to bring RETs based distributed generation and supply of electricity into the mainstream of rural electrification planning
- Funding and financial mechanisms to bring RETs based services within the affordable and acceptable limits of the poor

A selection matrix for cast study has been prepared and those case studies are addressed which have high possibilities of replication and low overall complexity. The following case studies are briefly presented in the report

Case-study # 1	Use of biomass gasifier in cardamom drying in North-eastern states
Case-study # 2	Use of renewable energy technologies for island electrification in Sunderbans
Case-study # 3	Remote village electrification programme in Rajasthan based on SPV mini grids
Case-study # 4	SPV water pumping for agriculture in Punjab
Case-study # 5	Small hydro as an option for village electrification in Western Ghats
Case-study # 6	Implementation of Solar Home lighting Systems in rural India
Case-study # 7	Micro credit facility brings light to rural areas

In each case study, the requirement of the target population has been mentioned along with appropriate renewable energy technology, the percentage of population benefited out of it and the probability of replication. Almost all above-mentioned case studies (6 out of 7) have the large potential of replicability.

Assessment of capacities

The report discuses the existing capacities in terms of policies, framework, legislative, financial institution, technicality etc and also identifies the gaps for promotion of renewable energy. Different stakeholders responsible for promotion of renewable energy technologies have been identified and the capacity status associated with each stakeholder is discussed in table 3.17. The report also discusses (in the same table) different capacity development measures that are required for different stakeholders.

Identification of niches

The niches discussed here are based on specific feasibilities that have been carried out with an understanding that once successfully demonstrated, each of these applications will have potential for replication in similar situations. A niche selection matrix is prepared (shown in table 3.18) and the potential niches have been identified on the basis of following examples.

Niche # 1: Barangay (village) Manganese Hybrid PV - Wind Turbine battery charging System in the Philippines
Niche #2: Use of biomass gasifier for limekilns in Meghalaya
Niche #3: Biomass gasifier based Milk-cake making
Niche # 4: Dairy cooperative in rural Rajasthan to be facilitated by PV powered Milk-Testing Machine

The understanding of the "niche" is based on the condition that a "driver" should be identified in each feasibility around which either the economic or social development of the community takes place. In other words, the rural community is able to see a direct linkage between the particular RET application and their socio-economic development.

In each case, the appropriate technology adopted for meeting the energy demand for a particular application has been addressed.

Other programme such as Remote Village Electrification (RVE) programme of the MNES, Accelerated Rural Electrification Programme (AREP) of the REC/MoP, R&D programme of MNES, Externally aided projects related to rural electrification etc which have relevance with the current theme has also been discussed. The experience gained in these programme have been assessed and mentioned in table 3.24

Barriers to RET

The report discussed various existing barrier of RETs for market penetration. In this context, following observations have been made

- Due to lack of clear, long term and consistent policy for the promotion and utilisation of RETs, renewable energy fail to become part of overall mainstream energy planning at government level.
- The high initial cost of RETs is a barrier especially in the developing countries where income levels are low. Subsidies are essential in order to make RETs affordable to the users.
- The awareness about the new funding avenues (such as

Clean Development Mechanism and the Prototype Carbon Fund), which could be accessed for financing RE projects, is low.

- Lack of development of appropriate products based on assessment of local needs is limiting the use of renewable energy resources. The R&D efforts to develop/adapt specific RE products to meet the local market requirement are essential for successful RE programme

Policy outlines

Problem and its objective specific to RE sector in India have been identified and explained as follows

Problem definition	Objective	Policy outline
Individual policies and programmes for each renewable technology, with different set of agenda, targets and priorities often lead to competition within the sector and restrict mechanisms for harnessing the complete RE potential	A national policy for assessment, exploration and utilisation of renewable energy has been able to facilitate the use of most viable renewable option for a chosen project leading to a scenario where a substantial share of energy demand is met through renewable sources	▪ Assessing long term goal of concerned ministries and department and integrating them in developing an overall vision and target for the development of RE sector ▪ Ensuring similar investment and effort in all R&D of RETs in order to bring them to an equal level of maturity ▪ Assessment and capacity building of all important stakeholders to facilitate formulation as well as implementation of an integrated RE policy
The subsidies/incentives granted for promotion of RE technologies are unable to increase the competitiveness of renewable markets	Public-private partnerships have found RE to be technically and financially attractive business proposition and are able to work effectively	▪ Reflecting actual price of fossil fuels in market to make policy outlines reflecting RE more economically competitive ▪ Introducing performance based subsidies ▪ Introducing generation linked tax credit ▪ Indigenisation of RE technologies keeping social acceptance as critical instrument ▪ Continued R&D for technology maturity
Current RET implementation mechanisms are not making an impact on poverty reduction because they do not incorporate livelihood and income generation activities at local level	Energisation of villages based on RET projects has created enormous job opportunities for livelihood and improved quality of living standard of rural population	▪ Linking of RE service with poverty alleviation ▪ Linking rural development schemes with RET implementation programmes ▪ Capacity building of the local people and NGOs ▪ Participation of local population in execution of RE projects ▪ Availability of upgraded technologies to local craft/ industries ▪ Creation of market supply network for local craft/ industries ▪ Awareness creation about the possible opportunities of livelihood generation activities associated to electricity
The sustainability of RET projects could not be proved due to insufficient resource in terms of technical manpower, institutions and governance issues	Capacity building of all levels has resulted in a viable and competitive environment for promotion and success of RETs	▪ Empowering a range of decision makers, starting from user groups at village level (women self help groups, local governance units etc) to planning and program implementation bodies at district and state levels to understand the wide range of issues related to efficient use of RETs. ▪ Training of trainers (ToT) and others, using prepared/compiled training material and modules ▪ Creating a database and atlas of RE resources that can be accessed by all stakeholders to plan, prepare and implement an RE project ▪ Creating market-facilitation and enterprise- development organisations for RE ▪ Promoting joint R&D by industry and academic/ research institutions and technology ventures

Strategy outline for each specific objective has been assessed through stakeholder's reaction and is shown in table 4.6 to 4.9.

The study also presents some of the facts in line with the above discussion for Nepal. Being a very small country and similar socio-economic attributes, the entire country is considered as one zone. Biomass is the major source of energy. In Nepal, energy requirement in residential sector is mainly met through traditional fuel such as fuel wood, agricultural residue and animal dung (94% of the total consumption in the residential sector).

The critical energy requirement in productive sector are for water pumping for crop irrigation and for small scale income generating activities such as fish farming, poultry farming, cattle rearing etc. Water for drinking, street lighting and energy for public health center (PHC) are the requirements under the social/ community services.

Nepal is the second richest country of the world in water resources. It has abundant hydroelectric potential estimated to be as high as 83GW of which 42 GW is considered economically feasible. Nepal has immense potential of tapping solar energy. On an average the country has 6.9 sunshine hours per day totaling 2482 sunshine hours per year. The solar insolation here is estimated to be around 4.5 kWh/sqm/day. There is a potential of 1.3 million biogas plants in Nepal. People in this region have been using microhydro, biogas and solar PV based systems. But there is little exposure of other technologies such as biomass gasifier and wind based systems in this region

The report discusses the existing capacities and the necessary adjustment required in the existing system of subsidy for extensive use of RETs.

CHAPTER 1 Background

1.1 Eighty per cent of the total number that lack access to electricity, live in rural areas of South Asia and Sub-Saharan Africa, but with migration and population growth expected in urban centers over the coming decades, this proportion is expected to change. For example, among all developing countries, Bangladesh, with 80% electricity deprivation, is witnessing the highest annual urban population growth rate—5.9% in the year 2000 (UN Population Division 2001). The absence of employment opportunities in rural areas leading to rural-urban migration contributes to this growth rate—one that, in turn, perpetuates urban poverty due to the pressure created on already weak urban infrastructure systems.

1.2 India faces a similar predicament with non-access to electricity in rural areas being a major push factor for urban migration. Some 140,000 villages in India (out of a total of 586,000)[1] remain to be electrified—many more still, are officially electrified, but face brown-outs, black-outs, voltage fluctuation and, in some cases, have lost all semblance of being electrified. In Vietnam, 80% of the population lives in rural areas and about 20% of households have no access to electricity. Despite its aggressive grid based rural electrification program, there will remain over 3 million rural households without access to electricity in the year 2010. In this country, biomass supplied the largest share representing 71% of the total energy consumption (out of 30,745 ktoe) in 1998. In Cambodia, Lao PDR and Vietnam, 34 million people in rural and mountainous areas live without access to reliable electricity services[2]. A majority of these people are very poor with income of about $1 per day.

1.3 Though electricity is not the only energy requirement and is by no means a direct translation to rural energisation, it is very often the starting point of development. It seeds the process of development by facilitating education and connectivity with outside world through radio/ tape-recorder/TV. It is also the most versatile form of energy for use in various applications. It is estimated that energy for agriculture and rural living accounts for a small proportion of the total final energy demand of countries, but actual estimates are difficult to find.

[1] http://powermin.nic.in

[2] Nguyen Thi Kim Lien, Economic and social commission for asia and the pacific in regional semiar on commercialisation of biomass technology, 4-8 June 2001, Guangzhou, China

Fuel wood and crop residues are the main fuels for cooking and heating in households. They account for 80% of total households' energy supply. Agriculture accounts for 5%, energy for lighting is only 4% and industries are estimated to consume only less than 10% of total energy use.

1.4 Coming to the supply side, the region has abundant renewable resources that can be used for various applications. Most of the countries in the region have initiated the national level programme for harnessing these resources.

CHAPTER 2 Rationale and motivation

2.1 This initial assessment report for the GNESD focuses on India for two reasons- i) the country has a large unserved population in terms of grid electricity, (only 43.5% of the households have access to electricity), and ii) it has a rich experience of utilizing renewables for the benefit of the rural population. The study also presents the case-study on Nepal that discusses some of the issues relevant for this assessment.

2.2 Though Renewable Energy Technologies (RETs) have already proven themselves and made a niche in several applications relevant for enhancing energy access of the poor; they continue to suffer from issues related to i) technology options and their techno-commercial viability; ii) management and community involvement in planning and implementation; iii) institutional requirements, including the regulatory and policy framework to bring RETs based distributed generation and supply of electricity into the mainstream of rural electrification planning; and iv) funding and financial mechanisms to bring RETs based services within the affordable and acceptable limits of the poor.

2.3 In order to address the above issues, this report uses case-studies extensively as they have universally been found to be relevant for sharing of experiences and enhancing the acceptability of RETs. The case-studies in this report have served three main purposes:

1. those in the box are used to substantiate a particular discussion thread.
2. those in section 3.5 are used to highlight how RETs have been found to be relevant in specific cases and their potential for replicability in similar scenario.
3. those in section 3.7 are used to indicate that there exists a well-studied feasibility for utilizing RETs for socio-economic benefits of the target community.

Although most of the case-studies are from India, one case-study from the Philippines has also been taken. Philippines was included in the Energy Access I report of TERI.

CHAPTER 3 Initial assessment

3.1 Characterisation of population and zones

3.1.1 This study characterizes the population based on Below Poverty Line (BPL) estimation done for the census 2001[1]. BPL is an absolute poverty line used by Government of India to define the poor that segregates the entire population in two segments; Below Poverty Line (BPL) and Above Poverty Line (APL). This reference line has been made to benefit the poor with special schemes and programs and is refined before the start of each Five-Year Plan. For the present study, BPL-1997 definition that was used for the census 2001, has been adopted. As per this definition expenditure capacity is the primary criteria for identifying poor, unlike in 1992 when incomes of the individual family were the primary criteria. However, a nationwide survey conducted in the year 1999-2000 for BPL census adopted a scoreboard ranking system based on socio-economic indicators that included 13 indicators on which a family is ranked before identifying it as poor. Some of these are land holding, type of house, availability of clothing, food security, sanitation, consumer durable ownership, literacy status, etc[2]. The results of the survey are not yet adopted officially.

3.1.2 There are distinct advantages of using this characterization for the purpose of the current study- a) most of the subsidy and support schemes for the promotion and use of renewable energy devices in the country use BPL categorization[3] ; b) affordability of renewable based services by the poor is still an unresolved issue; BPL categorization that identifies expenditure capacity as a criteria is relevant in this case; c) National Statistical Survey Organization[4] presents the data on primary source of energy used for lighting in various categories of MPCE (monthly per capita expenditure). This data is one of the basic data that has been used in this study.

[1] http://planningcommission.nic.in/plans/planrel/fiveyr/10th/volume2/v2_ch3_2.pdf

[2] Rajesh Sinha, 'The poverty of statistics', Outlook 14 June 2004, pp34-35

[3] In 1997-98 Government's finance on solar home lighting system for general category was $120 while for BPL category it was $150

[4] NSSO 2001, 'Energy used by Indian households (1999/2000)', NSSO 55th round, New Delhi: Ministry of Statistics, Government of India, report no. 464 (55/1.1/6)

3.1.3 The characterization of zones has been done keeping in mind the dependence of availability of renewable resources in different agro-climatic conditions. The entire country is divided into zones representing six distinct agro-climatic conditions. These are – i) per humid, ii) humid, iii) moist sub-humid, iv) dry sub-humid, v) semi-arid, and vi) arid. Data pertaining to forest cover, cropping pattern, water table etc. is available as per this categorization (Appendix-1). There is another categorization based on the climatic conditions that is frequently used for designing energy efficient buildings in the country. Solar and wind resource data is categorized as per the six climatic zones- i) hot and dry, ii) warm and humid, iii) moderate, iv) cold and cloudy, v) cold and sunny, and vi) composite. [1] (Appendix-2). For the purpose of this study, the above two maps are superimposed on each other to identify regions that are common to both the sets of categories.

3.1.4 Subsequently two regions – A) arid and dry, B) humid- are selected for the scope of this study. One representative state from each of the two regions is used for final analysis. These are Rajasthan from A) and Meghalaya from B). The two chosen states represent two different dimensions of poverty as discussed in subsequent sections.

3.1.5 Rajasthan

Rajasthan in north-western India, with an area of 342,239 square kilometers, is one of the most dry and hot states in India. The state is divided into the hilly and rugged southeastern region and the barren northwestern Thar Desert. Rajasthan with its varied topography has a wide range of climatic conditions, which vary from extremely dry and arid in the western Thar deserts, to humid in the eastern and southeastern parts of the state. Summer everywhere, except in the Aravalli hills, is extreme with the mean maximum temperature being 42° C. There are severe hot winds that sweep across the state with dust storms, especially in the desert tract. In the winter the temperature is about 20° C. While southeastern Rajasthan experiences the southwest monsoon which brings 90 percent of the rainfall, the western deserts have scanty rainfall, with the average annual rainfall in the state being 100 millimeters or 4 inches. Rajasthan is a mineral rich state with rich deposits of zinc concentrates, emerald, garnet, gypsum, silver ore and mica. Small-scale industrial units numbering over 0.2 million have created an employment potential for over 0.8 million people.

In this state, the official BPL as per definition in section 3.1.1 is adopted from the MPCE class of less than $22 in rural areas and less than $45 in urban areas (Appendix-3). As per the

[1] 'Climatic zones and rural housing in India', 1988, Edited by N K Bansal and Gernot Minke 287p.

census 2001, there are a total of 1.578 million BPL families in this state out of 9.342 million. A recent survey in 100 hamlets (small clusters of families around the main village) of Udaipur[1] which is one of the developed districts of Rajasthan, indicated that more than 40% of people are below poverty line with average monthly per capita household expenditure of $10.

Rajasthan is characterised by high cost of basic services as more than 60% of the total area is desert with sparse population distribution. The agriculture sector largely depends on rainfall with severe drought. 50% of the total landholding continues to be small or marginal and cover only 10% of the cultivated area (Appendix-4). The poor quality of land and scarce irrigation facilities affect even the larger landholdings so that land inequality is compounded by ecological fragility. This results in low productivity making food security the primary concern[2].

The availability of potable water for human and livestock is also difficult. The Human Development Index[3] of Rajasthan is very low to a value of 0.56-0.66 with literacy rate of 36-55%. Social and economic structure of the state is also poor. Health care delivery system which is one of the basic needs of sustainable livelihood itself is abysmal, unregulated, too far with unqualified doctors (Box #1).

Box #1 Health care delivery in Rural Rajasthan: an indicator of poverty

The study was carried out to collect information on delivery of health care in rural India. Study area was poor rural area in Rajasthan and used a set of interlocking surveys to collect data on health and economic status, as well as the public and private provision of health care in 100 hamlets of Udaipur district between January 2002- August 2003. The continuous facility survey (CFS) was used for the weekly monitoring of the available facilities.

The households in the Udaipur survey are poor. In terms of measures of health, 80% of adult women and 27% of the adult men have hemoglobin levels below 12 grams per deciliters. Symptoms of disease were wide spread. Few people reported difficulty in physical activities that are required to earn a living in agriculture.

The average visit to medicinal facility is 0.54 times a month. The expenditure share for health care visit is highest for the poorest (15% MPCE) and lowest for the richest group (11% MPCE). The average household spends 7% of its budget on health.

Public Health care facilities

Official policy provides for one subcentre, staffed by one trained nurse for every 3,000 individuals. Primary Health Centres (PHCs) and Community Health Centres (CHCs) are supposed to be open six days a week, six hours a day. During the survey it was found that 45% of the medical personnel are absent in subcentres and aid post. Centres are closed for 56% of the time during regular opening hours. There were clearly better and worst facilities. The public facilities are open infrequently and unpredictably, leaving behind people to guess whether it is worth walking for over half an hour to cover the 1.4 miles that separate the average village from the closest public health facility.

Source: Abijit Banerjee, Augus Deaton and Esther Duflo, Economic and Political Weekly, February 28, 2004, pp 944-949.

[1] Abijit Banerjee, Augus Deaton and Esther Duflo, 'Health care delivery in Rural Rajasthan', Economic and Political Weekly, February 28, 2004, pp 944-949.
2 Pradeep Bhargava, 'Food security and public distribution system in Rajasthan' http://www.eldis.org/static/DOC9752.htm.
3 'Rajasthan Human Development Report' 2002, Published by Government of Rajasthan, 192p.

The report on financial status of rural poor of Rajasthan indicates that the poor borrow from various sources to meet their needs[1]. This study re-confirmed the earlier findings that health related expenses are one of the major causes of indebtedness amongst the poor (Box#2).

Box #2 Financial status of Rural Poor: A study in Udaipur District

The objective of the study was to understand the financial flows of the rural poor and to have an insight into their financial status. Continuous drought for the past few years have shifted source of income from agriculture to non agriculture enterprises. Most of the people go out to Udaipur to work in non farm enterprises. Many a times the income is in kind. It was found that poor borrow from local moneylender to meet their requirements while they stash away their savings in earthen pots. This was mainly because commercial bank loans are for productive assets compared to social consumption while maximum expenditure of rural households were health-related expenses that lead the poor to indebtedness. A combination of factors like information about income opportunities, accessible and cheap health care facilities, credit on affordable terms and awareness about the unnecessary expenses on social functions would help them in managing their money.

Source: M S Sriram & Smita Parhi, http://ideas.repec.org/p/iim/iimawp/2004-02-01.html

3.1.6 Meghalaya

Meghalaya is one of the states in the North East region of the country and is marked by uneven spatial distribution of population, attributed to the difficult hills and terrains. Overall, indigenous people account for over 30% of the total population. The general topography of this zone is mountainous, rugged and vast areas are inaccessible. During the summer the maximum temperature rises to about 36-38^o C whereas during December-January the temperature is at the lowest. Most of the hilly areas in the region experience temperature close to freezing point during the winter nights.

Agriculture is the dominant activity in Meghalaya with over 70% of the population engaged in farming and allied activities. The agriculture in the region remains rain fed and non-mechanised resulting in low cropping intensity. In spite of highly favorable conditions for both flow and lift irrigation, only a negligible area is under irrigation in the region.

The region's economy is characterized by low per capita income, low capital formation, inadequate infrastructure facilities, geographical isolation and communication bottleneck, unsustainable exploitation of natural resources, low progress in industrial field, lack of private sector investment and high unemployment rate among the relatively high literate people. Though the region is rich in natural resources in the form of hydro, oil and natural gas, low ash coal limestone and dolomite deposits; yet the development has not been commensurate with its rich resource base. The CMIE (Centre for Monitoring India's Economy) index of relative development of infrastructure[2]

1 M S Sriram & Smita Parhi, 'Financial status of Rural Poor: A study in Udaipur district', http://ideas.repec.org/p/iim/iimawp/2004-02-01.html.

2 It is based on road network, percentage of villages connected by metal road, power generation capacity, percentage of villages electrified, percentage of gross cropped area irrigated, number of medical institutions, number of schools, percentage of villages receiving safe drinking water

ranks the state below 15 among 25 states of India. Thus the overall development of infrastructure facilities has also been lagging in the state.

3.1.7 The North East region has been given a special focus for accelerated development. This region has high potential for small hydro and biomass based options. To off set the higher costs of infrastructure development in this region, the Central Financial Assistance for most RETs programmes is upto 90 per cent in all NE states. Ten per cent of the gross budgetary support for this sector is earmarked for NE states including Sikkim.

Table 3.1 Central finance assistance for the selected RETs[1]

Systems	**General area (GA)**	**Special Area (SA)**
Solar Home System (SHS)[2]	$188	$338
SPV power plants (stand-alone) with distribution line	$3155/kW	$5680/kW
Direct drive windmills	$445	$666 (for islands)
CFA for installation of Aero-Generators/Hybrid systems for community use and Direct use by Central/State Govt. Defence and paramilitary Forces etc.	75% of ex-works cost subject to a maximum of $4444/kW	90% of ex-works cost subject to a maximum of $5333/kW
Govt. sector SHP projects (upto 100kW)	90% of the project cost upto $1335/kW for N.E region, Sikkim, J&K, Himachal Pradesh& Uttaranchal 60% of the project cost upto $888/kW for hilly regions of all other states not considered in special area & Islands 40% of the project cost upto $445/kW for plain &other regions of all other states	
Biomass gasifier based village electrification	60% of the cost of $33333 for the basic package of 50 kW project	90% of the cost of $33333 for the basic package of 50 kW project

1. The CFA for SPV system is based on the cost, which includes supply of system at the site, installation, commissioning and AMC (Annual Maintenance Contract) for 2 years including replaceable guarantee for parts and components such as battery, electronics, lamps etc. For PV modules, the replaceable guarantee is for 10 years.
2. CFA for SPV for general areas: 50% of the cost subject to a maximum as mentioned above.
3. CFA for SPV for special areas (The state of North-East, Sikkim, Special Category states (Jammu & Kashmir, Himachal Pradesh, Uttaranchal)& Unelectrified Islands): 90% of the cost subject to a maximum as mentioned above.
4. CFA for installation of windmills: 50% of ex-works cost of windmills, except for unelectrified Islands for which upto 90% of ex-works cost, subject to the upper limits as mentioned above.
5. 50kW project covers biomass gasifier system, housing and local distribution. Provision of additional $3333 per 50kW plant and AMC for a period of 5 years has made in order to ensure regular availability of biomass, provision for collection, processing and storage and O&M.

[1] MNES annual report 2004
[2] Only one model is considered i.e Model 4 (74W module, 2 lights, 1 fan)

3.1.8 Electrification data of the two states shows that only 54.7% and 42.7% of households are being electrified in Rajasthan and Meghalaya respectively[1,2]. Poor population having access to electricity has been computed using the NSSO data and is given in table 3.2. As said earlier, this computation is based on the MPCE class which in itself is very low in selected states. There is sizeable population that has more expenditure capacity, but is considered to be generally poor in terms of lack of basic amenities as per the survey. The growth rate has not been computed here because the two consecutive BPL census (1992 and 1997) used different benchmarks (income and expenditure) making the comparison difficult.

Table 3.2 Electrification status of low-income population

Type	Rajasthan	Meghalaya
Urban		
Grid connected hhs	1267643 (58%)	46190 (51%)
Not connected hhs	917948 (42%)	44378 (49%)
Rural communities		
Isolated		
Grid connected hhs	3220516 (45 %)	135168 (41%)
Not connected hhs	3936187 (55 %)	194510 (59%)
Rural dispersed	NA	NA

3.1.9 The above table indicates that large percentage of poor both in urban and in rural areas are not connected to the grid.

3.2 Needs and energy requirements

3.2.1 Energy requirements have been assessed under residential, productive and social/ community services. Under each of the above three categories, 2-3 critical requirements have been identified based on the previously adopted norms, primary survey or case-studies. Accordingly, energy requirements in residential sector are mainly for cooking, lighting, space heating and cattle feed preparation. Among these, cooking and lighting are major energy consuming activities and use biomass, kerosene, Liquid Petroleum Gas (LPG) or electrical energy. Biomass meets cooking energy demand (75% of total energy consumption) in residential sector while kerosene is serving mainly for lighting needs (51% of rural households) in the absence of electricity[3]. The figures are no different for the

[1] 'Census of India 2001 : Provisional Population total', Government of India, 184p
[2] 'Census of India 2001: tables on houses, household amenities and assets', Government of India,522p
[3] NSSO 2001, 'Energy used by Indian households' (1999/2000), NSSO 55th round, New Delhi: Ministry of Statistics, Government of India, report no. 464 (55/1.1/6)

identified states. Seventy eight (78%) and 81% of households use firewood for cooking energy in Rajasthan and Meghalaya respectively, while the share of households to use kerosene is 44% and 56% (Appendix-5).

3.2.2 The energy scenario of rural Rajasthan is very poor. Women undergo a lot of drudgery even to meet their daily cooking energy needs. A study in 1,989 households in 13 villages of Rajasthan confirmed that unavailability of kerosene is reason for not using modern energy rather than non-affordability[1].

Box#3 Unavailability of clean fuels, women hardship and health impacts in rural Rajasthan

Rural energy occupies centre stage in rural development issues and cooking energy holds major share in household energy consumption. A survey covering 6,403 females and 5,552 males from 1,989 households in 133 villages revealed that women undergo a lot of drudgery due to the use of bio-fuels. Almost 99% of households in rural areas of Rajasthan use bio-fuels for cooking. The majority 87% use fuel-wood while dung cake and crop residues are used in 84% and 27% of households. The daily average energy consumption is about 4.3 kg per household. They walk approximately 2.5 km to collect the fuel. About 50 hr per month per household are expended in fuel-wood collection. The use of kerosene is negligible in these areas because of unavailability more than un-affordability. The people are willing to pay for kerosene, the next clean fuel in the energy ladder. Therefore there is a need to meet the unmet demand by addressing market failures.

Source: Vijay Laxmi, Jyoti Parikh, Shyam Karmakar and Pramod Dabrase, Energy for Sustainable Development, Volume 7, no-1, 2003, pp 50-68.

3.2.3 In the productive sector, water pumping for crop irrigation and small-scale income generating activities have been identified as critical requirements. Water for drinking, street lighting and primary health care are the requirements under the social/ community services. [2]

Following sections discuss various approaches for estimating energy requirements in different sectors.

3.2.4 Electricity access to BPL

There have been several programs in India to estimate and provide electricity to poor. Kutir Jyoti programme meant for providing single light point to BPL families is one such programme[3]. Though energy requirement and electrification level of the rural poor households could be linked with number of Kutir Jyoti connection, it does not give a clear picture as it does not include the urban poor and does not reflect the actual energy requirements of the poor. Recently, the rural electrification target under the Electricity Act 2003, specify that

[1] Vijay Laxmi, Jyoti Parikh, Shyam Karmakar and Pramod Dabrase, 'Household energy, women hardship and health impacts in rural Rajasthan, India: need for sustainable energy solution', Energy for Sustainable Development, 7 (2003) pp 50-68.

[2] Specific surveys for the purpose of identifying renewables based income generation activities have been done in the two studied states. These are discussed as case –studies for the purpose of identifying niches for renewables in the section 3.7

[3] TERI 2003, 'Impact of power sector reform on poor: a case study of South and South East Asia', New Delhi: The Energy and Resources Institute. 60pp. TERI report no. 2002RT45.

at least one unit of electricity per day should be provided to all households below poverty line.

3.2.5 As surveyed in Rajasthan

According to a recent household level survey conducted in 36 unelectrified villages in Karauli district of Rajasthan (one of the most backward districts) to assess the minimum electricity requirement of rural households; 33% need two light points (295 households out of 869 surveyed households) and 67% of households need two light points with TV /fan (574 out of 869 hhs) as domestic load[1]. The survey indicated clear preference for enhanced lighting for domestic chores. Drinking water, street lighting and flourmill were other requirements of these villagers.

3.2.6 As surveyed in Meghalaya

Survey carried out in seven villages of Meghalaya for the estimation of energy requirements and biomass potential indicated that the maximum electricity requirement for villages varies between 0.26-0.48 kW per household with a requirement of 3 light points depending on the size and number of clusters in a village. It was found that cooking and space heating are the dominant energy end use in Meghalaya[2]. Firewood obtained during yearly biomass weed clearing, forests residues and bamboo are utilised for cooking and space heating. A typical household consumes 12-20 kg of firewood daily for cooking and 25 kg per day firewood for space heating during the winter months. Kerosene is used for lighting and the devices commonly used in the village are wick lamps, lanterns etc. The monthly consumption of kerosene in the villages ranges from 5-10 litre/family depending on the household size. It was found that the villagers are willing to pay only $0.4- $0.6 per month for the electricity for lighting. Lime processing, turmeric boiling and bakery are the small-scale industry clusters which are found in almost all part of the state. In these industries heat is used during processing.

3.2.7 Normative energy requirements

The Ministry of Non-conventional Energy Sources (MNES) has estimated typical energy requirements of a village for the purpose of launching Village Energy Security Programme (VESP)[3] to meet the national targets of complete village electrification by 2007 and complete household electrification

[1] TERI 2004, 'Feasibility studies and survey of 36 unelectrified remote villages in district Karauli of Rajasthan', New Delhi: The Energy and Resources Institute. 56pp. TERI report no. 2004RT21.
[2] TERI 2003, 'Potential assessment of biomass gasifier for various applications in north eastern states', New Delhi: The Energy and Resources Institute. 155pp. TERI report no. 2002BE61.
[3] 'Outline plan for creating energy security in villages through biomass', April 2004, MNES, Government of India, New Delhi.

by 2010. A typical size of 100 household has been considered for this purpose. The study assumes that provision for 2 light points per household and 100 Watt power to about 30% household for entertainment would meet the domestic load requirement of a remote village. While three pumps of 3.75 kW each for irrigational and drinking water purposes and 500 W for other community services with strict load management has been set as minimal energy requirement for community services. Some of these community services are fan and light for school, small shops, fixed operational hrs for other rural industry applications like flour mill etc.

3.2.8 Energy requirement for supply of drinking water

The minimum need of drinking water supply has been specified as 40 liters per capita per day (LCPD) with in walking distance of 1.6 km or elevation difference of 100 meters in hilly areas[1]. There should be at least one handpump /spot-source for every 250 person. If there is additional drinking water need for cattle feed, it is proposed to be met through rain-water harvesting structures/spot sources. For an average village of 500 population (5 persons per household and 100 households per village), one energized pump rated 3.75 kW is considered. The Remote Village Electrification (RVE) programme of the MNES envisages the use of one Solar PV driven pumping system for the supply of drinking water[2].

3.2.9 Agricultural requirements

Typical practice in India is to use a minimum of 5 Hp pump for agricultural purposes. Five to ten Hp rating pumps are required for irrigating over 2-4 ha of land which is an average land holding in India[3]. There is a variation of pump size as the water table (head) and quantity of underground water available is not same in all regions. For example Rajasthan being in the extreme dry zone, has very deep water table and therefore pump of higher rating is required to draw same amount of water below 50 meter (Box#4).

Box#4. SPV water pumping for small farmers

About 200 solar PV water pumping systems, based on special PV DC-floating system, have been installed in the past seven years. The system was developed by Polyene Group of Industries in conjunction with a German firm, Hydrasol to meet the water requirements of the small/ marginal farmer from open wells/ canals. A 860 watts (1.15 Hp) PV DC floating pump system is capable of giving water discharge of 120,000 litres over the day at a head of 7 metres. System meets the requirements of small farmers as the average land holding of small farmers is about 1-1.5 ha.

Source: "Renewable Energy Technologies: applications to industries and agriculture", Edited by C Palaniappan, Ajit Kumar Kolkar and T M Haridasan, Proceedings of the Millenium International conference on renewable energy technologies, 9-11 Feb 2000.

[1] TEDDY 2002/2003, published by The Energy and Resources Institute, New Delhi, India, 503p.

[2] http://planningcommission.nic.in/plans/planrel/fiveyr/welcome.html.

[3] National Sample Survey Organisation (1997), "Operational Land Holdings in India, 1991-92 -Salient Features", Report no. 407, Government of India, New Delhi.

3.2.10 To summarize the above, the minimum requirement for a village in India has been estimated as mentioned in the table 3.3. Several renewable energy technologies are relevant for energy requirements of the poor, tables 3.4a and 3.4b lists them according to the identified needs in the states of Rajasthan and Meghalaya. A brief description of these systems follows in next section.

Table 3.3 Minimum energy requirements for villages in India

Category	Type of Requirements	Energy requirements	Group	Impact (*)	Priority (*)
Residential	Electricity for lighting and other domestic requirements, particularly for entertainment	150 W/hh	All	Improving the living standard, educational status, fostering lighting based income generation activities etc	High for lighting Medium for entertainment
Productive	Water pumping for crop irrigation	7.00 kW/village[1]	Rural	Increased food production with increased income	High
	Small scale industry	5.0 kW/village	All	Increased income	Very High
Social/Community Services	Water for drinking	3.75 kW/village	All	Meeting the minimum requirement of livelihood, safety, social gathering	Very High
	Street lighting	0.5 kW/village	All		Medium
	Primary health center	250W	All		Very High

Table 3.4a Energy technologies and requirements for zone – Rajasthan

Category	Requirements	Renewable Technologies	Compatibility with users (*)	Competing non-renewable
Residential	Lighting for reading Entertainment Information dissemination	Solar PV, Wind, biomass gasifier, PV/wind hybrid	H (PV), L (all others)	Kerosene, candles, battery
Productive	Water pumping for crop irrigation Small scale industry	Wind, Biomass gasifier, solar PV(where water table is not very deep) Biomass gasifier, PV	H (PV), L (all others)	Diesel generator
Social/ Community Services	Primary health center Street lights Drinking water Light for community hall	PV, biomass gasifier, hybrid	H (PV), L (all others)	Nil

[1] 7 kW load is required for irrigating 4 ha of land. Depending upon the land size load will be different.

Table 3.4b Energy technologies and requirements for zone – Meghalaya

Category	Requirements	Renewable Technologies	Compatibility with users (*)	Competing non-renewable
Residential	Lightning for reading Entertainment Information dissemination	Small hydro Biomass Solar PV	H (all others), L (biomass)	Kerosene, candles, battery
Productive	Water pumping for crop irrigation Small scale industry	Small hydro Biomass	H (all others), L (biomass)	Diesel generator
Social/ Community Services	Refrigeration for vaccine conservation Street lights Drinking water Light for community hall	Small hydro Biomass Solar PV	H (all others), L (biomass)	Nil

(*) H = high; M = medium; L = low

3.3 Technologies

This section presents an assessment of the appropriate renewable technologies in terms of their technical and commercial maturity.

3.3.1 Technological options

Solar PV, biomass , hybrids and mini-micro hydro are the technological options that are discussed here.

3.3.2 Solar Photovoltaics

It operates on the conversion of sunlight to DC electricity. The electrical energy thus produced is either used directly e.g. for driving a motor-pump unit for pumping water, or stored in batteries for later use. The use of SPV has been well accepted in rural electrification applications. Types of SPV systems that are commonly used for rural applications and their typical configurations are described below:

Solar Home System (SHS): It consists of a single PV module of 18- 75 Wp capacity; a deep discharge type lead acid battery; charge controller; 1, 2 or 3 CFLs (compact fluorescent lamps); and a DC power point for another appliance such as radio, tape recorder. The module generates energy that is stored in the battery and can be used at any time of the day. Usually, the module life is in excess of 20 years; however, the battery needs to be changed in 4-5 years. The biggest challenge for spreading the SHS market to rural remote areas is related to the after sales service and availability of spares, particularly for electronic components in charge controller and luminaries. These components often malfunction and their reliability is considered poor.

Small capacity village power plants or mini-grids: In villages where households are not very spread out, power plants or mini-grids are a preferred configuration as they have the option of supplying AC electricity that can be used for various domestic and commercial applications. A mini-grid refers to small power plants that supply 220 volts 50 Hz three-phase AC electricity through low-tension distribution networks to households for domestic power, commercial (e.g. shops, cycle repair shops, flour mills) activities, and community requirements such as drinking water supply and street lighting. They use state-of-the-art batteries and inverters to ensure long life and reliable field performance. In the users' perception, it also has all the features of grid power supply, e.g. substation, overhead Low Tension (LT) lines, service connections, tariff structure etc., that brings it close to the conventional power supply system. An appropriately designed mini-grid can easily supply power for 8-10 hrs daily. Though there is no limit on the capacity of the mini-grid, SPV based mini-grids are typically in the range of 25-100 kWp, however in Rajasthan, 10 kWp capacity mini-grids are also installed. The installation, operation and O&M of these mini-grids are normally contracted on a turnkey basis to the PV supplier. At the local level, the village community is expected to play a critical role in facilitating payment collection, monitoring of theft, complaint redress etc.

Water pumping system: Pumping of water is one application which does not require battery storage. In this system, PV modules are directly coupled to motor-pump unit and water is pumped as long as the sun shines. There are several system designs based on various types of motor and pump sets. The most commonly used ones in India are 900 or 1800 Wp DC surface and AC submersible motor-pumpsets. These pumps are suitable for both drinking and irrigational requirement.

3.3.3 Biomass gasification

Biomass gasification is the process through which biomass fuels can be converted into producer gas. Biomass is plant matter such as trees, grasses, agriculture crops etc. Biomass is a renewable source of energy; it can be used as a solid fuel, or converted into liquid or gaseous forms, for the production of electric power or heat. Electricity from biomass can be produced in two ways:

- *Steam cycle route:* Biomass fuel is burned in a boiler to produce steam; the steam then turns a turbine, which is connected to the generator. This method is used for large capacity plants (MW range).
- *Biomass gasification route:* Biomass is converted (thermo-chemical process) into a fuel gas (called producer gas)1 in a reactor or biomass gasifier. The producer gas, after undergoing cleaning, can then be used in an internal combustion engine for producing electricity. This method is preferred for small capacity plants (kW range).

[1] Producer gas is a low calorific value gas (1000-1200 kcal/Nm^3). It consists of combustible gases — CO, H_2, CH_4; and inert gases —CO_2, N_2

In remote, geographically scattered, unelectrified villages large capacity steam cycle plants are not relevant. Biomass gasifier power plants are of two types:

Dual fuel engine based: In these, producer gas is used in diesel engine under dual fuel mode (i.e. fuel-mix is a mixture of diesel and producer gas), resulting in up to 80% replacement of diesel by producer gas. The smallest capacity of dual fuel system tried in India is 3.75 kW, while the largest plant is of 500 kW capacity; majority of the systems have capacities ranging between 50 to 150 kW.

100% producer gas engine based: Recently, focus has shifted to developing biomass power plants, which do not consume diesel for operation and operate solely on producer gas. In such system, spark-ignited engines (natural gas or modified diesel engine) are used. Various Indian institutions are engaged in the development of this technology; The Indian experience in biomass gasifier based village electrification projects is limited to about 10 pilot projects. These operate on a fuel mix that consists of about 30% of diesel and 70% of producer gas. Different types of biomass fuels e.g. fuel wood, coconut shells, rice husk, Ipomea, Lantana etc. have been used. The specific wood consumption (dual fuel systems) has been reported to range between 1.0 -1.4 kg/kWh.

Sustainable supply of biomass is perhaps the most important factor while opting for biomass power for village electrification. For forest based or agriculturally prosperous villages, biomass supply (at least in the short term) is usually assured. However, for long-term sustainability of biomass power projects (particularly for states like Rajasthan), dedicated energy plantations for supplying biomass becomes important. For example, in semi-arid regions, 4-8 tons of biomass (*Prosopis juliflora*) can be produced per hectare per year. The annual wood demand for a small (20 kW) biomass power plant (serving about 50 households and producing 100 kWh daily) is estimated about 50 tons; which will require energy plantation of about 10 hectares.

3.3.4 Wind/ PV hybrid systems

In order to maximize the benefits of the complementary nature of solar and wind resources, and to optimize the cost of systems, hybrid is a viable option. The combined capacities of the wind generator and solar module are able to generate required energy at costs lower than that of solar PV alone. Hybrids have the advantage of supplying energy for longer duration as batteries are constantly receiving charge both from the wind and from the sun. A few systems are currently in operation in various institutions in the country.

3.3.5 Mini and micro hydro

Small Hydro Power can be divided broadly into three categories Micro (less than 100kW), Mini (100kW-1MW) and Small (1MW-25MW) hydro. Micro hydro systems are generally stand-alone systems, i.e. they are not connected to the electricity grid.

Micro-hydro systems operate by diverting part of the river flow through a penstock (or pipe) and a turbine, which drives a generator to produce electricity. The water then flows back into the river through a civil construction known as the tail race. Micro-hydro systems are mostly "run of the river" systems, which do not envisage construction of reservoirs or dams. This is preferable from environmental point of view as seasonal river flow patterns downstream are not affected and there is no flooding of valleys upstream of the system. A further implication is that the power output of the system is not determined by controlling the flow of the river, but instead the turbine operates when there is water flow and the output power is regulated or governed. The systems can be built locally at low cost, and the simplicity gives rise to better long-term reliability. Micro-hydro systems are particularly suitable as remote area power supplies for rural and isolated communities, as an economic alternative to extending the electricity grid. The systems provide a source of cheap, independent and continuous power, without degrading the environment. The power available at a typical hydro site is due to the discharge and the head available.

3.3.6 Maturity and reliability of technology

SPV technology has been well established with about 1.73 MWp grid connected and 790 kWe offgrid power generating systems till March 2004. Other than this, there are about 11,70,000 lighting systems of all types that are currently operational[1]. Though the technology is one of the most matured among renewables, the field reliability of SPV systems critically depends on the level of after sales service infrastructure that is available. This becomes particularly challenging in rural remote areas where, on one hand, the logistics of supply, transportation, stocking etc. are unfavourable; on the other, thin market volumes do not justify investments in after sales service network either by the supplier (public or private sector industry) or by the provider (government set-up). Another problem is the replacement cost of the battery, which is often considered very high by the rural poor households. In fact in many cases, the systems are found to be abandoned for want of battery replacement.

The above problems related to SHS are partially taken care of in mini-grids where the main equipment is housed centrally in a building and hence, is operated and maintained centrally. However, O&M requirements include maintaining the LT

[1] upto march 2004. Source: MNES

network and centralized battery bank, switching on and off the plant as well as monitoring the overdraw/theft of electricity. Yet another challenge is associated with the supply and servicing of energy efficient AC devices such as lamps, fans etc. Unlike SHS which is a DC system and hence only DC devices can be used, mini-grids supply single phase AC and can, theoretically, use all AC devices that are available in any local market. However, this practice is not followed because of the limited and expensive energy that is available from the SPV mini-grid. In order to ensure a good demand side management practice, the service company provides CFL lamps and other energy efficient AC devices to the users initially, which in most cases is the government contractor or its sub-contractor. It is yet to be seen how effective the service company will be in providing the spares and other services, and how willing the community would be in buying expensive spares. Thus this arrangement for management and O&M of mini-grid is as vulnerable to the after sales service network as the SHS market is. Besides, the cost of replacement of battery bank is still an issue that is often overlooked at initial planning stages.

As far as biomass technology is concerned, the sheer lack of experience itself is a challenge in adopting this technology for rural electrification. Though the problem of battery replacement is not faced in biomas gasifier mini-grid, the reliability of the system of biomas supply (not only its availability in the region, its processing, transporting, storage etc) itself is a challenge. Further, the biomas gasifier mini-grid being a combination of mechanical, thermo-chemical and electrical systems, requires a more stringent and specialized daily and seasonal O&M requirements, as compared to SPV mini-grid, which is predominantly an electrical system. Other challenge is the supply of diesel in such remote areas for gasifier on dual fuel mode.

Lack of experience is also one of the challenges in the case of wind/PV hybrid.

In case of mini-micro hydro systems, river should be perennial in order to ensure continuous flow of water. Non-availability of such data may prove the system to be redundant after some time. Such data is very difficult to obtain and the government is now initiating the process through the nodal agencies in various states. Another concern of small hydro projects is that since there is no reservoir, the system may have a lesser power output in the lean season. Being the most important features, the design of the electro mechanical components should be accurate and well fabricated. The Electronic load controllers are to be made more rugged to the local weather conditions. Table 3.5 summarizes the above discussion.

Table 3.5 Status of various renewable energy technologies in India

Technologies (from table 3.4a and 3.4b)	Degree of maturity	Degree of penetration	Advantages	Disadvantages	Minimum requirements for application	Cost[1]in $
Small Hydro	High	Medium	Low cost structure (installation and O&M), easy maintenance, indigenous manufacturing of all components, low energy cost	Very less power in lean period, most hydro sites are inaccessible	For 1kW, if head is 30m then minimum flow rate should be 4lit/sec[2]	$2500-3000/kW
Solar PV (minigrid)	High	High	Negligible O&M cost, easy maintenance, environment friendly, Easy installation, certainty in availability of resources	High initial investment, battery replacement in interval of around 5 years	Min 4-4.5 kWh/sq.m/day of solar insolation[3]	$7335-7780/ kW
Biomass gasifier	Medium	Low	Low cost of installation, local manufacturing of all components, low energy cost	Community mobilization is needed,	1.5-2 kg of biomass for producing one unit of electricity	$2225-2250/kW
Wind mills	High	Medium			Start up wind speed of 2.5-3 m/s	$2225-2250/kW for small aero generator

3.4 Assessment of renewable resources

India's fossil fuel resources are limited in comparison to global reserves but abundant renewable resources bless the country. Though the resources are not yet been fully assessed or adequately tapped, the country has the policy framework in place for assessment, technology development and implementation to tap the potential of renewable energy. The national potential and achievements are been given in table below.

Table 3.6 Renewable energy potential and current achievements

Technology	Unit	Potential	Achievement[4]
A. Power from Renewable			
Wind power	MW	45000	2483
Small hydro power (up to 25 MW)	MW	15000	1603
Biomass power/ cogeneration	MW	19500	613
Biomass gasifiers	MW		58
Energy Recovery from wastes	MWe	1700	41.50
Solar PV	MWp	20 mW/ sq. km	3.87

[1] Cost includes installation, distribution networking and commissioning of the power plant.
[2] Required power depends upon the combination of head and flow rate.
[3] to produce reasonable power with better efficiency.
[4] Upto March 2004.

Technology	Unit	Potential	Achievement[4]
B. Decentralised energy systems			
Family size biogas plants	Lakhs	120	36.5
CBP/IBP Plants	Nos.	-	3902*
Improved chulhas	Crores	12	3.39
Solar PV	MW/sq km	20	
– Solar street lighting	Nos		52102
– Home lighting systems	Nos		307763
– Solar lanterns	Nos		509894*
– SPV power plants	KWp		1791
Solar water heating systems	(million sq m collector area)	140	0.80
Solar cookers –	Nos	-	555000
Solar PV pumps	Nos	-	6414
Wind Pumps	Nos	-	854
Hybrid systems	kW	-	552.86

*upto march 2003
SOURCE CBP: Community biogas Plants, IBP: Institutional Biogas Plants,
1 Lakh = 100,000, 1 Crore = 10,000,000

3.4.1 India receives 5000 trillion kWh of solar energy annually, and is characterized by230-300 sunny days in an year. Average daily solar radiation incident over the land area is in the range of 4-7kWh/sq.m. It is estimated that if only 1% of the total land area (2.3 million sq. km) is used to harness the solar energy incident upon it then even with net 2% of conversion efficiency; 600,000MW of power can be produced. This translates into an SPV power generation potential of 20 MW/sq. km. Similarly availability of wind resources throughout the country has been checked and in 10 states wind potential has been observed. The gross wind potential in the country is found to be 45195 MW which is based on assuming 1% of land availability for wind power generation in potential sites. An annual mean wind power density greater than 150 W/m^2 has been recorded at 219 wind monitoring stations covering sites in 13 States and Union Territories.

3.4.2 As against the potential of the order of 19,500 MW, which includes around 3,500 MW of surplus power from bagasse based co-generation and 16,000 MW of grid quality power from surplus biomass material, a capacity of 613 MW has been commissioned and 644 MW capacity is under implementation till march 2004. Though currently there is no biomass resource atlas available for India but some southern states of India such as Tamil Nadu, Andhra Pradesh and Karnataka have been leading in this sector. Studies and survey indicate biomass potential in other states also.

As against the overall small Hydro potential of 15,000MW, 10,324 MW has been identified in 4233 potential sites. A capacity of 1603 MW has so far been installed and an additional 454MW is under installation. Himachal Pradesh, Jammu and Kashmir, Uttaranchal and Arunachal Pradesh are the states with maximum small hydro potential. In Meghalaya 98 potential sites have been identified with estimated capacities of 181MW.

State wise renewable resources are discussed below (Table 3.7)

3.4.3 Solar

Most parts of Rajasthan get about 250-300 sunny days and the average solar radiation incident over the land area is in the range of 5-7kWh/sq.m/day. Hot wind generally sweeps across the state particularly in the western region of Rajasthan. Even the other part of Rajasthan experience hot wind for 4-5 months in a year. Therefore, solar PV based system or its hybridization with wind could be a good option. Though solar insolation in Meghalaya is not very impressive (total radiation varies from 4-5.4kWh/sq.m/day), but it could be an ideal option for small-scattered load.

3.4.4 Wind

As estimated, Rajasthan has a gross wind potential of 5400MW. There is no wind data available for Meghalaya though 3 sites have been identified as probable windy sites in Meghalaya.

3.4.5 Biomass

There is over 20 million tonnes of biomass available in Rajasthan, which could be a very good source for power generation. Though at present the penetration of Biomass gasifier based power plant is low in Rajasthan; it has a good potential as forest based as well as crop residue based resources are available in certain parts of the states. People in this region have been using solar PV based systems. But there is little exposure of other technologies. Data and field survey of Meghalaya indicate that the production of crop residue in the village is very low. Small quantities that are obtained, is either left in the field or utilized as pig feeds. All the forest in the villages is unclassified (not classified whether dense forest, normal forest or others) state forest, comprising of bamboo and other tree species. Primary survey in the villages indicates that about 50-60% of the geographical area of all villages comprises of forests. Estimation based on the above discussion shows that the availability of surplus biomass is about 712 tons/year.

3.4.6 Hydro

With an estimated potential of 181 MW, there is an enormous scope for using small hydro-based power generation in Meghalaya.

Table 3.7 Renewable resources in selected zones

Climatic/Phyto-geographical zones Resource	Zone A): Rajasthan	Zone B): Meghalaya
Solar 1. Direct	Minimum direct radiation of 3.7 kWh/ sq.m /day in the month of December and January and maximum of 5.2 kWh/ sq.m /day in the month of April and May	Minimum direct radiation of 2.5 kWh/ sq.m /day in the month of December and January and maximum of 3.4 kWh/ sq.m /day in the month of April and May
2. Total (direct+ diffuse)	Minimum total radiation of 4.6 kWh/ sq.m /day in the month of December and January and maximum of 7.4 kWh/ sq.m /day in the month of April and May	Minimum total radiation of 4.0 kWh/sq.m/day in the month of December and January and maximum of 5.4 kWh/sq.m/day in the month of April and May
Wind[1]	Minimum annual wind speed of 20m/s at 30m height and minimum wind power density of 260W/m2 at 50 m height.	Data is not available.
Biomass	0.72 million tonnes (Bagasse) 0.23 million tonnes (rice husk) 0.19 million tonnes (ground nuts) 0.09million tonnes (cotton waste) 20 million tonnes (agro residue)	Surplus biomass availability for power production is about 712 ton/yr

SOURCE: 'Solar radiation over India' Anna Mani and S Rangarajan, www.mnes.nic.in , www.windpowerindia.com

3.5 Case studies

The analysis till now presents the following:

- Selected zones- Rajasthan and Meghalaya represent two different dimensions of poverty.
- Basic energy requirements are for- (i) improved lighting and communications at residential level, (ii) agricultural pumping and power for small scale industries at productive level and (iii) drinking water, health etc. at community level.
- Identified suitable technologies are – Solar PV, Small hydro and biomass gasifier.

Based on the above, the case studies have been chosen that cover all of the above aspects. The selection matrix of the case studies is given below and following case studies are briefly presented in this section:

[1] Data is obtained from the wind monitoring station of the potential sites (for the stations having wind power density > 200w/m2 at 50 m height) in the state. In Rajasthan there are 7 such monitoring stations.

Case-study # 1 Use of biomass gasifier in cardamom drying in North-eastern states
Case-study # 2 Use of renewable energy technologies for island electrification in Sunderbans
Case-study # 3 Remote village electrification programme in Rajasthan based on SPV mini grids
Case-study # 4 SPV water pumping for agriculture in Punjab
Case-study # 5 Small hydro as an option for village electrification in Western Ghats
Case-study # 6 Implementation of Solar Home lighting Systems in rural India
Case-study # 7 Micro credit facility brings light to rural areas

Table 3.8 Case study selection matrix

Potential case studies **Criteria**	Case study 1	Case study 2	Case study 3	Case study 4	Case study 5	Case study 6	Case study 7
Representativeness							
Replicability	High	High	High	Medium	High	High	High
Potential population benefited	200hhs in a state	100% in two islands	100% Rural population of village	6414 pumps till march 2004	7 villages with 100% beneficiaries	Over 2533 till March 2003	Over 10000 sold till March 2003
Complexity	Low	Medium	Low	Low	Medium	Low	Low

3.5.1 Case study #1. Use of biomass gasifier for large cardamom drying in North Eastern states

The biomass gasifier technology has been befitting more than 150 large cardamom growers of Sikkim in variety of ways. The case has special relevance to this study, as the activity was carried out in one of the North-Eastern states of India and Meghalaya is also a North Eastern state. Thus the technology developed, in concern with the problems and hindrances for suitability, adoption and promotion of renewable technologies in north-eastern states, will adequately suit the Meghalaya too.

Sikkim is the largest producer of large cardamom in world with total annual consumption of 20,000 metric tonnes of fuel wood. Actually, the highest large cardamom producers are small farmers who cannot afford high cost technologies. Moreover basic problems like difficulty of transportation in hilly areas and unelectrified villages do not leave space for choices to adopt modern technologies. The practice of burning of big logs of wet wood in traditional `*bhatti*' (oven made of blocks of stones and bricks) and passing the resulting smoke through a thick bed of cardamom placed on a mesh structure made of bamboo wiremesh is followed traditionally all over India for the drying of harvested produce[1].

[1] Sanjay Mande, Anil Kumar, V V N Kishore, 'A study of large cardamom curing chambers in Sikkim', Biomass & Bioenergy 16 (1999) 463-473.

The updraft gasifier system designed and developed by TERI[1], have an advantage of operation without electricity and easy transportation to hilly areas that are basic hurdles of technology adoption in hilly areas. The technology provides healthy working atmosphere to farmers by higher combustion efficiencies and smoke reduction that in turn saves 50-60% of fuelwood. The rich natural colour (reddish) of the fruit, 35% more oil content and absolutely no burnt smell[2] (common to the traditional product) is fetching 10-20% more price in local trading centres providing economical benefits to the gasifier users. Further, the systems have ability to dry large quantities of harvested produce in one cycle of lesser duration.

A low cost gasifier based systems for thermal applications such as the above, has potential for application in other rural industries like ginger, tobacco, cashew, etc. There are a variety of similar activities being carried out in North-Eastern part of India viz. lime processing, tea processing, arecanut processing, cashew nut processing, pottery making, fruit processing, turmeric boiling, ginger drying, yarn dyeing, large cardamom drying, etc. Out of these lime, cashew nut and fruit processing is carried out in Meghalaya. One of these applications is discussed in later section of this study.

Table 3.9 Data Case Study #1

Category	Requirement	Energy req.	Technology	% covered with RETs	Target population	Case study context
Productive	Use of biomass in for large cardamom drying	2-2.5 kg/kg of fresh cardamom (traditional) 0.8 kg/kg of fresh cardamom (updraft gasifier)	Biomass gasifier	58 MW have been installed under Govt. funding schemes till March 2004	*Rural*	Thermal applications for rural industries in humid zone

3.5.2 Case study # 2. Use of appropriate renewable technologies for island electrification in Sunderbans

There are about 24,500 villages, which have been identified by the Government of India as remote villages that cannot be electrified through grid electricity. The identified zones of the study, especially Meghalaya, consist of more than two thousand of such villages. The case study of Sunderban island electrification is a good example of electrifying such villages by renewable energy technologies. Sunderbans, is characterized by mangrove swamps and islands interwoven by a network of small

[1] TERI 1998, 'Design, development and fuel testing of an advanced large cardamom curing, chamber prototype for Sikkim', New Delhi: Tata Energy Research Institute. TERI report no. 1996RT52.
[2] Kusum Lata, Sanjay Mande and V V N Kishore, 'Studies on quality improvement of large cardamom using an advanced gasifier based dryer', Renewable energy technologies for new millennium, NREC-2000, 20-22 Dec 2000, pp303-309.

rivers, waterways etc. Due to its tough geographical terrain, it is very difficult to extend grid network to supply power to its population. Traditionally the majority of the population had been depending upon kerosene and diesel generating system to meet their electricity requirement. Because of its remoteness, cost of diesel and kerosene is also comparatively high. Therefore, WBREDA (the nodal agency of Ministry of Non-conventional Energy Sources for the state of West Bengal in eastern part of India), decided to electrify the islands with renewable technologies. A total of about ten biomass gasifier and solar PV power plants have been installed for the purpose in different islands of Sunderbans.

These plants are now meeting domestic and commercial demands of the villages. Electrification has improved the life style of villages, has created many more job opportunities and income generation activities. Drinking water, street lighting and primary heath services are no more a constraint of development for these villages. It has been revealed from a field survey[1] that running of an ice mill has created many job opportunities in the village after electrification through biomass gasifier based power plant. Increased business hours as a consequence of market place electrification has increased monthly turnover of about $20.47. The rural population of the island is now privileged by running of a hospital where operation can also be performed due to availability of continuous and reliable electric power. Vaccine preservation in medicine shop is also supporting this activity. Each electrified household and commercial unit saves about $2.67 on monthly electricity bill due to reduced cost of power generation by biomass gasifier in comparison to diesel generator.

The installation of solar power plants has also contributed to establishment of several commercial activities in villages. The villages now have a row of shops (cycle repairing, teashop, Public telephone booth, general provisions, medicine shop, jewellery shop with buffing machine etc.). Education is one attribute that has been facilitated by the electrification. One educational coaching centre is run by a girl at night that pays $2.6/month for monthly charges towards a single light connection and earns $12/month in return. There is a large demand of video show as there is no other source of entertainment. Some video parlours are run through on solar generated electricity. They invest around $0.8-1 in each show (hire charges for the video player, screen and energy charges) and earn $3-4 in return.

[1] Kakali Mukhopadhayay, 'An assessment of a biomass gasification based power plant in the Sunderbans', Biomass & Bioenergy 27 (2004) 253-264.

Table 3.10 Data Case Study #2

Category	Requirement	Energy req.	Technology	% covered with RETs	Target population	Case study context
Residential, Productive and community	Lighting for domestic purpose, Small shops, coaching center, Water pumping	5 kWh/m2/day (by SPV)	Solar PV	Two Islands of Sunderbans have been fully electrified	Rural isolated	Remote village electrification
Residential, Productive and community	Lighting for residential, Small shops and Hospital	1 kg/kWh (by biomass gasifier)	Biomass gasifier	100% (whole village)	Rural isolated	Remote village electrification

3.5.3 Case study #3. Remote village electrification programme in Rajasthan based on SPV

Rajasthan Renewable Energy Corporation Limited (RRECL) situated in western India, is implementing the programme for electrification of remote villages and hamlets in the state through non-conventional energy sources. The model employed envisages electrification through a 10kWp SPV stand-alone power plant in each village, with a provision of 100 watt connected load to each household. The electricity is provided at 230 VAC, single phase through an LT distribution line. A minimum of 20 consumers/ beneficiaries are registered prior to undertaking the electrification work. The implementation of the projects is carried out through EPC-cum-O&M turnkey contractors. A sum of $60 per household is deposited as security and $2 per month is charged against energy charges. The work related to wiring for two lights and a plug point is included under the scope of the contract.

To ensure successful operation of the power plants, committees are formed at different levels. The Village-Level-Committee comprises all the beneficiaries, project officer of RRECL and an operator of the EPC contractor. This committee is responsible for collection of monthly charges from the beneficiaries and depositing the collected amount in its account by the 10th of every month; the committee also decides on the registration of new beneficiaries, disconnection of the defaulters and regulation of the electricity supply time. The issues related to the use of surplus electricity and operation of the accounts, etc. are dealt by an Executive Committee, which comprises four elected members from the beneficiaries, in addition to the Project Officer of RRECL and operator of the EPC contractor.

Table 3.11 Data Case Study # 3

Category	Requirement	Energy req.	Technology	% covered with RETs	Target population	Case study context
Domestic	Institutional framework for promotion of SPV	NA	SPV	Rural population in villages of the state	Rural and urban poor	Dry and arid

3.5.4 Case study # 4. SPV water pumping for agriculture in Punjab

A scheme of financing solar photovoltaic pumping systems was introduced by MNES in Punjab, Western North part of India. As discussed in section 3.4 the dry and arid zone has abundant solar energy resource and very poor irrigation facilities. Knowing the potential there is a need to promote the SPV based technology in the region with adequate financing mechanism. This case study details how a suitable financing mechanism can support the promotion of potential technology in such zones. Initially 1Hp system with 50% capital subsidy was introduced by MNES, which was not of great success as 1 Hp system could not meet irrigation requirement of farmers and expected contribution from each household was also very high. Later on Punjab Energy development Agency (PEDA) financed 2 Hp capacity systems. The 2 Hp system is capable of delivering about 140,000 litres water every day from a depth of about 6-7 metres.

As discussed in section 3.2 this quantity of water is considered adequate for irrigating about 1.5-2.3 ha land holding for most of the crops. PEDA also helped financial institution to take soft loans from Indian Renewable Energy Development Agency (IREDA) and offer pumps under lease-finance scheme. The scheme has been very successful in the state with total installation of about 1400 pumps. It has been estimated that the farmer is saving about $800-$1000 in diesel related expenses per year. The successful implementation of this project in Punjab has encouraged other states like Haryana, Uttar Pradesh, Gujarat, Bihar, Andhra Pradesh etc to propose implementation of similar projects in respective states.

Table 3.12 Data Case Study # 4

Category	Requirement	Energy req.	Technology	% covered with RETs	Target population	Case study context
Productive	Irrigation	2 Hp	SPV	6414 pumps have been installed till march 2004	Rural farmers with 2-4 ha land holding	Dry and arid zone

3.5.5 Case study # 5. Small hydro as an option for village electrification in Western Ghats

Western Ghats of Karnataka, the southern part of India, have the characteristics of humid zone as in Meghalaya. The small hydro potential in these ghats has been tapped by installation of seven pico-hydro projects. Small hydro is generally categorised according to their capacities into three categories, a) small hydro: 100 kW-25 MW; b) micro hydro: 10 kW- 100 kW; c) Pico hydro: 0-10 kW. The technology demonstrated in Western Ghats has the potential of its replication in other regions of humid zone. All the seven projects are "run-off-the river" type. All these projects have made enormous impact on the livelihood development of the villages by creating more income generating activities.

In Banjarumale, a village electrified through the project, a 8 kW system has enhanced Beedi (a rolled leaf which is filled with tobacco powder for smoking) rolling business due to extra light hours they get because of the hydro project. Similarly in Assolli (5kW) it helped people in manufacturing of Jaggery at night which needed light to observe the colour of the product, which otherwise would have been possible only in day light. Some of the plantation owners like in Jambardi & Doobla used power to increase the productivity of tea/ coffee. The electricity is used very efficiently to dry the leaves since the area is always affected by rainfalls and remains cloudy throughout the year. Some of the other income generation activities like battery charging have also been undertaken due to availability of small hydropower.

Table 3.13 Data Case Study # 5

Category	Requirement	Energy req.	Technology	% covered with RETs	Target population	Case study context
Residential	lighting for small income generation activities carried out at household level	2-8 kW	hydro	Seven villages with 100% beneficiaries	Rural poor	Meghalaya (humid zone)

3.5.6 Case study # 6. Implementation of Solar Home lighting Systems in rural India

Uttam Urja is one of the projects, which provides energy services through entrepreneurs in few districts of Northern and Western North India i.e Bikaner district of Rajasthan and Tehri-Garwal & Dehra Dun districts of Uttaranchal. The aim of the project is to relieve the consumer from problems of high upfront costs, maintenance and replacement, which have so far been responsible for limited penetration, and impact of renewable energy technologies in rural areas. The project promotes individual and community ownership/management of energy services, technology transfer to and capability building of local entrepreneur and institutions, and improved access to credit.

In Uttam Urja Scheme[1], the customer pays a basic upfront cost of SHS and then equated instalments for a specified period after which the ownership of the device is transferred to him/her. During the loan period, major maintenance costs such

[1] TERI 2003, 'Lighting up lives of rural poor', Uttam Urja project brochure, New Delhi: The Energy and Resources Institute, 11p.

as battery and printed circuit board replacement are borne by the service provider. Institutional capabilities for infrastructure development service/ maintenance facilities have been created at the village or cluster level which is easily accessible to rural communities.

Uttam Urja Scheme promotes various renewable energy based products of different capacities to meet rural energy demands viz., domestic lighting System of 50 W, 25W and 30W, lantern of 3W, Kisan torch, solar panels of 2.5W, 5W and 10W for fans, radios and other music systems like tape recorders. Local assembly has reduced the system cost and delivery time while enhanced after sales service. Loan recovery has been observed to be 100% with quarterly or biannual payments as per convenience of the customer. The project proves that a good brand image, financing mechanisms, services and awareness can increase the market of solar home lighting (SHS) even at higher costs.

Table 3.14 Data Case Study # 6

Category	Requirement	Energy req.	Technology	% covered with RETs	Target population	Case study context
Residential	Domestic lighting system, torch, solar modules for fan and other entertainment	2.5W-50W	Solar PV	Over 2533 SHS have been installed till March 2003 in the country under various programs	Rural poor	Rajasthan (Arid, dry zones)

3.5.7 Case study # 7. Micro credit facility brings light to rural areas

Chandrakanti project in Karimnagar and Khammam districts of Andhra Pradesh, the Southern part of India, seeking to deploy one lakh solar lanterns. The objective of the project is to provide solar lanterns at an affordable cost to rural people, especially women forming self-help groups. This has been fulfilled by a provision of credit facility at the micro level by Indian Rural Development Agency (IREDA). The scheme envisages offer of credit through intermediaries to provide solar lanterns at an upfront lease rental of $32 per unit to end users. The self-help groups, identified by the local administration, already have transactions with the local banks to get financial assistance for different purposes. As such they could take soft loans from the banks for the purchase of lanterns too. But considering the number of lanterns to be deployed bank loan alone would not be adequate. Hence IREDA plays important role in the project. “project Chandrakanti” envisaged initial deployment of 10,000 lanterns in the rural areas of Karimnagar to different self-help groups and their members. So far nearly 10,000 lanterns have been deployed. It has become a role model in which a large number of rural women have benefited by using the solar systems and this can be replicated in the other areas with appropriate modifications for sustainability.

Table 3.15 Data Case Study # 7

Category	Requirement	Energy req.	Technology	% covered with RETs	Target population	Case study context
Residential	Financing scheme for promotion of solar lantern	NA	Solar PV	Over 10000 Solar lanterns have been sold till March 2003 in the country under various programs	Rural/ urban poor	Both zones of the study

3.6 Assessment of capacities

This section discusses the existing capacities and then identifies gaps that are relevant to the theme of this initial assessment. Table 3.17 provides more details on assessment of capacities.

3.6.1 Policy, legislative and institutional level

The Electricity Act 2003: At the legislative level, the Electricity Act 2003 facilitates promotion of renewables by specifying that state regulatory commissions shall promote cogeneration and generation of electricity from renewable sources[1] of energy by providing suitable measures to the 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. Following the above, some state regulatory commissions have already issued the order on tariff from electricity procurement from RE sources. The Act further specifies that the central government must notify a National Policy permitting stand-alone systems (including those based on RE sources and non-conventional sources of energy) for rural areas. The Union Cabinet has recently approved the National Electricity Policy which seeks to expedite rural electrification and ensure supply of power at a reasonable rate for the overall development of rural India.

National Electricity Policy: While the Electricity Act provides an enabling framework for speedier and more efficient development of the power sector, the National Electricity Policy aims to make electricity available to all households, including rural areas in the next five years. The policy has set the minimum lifeline consumption of electricity at one unit (kilowatt hour) a household a day. It envisaged the supply of electricity to all areas while protecting the interests of consumers and other stakeholders, keeping in view the

[1] Section 4 of the EA: "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 source of energy and non-conventional sources for energy) for rural areas". Section 14: "…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…"

availability of energy resources, the technology available to exploit such resources, the economics of generation, utilising the different resources apart from looking into other energy security issues.

Policy for promotion of Renewables: India has a framework in place to tap the potential for renewable energy. National targets are towards 10% share for RE or 10,000 MW in the power generation capacity to be added during the period upto 2012[1]. The Ministry of Non-conventional Energy Sources (MNES) is the nodal agency of the Government of India for all matters concerning the promotion of renewable energy. The Ministry has formulated a strategy for integrated development of this sector with broad objectives as: (a) meeting the minimum energy needs through RE (b) providing decentralised energy supply in agriculture, industry, commercial and household sectors in rural and urban areas. The Ministry has nine regional offices, three specialised technical institutions and one non-banking financial company under its administrative control to promote RE sector in the country.

Remote Village Electrification (RVE) and Village Energy Security Program (VESP) Programmmes: MNES coordinates RVE programme that uses RETs for electrifying about 24,500 villages that are certified unviable for grid extension by the concerned power departments or electricity boards[2,3] . Recently, it has launched a Village Energy Security Program that focuses on demonstrating sustainable approaches to village energization using biomass. In the current financial year 2004- 05, about 25 test projects would be taken up in village across the country. Important components of the VESP approach are a) biomas based energy production systems for domestic (cooking, lighting, entertainment) , community (including drinking water supply) and rural cottage industries; b) electricity distribution preferable through a mini-grid; c) local management by a Village Energy Committee; and d) creation of a Village Energy Fund for O&M and other developmental requirements.

Rural Electricity Supply Technology Mission: In order to ensure a holistic and an integrated approach to provide electricity for all[4], a Rural Electricity Supply Technology Mission (REST) has been constituted. The Mission's objectives are; i) to identify and adopt technological solutions, ii) review legal and institutional framework and make changes, if

[1]Renewable Energy in India- Business opportunities
[2] Chaurey Akanksha, "Developments with Photovoltaic Research and Applications in India", 14th PV Science and Engineering Conference, January 2004, in Bangkok, Thailand
[3] MNES report 2003/2004, Government of India
[4] Mission: Power for all – 100% electrification to be completed by the end of the 10th Plan, by 2007; At least one unit of electricity per day to be provided to all the Below Poverty Line (BPL) households; State Governments to prepare and notify an Rural Electrification Plan for meeting the above goals

necessary, iii) promote, fund, finance and facilitate alternative approaches in rural electrification, and, iv) coordinate with various ministries, apex institutions, and research organizations involved in rural electrification towards meeting the national objectives. The Mission was constituted in the Ministry of Power on 11th September 2002.

As can be seen from the above, there are overlapping programmes with almost common objectives and vision being coordinated by different ministries. This is a strong requirement to enhance capacities within the ministerial set-up to develop mechanisms for frequent consultation and effective coordination in order to set realistic objectives, realizable time frames, effective monitoring mechanisms, and procedures for increased accountability and transparency. There is considerable potential for integrating the delivery of RETs based energy products and services in different schemes of various ministries. For example, under the programs for self-employment, the energy entrepreneurs or the skills of existing entrepreneurs can be strengthened to provide quality energy products and services.

3.6.2 Manufacturer, O&M and service industry

The renewable energy industry in India is not confined to the large organised sector. Small-scale and medium scale units represent a very large share of the RE industry. Most of these industries are catering to the requirements of rural energy devices such as biogas plants, biomass briquettes, fuel-wood based gasifier systems, biogas burners, portable metallic cookstoves, solar cookers etc. The manufacture of solar cells, Photovoltaic modules, wind turbines etc. is in the large-scale sector. Biomas gasifier for electricity generation is an upcoming sector where both medium and large scale industries are showing interests.

In many cases though the products are mature, their proliferation is constrained by the physical limitation of the manufacturer in handling large volumes of business. Except in areas like wind or SPV, the private manufacturers in the RE sector are very small with limited investment in manufacturing facilities or distribution network. Solar water heating systems, solar cookers, and gasifiers are some of the products where growth of business has been hampered. This implies that there is a need to encourage and develop new manufacturers and entrepreneurs for better realisation of the market. Similarly, the Energy Supply Companies (ESCOs) need to be motivated to enter into renewable energy supply markets.

3.6.3 Financial institutions

MNES provides financial incentives, such as interest and capital subsidy for investing in RETs. IREDA, an autonomous non-banking financial institution, is dedicated towards promotion of RE sector in the country. It operates a revolving fund for this purpose. In addition, the Rural Electrification Corporation (REC) under the Ministry of Power, finances rural electrification schemes in the country, and promotes and finances rural electricity cooperatives. Its mandate includes administering funds and grants from the Government of India and other sources for financing rural electrification, including viable decentralised power system organisations in cooperative, joint, private sector and other local bodies[1]. Table 3.16 lists the interest and capital subsidies provided by government of India through IREDA, some nationalised banks and other FIs for identified technology systems.

Table 3.16 Financing norms of RETs in India

Sector	Capacity	Interest rate (%)	Repayment	Term loan
Hydro Energy	Up to 25 MW	11.25	12 yrs	Up to 70% of total project cost
	Mini hydro	11.25		
	Small Hydro	11.5-12		
Wind Energy	10 MW	9.5-11	7-10 yrs	Up to 70% of total project cost
Biomass Co-generation	Up to 7.5 MW installed capacity with 63,87 and 100 kg/cm^2 pressure	12-11.25	10 yrs	Up to 70% of total project cost
	Above 7.5 MW installed capacity with 63,87 and 100 kg/cm^2 pressure	11.5-11		
Biomass power	1- 7.5 MW installed capacity with 63,87 and 100 kg/cm^2 pressure	11.5-10.75	10 yrs	Up to 70% of total project cost
Waste to Energy	Industrial waste	11.75	10 yrs	Up to 70% of total project cost
	Urban and municipal waste	10.5 up to 3 MW and 11 from 3-6 MW		
Bio-fuel	Ethanol production through biomass and bio-diesel production	10.5	8	Up to 70% of total project cost
Fuel Cells	Power applications/vehicle applications	10.5	8	Up to 70% of total project cost

Both IREDA and REC finance institutions and large customers of RETs such as cooperatives or industries. There is no institutional mechanism that targets individual user, particularly rural electricity user for enhancing the access to electricity. There are pilot attempts such as the Project Chandrakanti, discussed in section3.5 and Uttam Urja that has benefited rural women through a micro-credit scheme for purchasing solar portable lanterns. In this context, USAID funded SFCBI- Solar Finance Capacity Building Initiative is worth mentioning. This project is designed to increase the capacity for financing SHS by activities that are aimed at

[1] Renewable energy in India- Business opportunity, MNES, February 2004

training lending personnel and strengthening micro-credit organisations. Such initiatives need to be multiplied.

3.6.4 Technical Manpower

Lack of technical manpower is one of the basic constrains for biomass and hydro promotion in India. Designing of the technology, installation and maintenance is still limited to research organisations in most of the implementations. On-site training is given to local persons during installation of the technology for regular operation and maintenance. But eventually it is back supported by the research organisation for its smooth operation especially in the sector of biomass gasifier based power generation using 100% producer gas. There are few entrepreneurs, like “Ankur Scientifics” and “Grain processing”, other than research organisations that have made significant contribution for designing the biomass gasifier and making it a commercial commodity.

3.6.5 Capacity for R&D, standardisation and certification

India has had an impressive track record of developing several RETs and their products such as biogas plants, biomas gasifiers for thermal and electricity generation applications, solar thermal systems for domestic and industrial applications, SPV systems and their components, wind electric generators, wind pumps etc. Though most of the R&D is undertaken in academic and research institutions, there are three national level institutes dedicated for R&D, standardisation and certification of RETs and products. These are Solar Energy Centre (SEC), Centre for Wind Energy Technologies (C-WET) and National Institute of Renewable Energy (NIRE).

It has been observed that the general approach of R&D has been towards technology development without having a clear roadmap of its market penetration or the end-use. While this is essential in the initial stages, ultimately one has to look at the way a particular technology would be put to use. In other words, the approach to technology development should be demand driven rather than supply driven. To facilitate this, there is an urgent need to develop an appropriate model for public-private partnership for the development of renewable energy based products.

Further, for RETs that are near commercialization, a continuous process for the product/ technology upgradation is essential. Upgradation is required for a variety of reasons such as the performance enhancement, cost reduction, reliability enhancement, changing market needs, and making the product user-friendlier. However, in many of RE products, technology upgradation is not taking place because (i) manufacturers are small and have neither technical nor financial capacity to undertake such an effort and (ii) there is no mechanism that can facilitate this process. Solar water heating systems, biogas plants, solar cookers, and improved cookstoves can be cited as examples where upgradation is overdue.

Table 3.17 Capacity assessment

Stakeholder	Function/Activities	Capacity Status / Problems	Capacity Development Measures	Magnitude of CD needs / Priority
Legislative authorities, elected officials	Set national political priorities; social, economic, and environmental goals; legal framework conditions.	The members of such bodies are not fully aware of RE development and potential.	Awareness workshops and site visits of MP's to project sites are required.	Very high
Government macroeconomic and development planners	Define development goals and macro policy; general economic policies; cross-cutting issues; subsidies and trade policy; sustainable development goals, and frameworks.	Ministry of Non-conventional Energy Sources (MNES), Ministry of Power (MoP), Ministry of Coal (MoC) and State Electricity Board's (SEB) are responsible for energy planning and related issues. There is lack of coordination between them.	Joint meetings and capacity building workshops of the officials of various ministries	Very High
Government energy authority or ministry	Set sectoral goals; technology priorities; policymaking andstandard-setting functions; legal and regulatory framework, incentive systems; federal, state, and local level jurisdiction.			
Energy regulatory bodies	Have monitoring and oversight functions; implement the regulatory framework; administer fees and incentives.	Each state ERC follows different approach for tariff setting from RETs. Some of these ERCs are not fully familiar with nuances of RETs that may have a bearing on their pricing	ERC's need capacity building on various issues regarding RE pricing.	high
Market coordination agencies	Dispatch entities; have operational coordination functions; interface with industry investors; information brokers.	State nodal agencies of MNES and IREDA are major market coordinators and promoters of RE at state level. These agencies are aware of RE technologies.	Further strengthening of technical capacity is required.	medium
Non-energy governmental authorities/ministries	Sector policies; cross-cutting issues; inter-relation with energy policies; public sector energy consumers; require energy inputs for social services provision.	MoEF, MoI, MoA, MoUD are some of the non-energy governmental ministries which are also involved in RE promotion and development though indirectly.		
Energy supply industry	Private companies and public utilities; manage energy supply, electricity generation; fuels management and transport; finance some R&D.	Various industrial organizations such as wind energy developer's association, solar energy industries association etc		

Stakeholder	Function/Activities	Capacity Status / Problems	Capacity Development Measures	Magnitude of CD needs / Priority
Entrepreneurs and productive industry	Business development; economic value added; employment generation; private sector energy consumers.	In many cases though the products are mature, their proliferation is constrained by the physical limitation of the manufacturer in handling large volumes of business. Good numbers of local manufacturers are available in some parts of the country. Underdeveloped areas need local manufacturers and network of marketing /servicing agencies. There is a need to encourage and develop new manufacturers and entrepreneurs for better realisation of the market.	Education and training of entrepreneurs and development of industries in rural areas.	High
Energy equipment and end-use equipment manufacturers	Supply equipment for the energy industry and other industries, including vehicles and appliances; impact energy end-use efficiency; adapt/disseminate technology; finance some R&D.			
Energy equipment O&M services	Provide O&M. Feedback on performance and feasibility	As such there is no specific organisation which is devoted for O&M services. Mostly it is the part of equipment supplier. The Energy Supply Companies (ESCOs) need to be motivated to enter into renewable energy supply markets.	Capacity building of ESCOs	High
Credit institutions	Financing options for large- and small-scale energy generation; capital provision for energy using enterprises; financing options for household energy consumers.	IREDA, Banks, non banking financial institutes, and Rural Electrification Corporation (REC) etc are providing financial assistance to RE Projects. Some of these institutes do not have capability to assess the RE projects on technical viability. Few have reservations about technologies being used and long term viability of RE projects.	Adequate training in project appraisal is required.	High
Civil society / NGOs	Consumer participation and awareness; oversight and monitoring; environmental and social advocacy; equity considerations	Few local, national and international NGO's are working in promotion and implementation of RE projects.	Capacity strengthening required	low
Users	Users of renewable energy systems. Providers of feedback and knowledge about resources, cultural traits, technology performance, friendliness and suitability.	Commonly used RR systems are solar water heaters, solar cookers in urban areas and solar PV home lighting systems, solar lanterns, biogas, improved cook stoves etc are commonly used in rural areas. These vast diversity in lifestyle and socio economic status and cultures / habits. High capital cost is major barrier for promotion of RE equipments.	Development of low cost technologies and suitable micro credit financing schemes.	Very high

Stakeholder	Function/Activities	Capacity Status / Problems	Capacity Development Measures	Magnitude of CD needs / Priority
Energy specialists and consultancy firms	Strategic advice, problem definition and analysis; systems development; specialist services delivery; options analysis; information sharing.	Energy specialists and consultants are available in developed states. However, there is lack of experts in economically underdeveloped areas of the country.	Training and education of experts in RE areas.	medium
Academia and research organizations	R&D, knowledge generation, and sharing; formal and informal education; technical training; technology adaptation, application, and innovation.	Various universities and institutes are working in R& D. There are three national level institutes Solar Energy Centre (SEC), Centre for Wind Energy Technologies (C-WET) and National Institute of Renewable Energy (NIRE) dedicated for R&D, standardisation and certification of RETs and products. Funding and comprehensive long term policy/ road map for R & D in RE sector is required.	Policy development and funds allocation for R & D.	high
Media	Awareness raising, advocacy; information sharing; journalistic inquiry, watchdog functions; monitoring, public transparency.	Media need to focus on RE and its benefits		low

3.7 Identification of Niches with specific proposals

While identifying the niches, this study assumes that RETs can be successfully utilised in all those applications that have been highlighted through specific case-studies in section 3.5. This section therefore identifies niches in addition to the above case-studies, and discusses them with specific proposals. The niches selection matrix is given in table 3.18. The niches discussed here are based on specific feasibilities that have been carried out with an aim that once successfully demonstrated; each of these applications will have potential for replication in similar situations. The understanding of the "niche" is based on the condition that a "driver" should be identified in each feasibility around which either the economic or social development of the community takes place. In other words, the rural community is able to see a direct linkage between the particular RET application and their socio-economic development.

Table 3.18 Niches selection matrix

Potential Niches Criteria	N 1 (Hybrid PV-Wind)	N 2 (Lime Kiln)	N 3 (milk cake)	N 4 (EMT)
Representativeness				
Replicability	High. It depends on the solar and wind resource availability	High. As lime manufacturing is a highly wood energy consuming activity in Meghalaya	High. Most of the rural and semi urban population of Rajasthan is dependent on livestock related activities	High. Most of the rural and semi urban population of Rajasthan is dependent on livestock related activities and making a cooperative will increase the employment.
Potential population benefited	Rural population in Rajasthan	100% lime kiln owners of the state	100% rural population of Rajasthan in the business of dairy products	100% population in the business of dairy in 40 unelectrified villages of Rajasthan
Complexity	Medium	Low	Low	Low
Suitability/viability/sustainability				
Affordability	Medium	High	High	High
Effectiveness	High	High	High	High
Risk of obsolescence	Medium	Low	High	Low
Flexibility	High	High	High	High
Technological capability	Medium	High	High	High
Suitability and urgency	Medium	High	High	High
Adaptability	High	High	High	High
Environmental impacts	Low	Low	Low	Low
Social acceptance	Medium	Medium	High	High
CD requirement	High	Medium	Medium	Low
Income generation	Medium	High (60-70% of the total input cost of fuel)	High ($30/day)	High

3.7.1 Barangay (village) Manganese Hybrid PV - Wind Turbine Battery Charging System[1]

The Manganese Wind-PV battery charging station is the second Barangay Electrification Project implemented under the Energy Resources for the Alleviation of Poverty (ERAP) program of the Department of Energy (DOE), Philippines. The project was given as grant to the community. The direct beneficiaries were 20 households which were provided with batteries, house wirings and lamp loads. Manganese is an upland barangay in the Municipality of Anilao, Iloilo, Philippines. It has over 100 households and has a rich agricultural area ideal for cash-crops like vegetables and rice production. The major products are rice, squash, corn and peanuts.

The average monthly income level of the project beneficiaries in Manganese is PHP 1,885 ($34). The average expense for charging the battery (including costs of hauling the battery to the hybrid BCS) is about 1.3% of the total average expenditures. The use of gas before the operationalization of the BCS was about 1.9% which decreased to 1.06%, if compared to the average total expenditures of the households. Users of the system consume their battery energy for two 10-watt fluorescent for one to two hours use daily. After using the lights, the wick lamp is put on use.

During the use of battery, the fuel consumption (kerosene) mainly for the wick lamps, were cut into more than 50% from P 66 before they use the battery to PHP 21 pesos after using the battery. The expenses on kerosene for other households remained the same at PHP 32.5 a month.

Management and impact- The Barangay Power Association (BAPA), which is composed of the Chairman, Treasurer/Secretary, Auditor, and Operator (1 person), is tasked to manage the operation of the charging station. The households are now experiencing the bright lights and are happy about it. Other activities like arranging agriculture produce for transport to the central market the next day can now be prepared easily in the night. The merits of the clear lights are due to the possibility that children will have not have any problems reading their books or studying their lessons. Community activities like gatherings, birthday celebrations, weddings and baptisms use these electrical gadgets for additional merriment.

Table 3.19 RETs Niche N# 1

Category	Requirement	Power required	Technology	% covered by RETs	Zones of application	Target population	Equipment demand
Residential	Lighting for studying	20 watts/ hh/day	Hybrid PV - Wind Turbine Battery Charging System	20 hhs/100 hhs in a village	All	Rural	Two lamps per hh

[1] Personal communications with DOE official during a visit by TERI researchers in July 2004

3.7.2 Use of biomass gasifier for lime kilns in Meghalaya

East Khasi hill districts of Meghalaya are rich in lime stone. Two different kind of processes are being followed for its processing; wood based and coal based. Wood based units produce unslacked lime and supply the same for edible purposes, paint industry, bleaching powder while coal based kilns mainly produce slacked lime for tea garden, paper mill and other industrial applications. There are about 85 registered and 200 unregistered lime units in Meghalaya each comprised of about 2-3 lime kilns, where rural people from the state are employed as labourer. Approximately 1.5 ton of limestone is processed at temperature of 1000-1400 C to produce one ton of lime and about 12000-15000 kg of fire wood is consumed to process 18-20 ton of lime in each batch. By using a biomas gasifier instead of direct burning of wood, the consumption of wood comes down by 50-60% in each batch. This would translate into a direct saving as the firewood accounts for about 60-70% of the total input cost for the wood based lime kiln. This option is not only environmentally friendlier for this fragile region; it directly benefits the population that is employed in these kilns, and facilitate the economic development of the region.

Table 3.20 RETs Niche N# 2

Category	Requirement	Power required	Technology	% covered by RETs	Zones of application	Target population	Equipment demand
Productive	Thermal energy for productive use	710 kg wood/ton of lime processed	Biomass gasifier	Nil	Meghalaya	Rural	Approx 300 units in rural areas of Meghalaya

3.7.3 Biomass gasifier based Milk-cake making

Mawa (milk-cake) making (using firewood as fuel) is an important economic activity in villages in the district Karauli of Rajasthan. During monsoon season when the milk production is high, collection van from Rajasthan Co-operative Dairy Federation visits the villages to collect milk. However, as all the villages are not connected by road, transportation of milk daily to the market is a problem and hence significant quantity of milk is converted into *mawa* and *ghee* (clarified butter) at the household level in order to avoid milk getting spoilt. *Mawa* is generally made during festival and marriage seasons, when its demand is highest. In all, *mawa* is made for 6-7 months in a year. Here mawa is made either during morning hours or just after sunset (after milking the cattle). Biomass gasifier can be used for *mawa* making process. 10kg of milk can produce 2.5 kg of *mawa*, and for this process 15 kg of fuelwood is required. The minimum and maximum selling prices are $0.7 to 2.0/kg respectively. On an average one household can make 15 kg *mawa*/ day and can earn upto $30. This application saves the drudgery of collecting firewood and adds to the income of the family.

Table 3.21 RETs Niche N# 3

Category	Requirement	Power required	Technology	% covered by RETs	Zones of application	Target population	Equipment demand
Productive	Thermal energy for productive use	6 kg of biomass/ kg of *mawa*	Biomass gasifier	Nil	Rajasthan	Rural	One system per household

3.7.4 Dairy cooperative in rural Rajasthan to be facilitated by PV powered Milk-Testing Machine

In addition to the mawa making, another possibility also exits for initiating milk based income generating activities in this region. Most of the villages possess cattle and have expressed desire to sell the excess milk to the dairy. Villagers are willing to form the co-operative and have already started initial discussions with the dairy in Karauli. Once initiated, the scheme could spread to all the villages inside the sanctuary, which are on either side of the forest main road. However, they firmly believe that without the Electronic Testing Machine (EMT) at village milk collection centre, the co-operative will not run successfully. In all the electrified districts of Rajasthan, EMT is installed in milk collection centres.

These EMTs are essentially DC devices that can operate on battery. The prototype of a PV operated EMT can be easily developed by a PV manufacturer in the state that can be utilised for this purpose. The availability of PV operated EMT would facilitate the formation of milk co-operative in each village. Villagers of 40 unelectrified villages in this district can be benefited by this facility.

Table 3.22 RETs Niche N# 4

Category	Requirement	Power required	Technology	% covered by RETs	Zones of application	Target population	Equipment demand
Productive	Milk testing	DC power	PV	-	Rajasthan	Rural	40 villages of Rajasthan

3.8 Assessment of other experiences

This section discusses four programmes that have relevance with the current theme. Previous experiences are being summarised in table 3.23 .

- Remote Village Electrification (RVE) programme of the MNES
- Accelerated Rural Electrification Programme (AREP) of the REC/MoP
- R&D programme of MNES
- Externally aided projects related to rural electrification

3.8.1 Remote Village Electrification Programme

According to 2001 census about 43.5% of the rural households have been provided with grid electricity connections. Other than grid electrification 0.29% of rural households are electrified with solar energy and 0.16% with other renewable sources. The majority of the rural population still has no access to electricity and is dependent on kerosene lamps and lanterns for lighting. By focussing on unelectrified remote census villages and remote hamlets of electrified census villages, the RVE programme aims at bringing the benefits of electricity using RETs to people living in the most backward and deprived regions of the country.

The programme covers- a) surveys and studies for firming up electrification plan, b) installation and commissioning of appropriate systems from a selection of SHS, SPV mini-grids, biomas gasifier power plants, small hydro power plants and hybrid system, c) up-gradation/ renovation of existing systems including intensification of household coverage, d) monitoring and evaluation of individual projects, and e) training and capacity building at all levels.

The programme is being implemented through the state energy development agencies, state electricity boards, corporate entities for power generation, cooperatives, NGOs and village level governing bodies. Under this programme, Central Financial Assistance of upto 90% of the capital cost is provided as grant to the implementing agency. The remaining 10% can come either from the users or from some local developmental funds. So far, about 1563 remote villages and 316 remote hamlets are being electrified under this programme up to march 2004.

As per this programme, a remote village or remote hamlet is considered electrified if at least 10% of the households are provided with lighting facility. In addition, energy may also be provided for community facilities, pumping for drinking water supply or irrigation, as well as for economic and income generating activities in the village.

3.8.2 Accelerated Rural Electrification Programme (AREP)

As a part of the efforts of Govt. of India to achieve the goal "Electricity for All", Rural Electrification has been identified as a major thrust area. For this purpose an "Accelerated Rural Electrification Project" for electrification of *one lakh villages, one crore households*[1] was launched in February 2004 as a national programme with an overall outlay of $ 1300 million in which 40% was grant and 60% was on loan. The scheme aims at electrifying 100,000 villages in the next two years with a special focus on six priority states. The definition of electrification to be

[1] One lakh= 100,000, One crore= 10,000,000

used for this scheme is –minimum 10% of households in a village to be connected.

The Ministry of Power formulated the Rural Electricity Supply Technology (REST) Mission in the year 2002 aiming at accelerating completion of electrification of all villages and households progressively by the year 2007 through local RE sources and decentralised technologies including through the conventional grid. The Mission is to promote technologies that could be used in providing affordable and reliable power supply to rural areas and effect implementation through distributed generation schemes. The implementation mechanism has the following components- a) overall planning and monitoring from conceptualisation to implementation; b) implementation of pilot projects from demonstrative purposes; c) technology development and research with an aim to reduce costs and development of fuel cells; d) capacity building at all levels[1].

3.8.3 R&D programme of the MNES

An R&D sectoral panel on solar PV has been constituted by the MNES for close monitoring and review of projects and identification of thrust areas for R&D. Some of the ongoing R&D projects include development of nano and microcrystalline silicon thin films and development of pre-paid electronic energy meters for village mini-grids.

In the case of biomass gasifier, thrust of R&D has been on developing customised technology packages for a variety of biomass materials for power generation and development of biomass atlas. Table 3.24 lists the various programmes being implemented by ministry in biomass sector.

R&D in the area of small hydro has been focusing at simplification and optimisation of system design and engineering practices; reduction in cost of all element of SHP project; improvement in equipment reliability and development of techniques for speedy construction so as to reduce the gestation period

Table 3.23 Status of various biomass energy programs

S.No	Program	Year of starting	Current status
1.	National Program on Biogas Development (NPBD)	1981	Ongoing (revamped in 2002)
2.	National Biogas Management Program (NBMP)	2002	Ongoing
3.	National Program on Improved stoves (NPIC)	1986	Terminated in 2002 (transferred to state governments)
4.	Integrated Rural Energy Program (IREP)	1985	Ongoing
5.	Rural Energy Entrepreneurship and Institutional Development (REEID)	2000 (pilot scheme)	Ongoing
6.	Women and Renewable Energy Development (WRED)	2000 (pilot scheme)	Ongoing
7.	Biomass power/ cogeneration program	1992	Ongoing
8.	Biomass Resource Assessment	1997	

[1] The AREP since than has been subsumed by the scheme for rural electrifications & household electrification announced on April 2005

S.No	Program	Year of starting	Current status
9.	Biomass Gasifier Program	1988	Action research projects closed in 2002
10.	National Program on Energy Recovery from Urban & Industrial Wastes	1995	Ongoing (with UNDP/GEF co-funding)
11.	Bio fuels	2003	Ongoing
12.	Biomass briquetting	1981	Ongoing

3.8.4 Externally aided projects related to rural electrification

India Rural Electricity Access Project: With a view to mobilize resources to implement the AREP, it is envisaged that an amount of US $ 50 million scalable upto US $ 1 billion will be obtained from the World Bank through their India Rural Electricity Access Project already under consideration of the World Bank and Govt. of India. The first phase of Bank funding will cover two states namely Rajasthan and Uttar Pradesh. It could be extended depending on the experience gained in the first phase. The focus of the programme would be strengthening of the rural electricity supply system both through grid extension as well as off-grid schemes using renewable and non-renewable sources of energy such as biomass, solar power. The project will focus on pilot demonstration on suitable institutional, commercial and technical models for sustainable rural service and delivery mechanism based on-grid, off-grid and renewable technologies[1].

Distribution, Reforms, Upgrades and Management project (DRUM): Activities are being launched with the purpose to demonstrate best commercial and technological practices that improve the quality and reliability of 'last mile' power distribution in selected urban and rural distribution circles in the country. DRUM will demonstrate new technologies (including RETs) and best commercial practices in electricity distribution in three to five rural and urban areas in selected reforming states.

MNES has been implementing the UNDP/GEF technical assistance project on 'optimising development of small hydro resources in the Himalayan and Sub-Himalayan regions'. The project has been implemented in the NE states including Meghalaya. The project includes preparation of zonal plans and a master plan for the region besides setting up 20 demonstration projects. It also envisages development of new and efficient designs of water mills.

[1] Personal communication with REC and www.recindia.nic.in

Table 3.24 Assessment of previous experiences

Experience (E) / Criteria	E 1	E 2	E 3
Description			
Objectives	Remote Village Electrification Programme	Accelerated Rural Electrification Programme and Rural Electricity Supply Technology Mission	R&D programmes of MNES
Goals	Electrification of rural villages through RETs	Accelerating completion of electrification of all villages and households progressively by the year 2007 through local RE sources and decentralised technologies including through the conventional grid.	To develop the RE technologies for specific applications
Results obtained	1563 remote villages and 316 remote hamlets are being electrified under this programme	The Mission was formulated in the year 2002 only	Various technologies have been developed in each RE sector. Some of the ongoing R&D projects include development of nano and microcrystalline silicon thin films and development of pre-paid electronic energy meters for village mini-grids
Population target	Population of 24,500 remote village of India	1,00,000 unelectrified villages (AREP)	Urban and rural population
Weak points	Lack of awareness and project assessment		Lack of sufficient R & D funds
Capacity status assessment of the project stakeholders	High for most of RETs.	Low for prospective project developers	High
Zones	Nation wide	Nation wide	Nation wide
Representativeness			
Replicability	High as all remote villages can be electrified through RETs only	High as all household have to be electrified by 2007	Each R&D project is expected to go to atleast one pilot demonstration in the field
Potential population benefited		100% un-electrified population	
Suitability/Viability/Sustainability			
Affordability	Low. Government subsidy and finances available	Low. Government subsidy and finances available	Medium. Government financial support is available

Experience (E) / Criteria	E 1	E 2	E 3
Effectiveness	High	High	High and pilot demonstrations builds the confidence in the technology
Risk of obsolescence	Low	Low	Medium
Flexibility	Medium as available resources have to be used for electricity generation	Medium as available resources have to be used for electricity generation	High
Technological capability	High	High	High
Suitability and urgency	High	High	High to keep updated with the users requirement and technology
Resilience			
Adaptability	High	High	High as the product is designed keeping users requirements
Environmental impacts	Nil	Nil	Nil
Social acceptance	High	High	Some times it is difficult to convince the user due to conventional perceptions and habits
CD requirements	High	High	High
Income generation	High as electrification opens new and innovative job opportunities	High as electrification opens new and innovative job opportunities	High

3.9 Barrier analysis and summary

The analysis in this section is based on a hypothesis that the constraints to the effective penetration to RETs are independent of the end-use application. In other words, an exercise to address the barriers to market penetration of RETs would be found relevant for the entire universe of RETs applications- from off-grid domestic to grid connected power generation.

Further, this analysis does not restrict itself to the scope of this report. It also incorporates the collective knowledge at this centre regarding barriers to effective penetration of RETs in the region[1].

3.9.1 Related to policy and regulatory aspects

The lack of clear, long term and consistent policy for the promotion and utilisation of RETs is the major issue across all the countries in South Asia. With lack of strong RE policy, based on proper resource assessment and planning, various RE initiatives seem ad-hoc and intermittent and thus fail to become part of overall mainstream energy planning at government level. Lack of comprehensive policy on RE leads to competition among RETs at times. For example, PV vs. biomass vs. small hydro for rural electrification depending upon the understanding and preference of the particular institution and/or the programme under which it is being pursued. In many countries, there is a recognition of importance of RE but policy remains at 'guideline' level without budgetary and legislative backup for the policies. Though the reform process started quite early in India, other countries in the region are at very initial stages or in some cases the process have not yet started. In almost all the countries, the conventional energy sources are provided with subsidies, direct as well as hidden, thus favouring the conventional sources. This is hampering the competitiveness of the RETs.

[1] TERI 2003, 'South Asia regional meeting on REEEP (Renewable energy and energy efficiency partnership' in Delhi on August 4-5, 2003, TERI report no. 2003RT23.

3.9.2 Related to financing

The high initial cost of RETs is a barrier especially in the developing countries where income levels are low. The issue of providing subsidies to address the issue of high initial cost, have been discussed at various levels, including its impact on the market. Subsidies are essential in order to make REs affordable to the users. However in the absence of mechanisms for effectively targeting them, these act as barriers.The high costs of these technologies result in lower rates of returns, though on lifecycle basis these technologies are viable. Moreover, the high market interest rates limit penetration of RETs. Absence of innovative financing options, like micro-credits are critical issues in this region (though there have been successful examples of RE initiatives with innovative financing models like the "Grameen Shakti" promoting solar photovoltaic systems in Bangladesh). The awareness about the new funding avenues (such as Clean Development Mechanism and the Prototype Carbon Fund), which could be accessed for financing RE projects, is low.

3.9.3 Technical and technology related issues

Lack of accurate information on availability of resources is also a common barrier among the South Asian countries, except India where substantial initiative is underway for wind, and biomass resource assessment. The absence of precise resource data limits the inclusion of RE technologies in the planning process and designing of specific promotional programmes. The Solar and Wind Energy Resource Assessment (SWERA) project, supported by GEF, is underway in Sri Lanka, Bangladesh and Nepal.

Further, lack of development of appropriate products based on assessment of local needs is limiting the use of renewable energy resources. The R&D efforts to develop/adapt specific RE products to meet the local market requirement are essential for successful RE programme. The support for market creation and facilitation without taking into account the local developmental needs usually result in premature termination of any initiative after cessation of the support programme. There is also a lack of pre-investment support for demonstration, technology transfer, performance testing etc. Although in India, the institutional structure is in place to promote RETs and their applications, in general, there is inadequate trained manpower to introduce innovations in product and system design, assembly, installations and implementation procedures.

CHAPTER 4 Policy outlines

4.1 Objectives and policy outlines

The overall assessment of the RE culminates to identification of some problems specific to RE sector in India. The problems and objectives have been listed in Table 4.1. The policy outline for each of the identified objective has been discussed further in this section. Tables 4.2- 4.5 critically examine the strengths, weaknesses, threats and opportunities of each of the identified objectives.

Table 4.1 Priority problems and associated objectives

Problem definition	Objective
Individual policies and programmes for each renewable technology, with different set of agenda, targets and priorities often lead to competition within the sector and restrict mechanisms for harnessing the complete RE potential	A national policy for assessment, exploration and utilisation of renewable energy has been able to facilitate the use of most viable renewable option for a chosen project leading to a scenario where a substantial share of energy demand is met through renewable sources
The subsidies/incentives granted for promotion of RE technologies are unable to increase the competitiveness of renewable markets	Public-private partnerships have found RE to be technically and financially attractive business proposition and are able to work effectively
Current RET implementation mechanisms are not making an impact on poverty reduction because they do not incorporate livelihood and income generating activities at local level	Energisation of villages based on RET projects has created enormous job opportunities for livelihood and improved quality of living standard of rural population
The sustainability of RET projects could not be proved due to insufficient resource in terms of technical manpower, institutions and governance issues	Capacity building of all levels has resulted in a viable and competitive environment for promotion and success of RETs

4.1.1. Problem

Individual policies and programmes for each renewable technology, with different set of agenda, targets and priorities often lead to competition within the sector and restrict mechanisms for harnessing the complete RE potential

Objective

A national policy for assessment, exploration and utilisation of renewable energy has been able to facilitate the use of most viable renewable option for a chosen project leading to a scenario where a substantial share of energy demand is met through renewable sources

Strengths

- All RE sectors fall under one ministry thereby giving them a common vision (Ministry of Non-conventional Energy Sources)

- Different sectors already have specific budgetary support

Weakness

- On account of limited annual budget for the RE sector, higher allocation to one technology results in lower allocation to some other

Threats

- Integration of RE sector with other energy and developmental sectors may not take place, and in an overall national energy planning exercise, RETs may be referred to in passing only

Opportunities

- Electrification of all un-electrified households by the year 2012 and un-electrified villages by the year 2007 as per Rural Electrification Supply Technology (REST) Mission of Ministry of Power, Govt. of India.
- The goal of 6.5% GDP growth, necessitating diverse sources to meet increasing energy demands

Policy outlines

- Assessing long-term goals of concerned ministries and departments and integrating them in developing an overall vision and target for the development of RE sector
- Similar investments and efforts in R&D of all RETs in order to bring them at an equal level of maturity
- Assessment and capacity building of all important stakeholders to facilitate formulation as well as implementation of an integrated RE policy

4.1.2. Problem

The subsidies/incentives granted for promotion of RE technologies are unable to increase the competitiveness of renewable markets

Objective

Public-private partnerships have found RE to be technically and financially attractive business proposition and are able to work effectively

Strengths

- There exists a large portfolio of RE based systems/devices for a variety of applications
- A well developed manufacturing base exists
- A policy framework is already in place
- Subsidies facilitate users to buy RE systems providing an incentive for market growth

Weakness

- Fiscal and financial incentives are not linked to performance resulting in sub-standard performance

- Under-developed infrastructure and other delivery services, especially in rural areas hamper the effectiveness of RE businesses
- There is no attempt at reducing the costs of RE systems, particularly the decentralised ones, as long as they are subsidised

Threats

- In an open and reformed electricity market, despatchability may be a deciding factor for supporting or discouraging the RE electricity
- Externalities of the conventional fuels are not considered, making their prices artificially low thereby offering a tough competition to RETs

Opportunities

- Mandatory share of RE as enshrined in the Electricity Act 2003
- Volatilities in the international oil prices
- Easy financing and incentives for the private companies for rural electrification, as per NEP 2005.

Policy outlines

- Reflecting actual price of fossil fuels in market to make RE more economically competitive
- Introducing performance based subsidies
- Introducing generation linked tax credits
- Indigenisation of RE technologies keeping social acceptance as critical instrument
- Continued R&D for technology maturity

4.1.3. Problem

Current RET implementation mechanisms are not making an impact on poverty reduction because they do not incorporate livelihood and income generating activities at local level

Objective

Energisation of villages based on RET projects has created enormous job opportunities for livelihood and improved quality of living standard of rural population

Strengths

- Capacity of RETs to contribute to livelihood generation is proven
- Upcoming Village Energy Security Programme of MNES targets livelihoods
- Availability of RE resources at the local level is in abundance

Weakness

- Lack of involvement of the local community in the project design leads to their failure
- In-sufficient revenue inflows to take care of O&M expenditure affect the sustainability of the project

- Lack of emphasis on product development, standardisation and quality assurance lead to unreliable products and services, reducing their acceptance by the community

Threats

- Lack of basic infrastructure in many rural areas, especially in the remote villages, making RE services low priority as compared to other basic amenities
- Lack of synergy between different ministries and government departments may lead to overlap in their schemes or underutilisation of their respective resources

Opportunities

- National priority to rural electrification and its rural employment guarantee programmes

Policy outlines

- Linkage of RE service with poverty alleviation
- Linking rural development schemes with RET implementation programmes
- Capacity building of the local people and NGOs
- Participation of local population in execution of RE projects
- Availability of upgraded technologies to local craft/ industries
- Creation of market supply network for local craft/ industries
- Awareness creation about the possible opportunities of livelihood generation activities associated to electricity

4.1.4. Problem

The sustainability of RET projects could not be proved due to insufficient resource in terms of technical manpower, institutions and governance issues

Objective

Capacity building of all levels has resulted in a viable and competitive environment for promotion and success of RETs

Strengths

- Success stories and case studies for awareness creation exist
- A certain setup to propagate RETs does exist at both central as well as at state levels
- The gaps in the existing technical and institutional capabilities have been identified

Weakness

- Issues like capacity building at various levels and infrastructure development do not get a priority in planning process

- There is a lack of coordination and interaction among different institutions/agencies working in this field

Threats

- In-operational RET projects may be cited as examples of inappropriate and impractical technological solutions

Opportunities

- In many situations and locations, RETs could be the only option
- Many international agencies are getting to realise the importance of these aspects

Policy outlines

- Empower a range of decision makers, starting from user groups at village level (women self help groups, Panchayats etc) to planning and program implementation bodies at district and state levels to understand the wide range of issues related to efficient use of RETs.
- Training of trainers (ToT) and others, using prepared/Compiled training material and modules
- Create a database and atlas of RE resources that can be accessed by all stakeholders to plan, prepare and implement an RE project
- Create market-facilitation and enterprise- development organisations for RE
- Promote joint R&D by industry and academic/ research institutions and technology ventures

Table 4.2 Swot analysis and policy outline for objective 1

		Internal factors	**Weakness**	**Strengths**	
Objective A national policy for assessment, exploration and utilization of renewable energy has been able to facilitate the use of most viable renewable option for a chosen project leading to a scenario where a substantial share of energy demand is met through renewable sources			On account of limited annual budget for the RE sector, higher allocation to one technology results in lower allocation to some other	All RE sectors fall under one ministry thereby giving them a common vision (Ministry of Non-conventional Energy Sources)	Different sectors already have specific budgetary support
External factors					
Threats	Integration of RE sector with other energy and developmental sectors may not take place, and in an overall national energy planning exercise, RETs may be referred to in passing only			Assessing long-term goals of concerned ministries and departments and integrating them in developing an overall vision and target for the development of RE sector	
Opportunities	Electrification of all un-electrified households by the year 2007 as per National Electricity Policy (NEP) 2005				Similar investments and efforts in R&D of all RETs in order to bring them at an equal level of maturity
	The goal of 6.5% GDP growth, necessitating diverse sources to meet increasing energy demands		Assessment and capacity building of all important stakeholders to facilitate formulation as well as implementation of an integrated RE policy		

Table 4.3 Swot analysis and policy outline for objective 2

Objective		**Internal factors**	**Weakness**			**Strengths**			
Public-private partnerships have found RE to be technically and financially attractive business proposition and are able to work effectively			Fiscal and financial incentives are not linked to performance resulting in sub-standard performance	Under-developed infrastructure and other delivery services, especially in rural areas hamper the effectiveness of RE businesses	There is no attempt at reducing the costs of RE systems, particularly the decentralised ones, as long as they are subsidised	There exists a large portfolio of RE based systems/devices for a variety of applications	A well developed manufacturing base exists	Some sort of policy framework is already in place	Subsidies facilitate users to buy RE systems providing an incentive for market growth
External factors									
Threats	In an open and reformed electricity market, despatchability may be a deciding factor for supporting or discouraging the RE electricity		Introducing performance based subsidies		Indigenisation of RE technologies keeping social acceptance as critical instrument				
	Externalities of the conventional fuels are not considered, making their prices artificially low thereby offering a tough competition to RETs							Reflecting actual price of fossil fuels in market to make RE more economically competitive	
Opportunities	Mandatory share of RE as enshrined in the Electricity Act 2003			Introducing generation linked tax credits					

Objective		**Internal factors**	**Weakness**			**Strengths**			
Public-private partnerships have found RE to be technically and financially attractive business proposition and are able to work effectively			Fiscal and financial incentives are not linked to performance resulting in sub-standard performance	Under-developed infrastructure and other delivery services, especially in rural areas hamper the effectiveness of RE businesses	There is no attempt at reducing the costs of RE systems, particularly the decentralised ones, as long as they are subsidised	There exists a large portfolio of RE based systems/devices for a variety of applications	A well developed manufacturing base exists	Some sort of policy framework is already in place	Subsidies facilitate users to buy RE systems providing an incentive for market growth
	Volatilities in the international oil prices						Continued R&D for technology maturation		
	Easy financing and incentives for the private companies for rural electrification, as per NEP 2005.								

Table 4.4 Swot analysis and policy outline for objective 3

Objective		**Internal factors**	**Weakness**			**Strengths**		
Energisation of villages based on RET projects has created enormous job opportunities for livelihood and improved quality of living standard of rural population			Lack of involvement of the local community in the project design leads to their failure	Insufficient revenue inflows to take care of O&M expenditure affect the sustainability of the project	Lack of emphasis on product development, standardisation and quality assurance lead to unreliable products and services, reducing their acceptance by the community	Capacity of RETs to contribute to livelihood generation is proven	Upcoming Village Energy Security Programme of MNES targets livelihoods	Availability of RE resources at the local level is in abundance
External factors								
Threats	Lack of basic infrastructure in many rural areas, especially in the remote villages, making RE services low priority as compared to other basic amenities		Linkage of RE service with poverty alleviation				Availability of upgraded technologies to local craft/ industries	
	Lack of synergy between different ministries and government departments may lead to overlaps in their schemes or underutilisation of their respective resources			Linking rural development schemes with RET implementation programmes		Capacity building of the local people and NGOs	Participation of local population in execution of RE projects	

Objective		**Internal factors**	**Weakness**			**Strengths**		
Energisation of villages based on RET projects has created enormous job opportunities for livelihood and improved quality of living standard of rural population			Lack of involvement of the local community in the project design leads to their failure	Insufficient revenue inflows to take care of O&M expenditure affect the sustainability of the project	Lack of emphasis on product development, standardisation and quality assurance lead to unreliable products and services, reducing their acceptance by the community	Capacity of RETs to contribute to livelihood generation is proven	Upcoming Village Energy Security Programme of MNES targets livelihoods	Availability of RE resources at the local level is in abundance
Opportunities	National priority to rural electrification and its rural employment guarantee programmes				Awareness creation about the possible opportunities of livelihood generation activities associated to electricity			Creation of market supply network for local craft/ industries

Table 4.5 Swot analysis and policy outline for objective 4

Objective Capacity building of all levels has resulted in a viable and competitive environment for promotion and success of RETs		**Internal factors**	**Weakness**		**Strengths**		
			Issues like capacity building at various levels and infrastructure development do not get the due priority	There is a lack of coordination and interaction among different institutions/agencies working in this field	Success stories and case studies for awareness creation	A certain setup to propagate RETs does exist at both, central as well as at state levels	The gaps in the existing technical and institutional capabilities have been identified
External factors							
Threats	In-operational RET projects may be cited as examples of inappropriate and impractical technological solutions		Create a database and atlas of RE resources that can be accessed by all stakeholders to plan, prepare and implement an RE project	To understand the wide range of issues related to efficient use of RETs			
Opportunities	In many situations and locations, RETs could be the only option		Empower a range of decision makers, starting from user groups at village level (women self help groups, Panchayats etc) to planning and program implementation bodies at district and state levels		Training of trainers (ToT) and others, using prepared/Compiled training material and modules	Create market-facilitation and enterprise-development organisations for RE	
	Many international agencies are getting to realise the importance of these aspects						Promote joint R&D by industry and academic/ research institutions and technology ventures

4.2 Stakeholders reaction

This section assesses the feasibility of policy outlines identified in section 4.1 through stakeholder's reaction. Tables 4.6- 4.9 capture these reactions.

Table 4.6 Stakeholder reaction for objective 1

Specific objective	A national policy for assessment, exploration and utilisation of renewable energy has been able to facilitate the use of most viable renewable option for a chosen project leading to a scenario where a substantial share of energy demand is met through renewable sources		
Strategic outlines **Stakeholders**	Assessing long-term goals of concerned ministries and departments and integrating them in developing an overall vision and target for the development of RE sector	Similar investments and efforts in R&D of all RETs in order to bring them at an equal level of maturity	Assessment and capacity building of all important stakeholders to facilitate formulation as well as implementation of an integrated RE policy
1. Energy Ministry	S	S	A
2. Regulatory Agency	S		A
3. Environment Ministry	S	S	A
4. Political parties	I		I
5. Local Government	I	S	A
6. Rural organizations	A		A
7. Indigenous organizations	A	S	A
8. Industrial enterprises	CS		I
9. Investors	CS	A	A
10. Multilateral banking	I	A	
11. Commercial banking	I	A	
12. Cooperation Agencies	I		
13. Project developers	CS	A	S
14. Power Utilities	CS	A	
15. Oil companies	I	A	
16. Professional associations	I	S	S
17. Transmission companies	I		A
18. Distribution companies	A		A
19. Environmental NGOs	A		S
20. Potential users	I	I	S
21. R&D institutions	A	A	S

A: accepted, CS: conditioned support, I: ignored, O: opposed, S: support

Table 4.7 Stakeholder reaction for objective 2

Specific objective	**Public-private partnerships have found RE to be technically and financially attractive business proposition and are able to work effectively**				
Strategic outlines **Stakeholders**	Reflecting actual price of fossil fuels in market to make RE more economically competitive	Introducing performance based subsidies	Introducing generation linked tax credits	Indigenisation of RE technologies keeping social acceptance as critical instrument	Continued R&D for technology maturation
1. Energy Ministry	*S*	S	S	S	S
2. Economy Ministry	S	S	S	S	A
3. Regulatory Agency		S	S	S	
4. Environment Ministry	CS	S	S	S	CS
5. Political parties	O				A
6. Local Government	I	A	A	S	A
7. Rural organizations	O			S	A
8. Indigenous organizations				S	
9. Industrial enterprises					
10. Investors		A	A	A	
11. Multilateral banking		A	A		
12. Commercial banking		A	A		
13. Cooperation Agencies					
14. Project developers	S	A	A	A	
15. Power Utilities					
16. Oil companies	O				
17. Professional associations	I	A	A	A	
18. Transmission companies	I				I
19. Distribution companies	I				I
20. Environmental NGOs	O	A	A	A	
21. Potential users	O	A	A	A	I
22. R&D institutions	CS	A	A	A	A

A: accepted, CS: conditioned support, I: ignored, O: opposed, S: support

Table 4.8 Stakeholder reaction for objective 3

Specific objective	**Energisation of villages based on RET projects has created enormous job opportunities for livelihood and improved quality of living standard of rural population**					
Strategic outlines **Stakeholders**	Linking rural development schemes with RET implementation programmes	Capacity building of the local people and NGOs	Participation of local population in execution of RE projects	Availability of upgraded technologies to local craft/ industries	Creation of market supply network for local craft/ industries	Awareness creation about the possible opportunities of livelihood generation activities associated to electricity
1. Energy Ministry	A	S	S	S	A	S
2. Economy Ministry						
3. Regulatory Agency		A				A
4. Environment Ministry	A	S				A
5. Political parties				S	A	A
6. Local Government	CS			CS	CS	CS
7. Rural organizations	CS	A				A
8. Industrial enterprises				S		
9. Investors	A					A
10. Multilateral banking		S				
11. Commercial banking						
12. Cooperation Agencies		A	CS			
13. Project developers			CS	A		S
14. Power Utilities			CS			
15. Oil companies						
16. Professional associations	CS					
17. Transmission companies	CS					
18. Distribution companies	CS					
19. Climate Change Office						
20. Environmental NGOs	A			A		S
21. Potential users	A	CS	CS	A	A	A
22. R&D institutions	A	A	A	A		

A: accepted, CS: conditioned support, I: ignored, O: opposed, S: support

[3] According to National Planning Commission (NPC),

Table 4.9 Stakeholder reaction for objective 4

Specific objective	**Capacity building of all levels has resulted in a viable and competitive environment for promotion and success of RETs**				
Strategic outlines **Stakeholders**	Empower a range of decision makers, starting from user groups at village level to planning and program implementation bodies at district and state levels to understand the wide range of issues related to efficient use of RETs.	Training of trainers (ToT) and others, using prepared/Compiled training material and modules	Create a database and atlas of RE resources that can be accessed by all stakeholders to plan, prepare and implement an RE project	Create market-facilitation and enterprise-development organisations for RE	Promote joint R&D by industry and academic/ research institutions and technology ventures
1. Energy Ministry	*S*	S	S	A	S
2. Economy Ministry	A		S		
3. Regulatory Agency			S		
4. Environment Ministry	S	A	S		
5. Political parties	A			A	
6. Local Government	A	CS	S		CS
7. Rural organizations	A	A		A	
8. Indigenous organizations	A			S	
9. Industrial enterprises	CS				
10. Investors	A	A			
11. Project developers	A		A	S	I
12. Professional associations	CS				
13. Climate Change Office	S				
14. Environmental NGOs		A		S	A
15. Potential users	CS				
16. R&D organizations	A	S	S		A

A: accepted, CS: conditioned support, I: ignored, O: opposed, S: support

CHAPTER 5 RETs in Nepal

5.1. Characterisation of population and zones

5.1.1. Nepal is a small country, divided into 3 ecological zones- mountains, hills and terai and five administrative regions – Eastern, Central, Western, Mid Western, Far Western Development regions (Appendix-6). Each development region is further subdivided into 3 ecological zones. Therefore the whole country has 15 eco-developmental regions. Human Development Index (HDI) which is one of the tools to measure the level of poverty in Nepal indicates that out of 15 eco-developmental zones; three zones are comparatively backward. These are the western hill, Mid Western Mountain and Far Western Mountain. However, these eco-developmental zones are homogeneous in terms of socio- economic attributes. Therefore the entire country can be considered as a single zone for the purpose of this study and the energy requirements and other related issues could be focussed for the entire country as a whole.

5.1.2. Nepal is a resource poor country. It has no proven deposit of petroleum product. Forest resources have been used as the traditional indigenous source of energy. There is a vast unused potential of electrical energy which can be harnessed. About 86% of the population of Nepal resides in the rural areas and their main occupation is agriculture. Rural communities fulfil their energy requirement by extensive use of biomass, which constitutes of fuelwood, agricultural waste and animal dung. Human Poverty Index (HPI) in rural areas (41.4) is almost double of the HPI in urban areas (23.2). The National Human Development Report, 2000 estimates Nepal HPI as 39.2.

5.1.3. The Nepal Living Standard survey (NLSS) which use household expenditure data, estimates 42 % of head –count index of poverty at national level. However 37.7% of the population live below poverty line in Nepal if $1/day were used as the poverty threshold. In this study 38% of population is considered as below poverty line.

Table 5.1 Low income Population

electrified poor households	624910
Unelectrified poor households	961384

5.1.4. In Nepal, out of 4174457 households, 1644499 households (39%) use electricity out of which 7% of them consume alternate energy like solar power, biogas, micro hydro etc*3*. Therefore the total un-electrified households in Nepal are 2529958. Again if it is assumed that 38% of the households are below poverty line then total un-electrified poor households in Nepal would be 961384.

5.2. Needs and energy requirements

5.2.1. In Nepal from the energy supply demand balance 2003-04 it is observed that energy requirement in residential sector is mainly met through traditional fuel such as fuel wood, agricultural residue and animal dung (94% of the total consumption in the residential sector). The energy requirement is mainly for cooking and lighting.

5.2.2. In the productive sector, water pumping for crop irrigation (84% of the population depend upon agriculture) and small scale income generating activities such as fish farming, poultry farming, cattle rearing etc have been identified as critical requirements. Water for drinking, street lighting and energy requirement for public health center (PHC) are the requirements under the social/ community services.

5.3. Assessment of renewable resources

5.3.1. Villages in Nepal are mostly inaccessible and far-flung. The diverse and rugged topography of the country impedes the full grid connection of each and every household. Nepal is the second richest country of the world in water resources. It has abundant hydroelectric potential estimated to be as high as 83GW of which 42 GW is considered economically feasible. Hilly topography of the country facilitates the installation of micro hydro to a great extent. There are numerous tributaries with a waterfall from the vertical elevated slope hill to plane areas where the villages reside. Of Nepal's 75 districts, 63 have a potential for hydropower.

5.3.2. There is a potential of 1.3 million biogas plants[1] in Nepal. Nepal has immense potential of tapping solar energy. On an average the country has 6.9 sunshine hours per day totalling 2482 sunshine hours per year. The solar insolation here is estimated to be around 4.5 kWh/sqm/day. Although there has been no wind mapping as yet, some places have the potential of utilizing wind energy. Hence, solar PV based system or their hybridization with wind could be a good option. Though at present there is no penetration of biomass gasifier based

[1] www.nepalnews.com.np

power plant, this technology also has a good potential because forest based as well as crop residue based resources are available plenty in almost all parts of Nepal. People in this region have been using microhydro, biogas and solar PV based systems. But there is little exposure of other technologies such as biomass gasifier and wind based systems in this region

5.4. Technologies

This section presents an assessment of the appropriate renewable technologies in terms of their technical and commercial maturity.

5.3.3. Biogas based power generation-Biogas, an inflammable gas is produced by anaerobic degradation of animal dung and can be used for cooking and lighting. Methane is the main component of the biogas. The system consists of an underground digester pit made of bricks/stones. A concrete dome shaped cover is constructed to collect the gas. The digester has two openings: An inlet for feeding the mixture the dung and water and an outlet for removing the digested slurry formed after the formation of gas. The gas outlet is placed at the top of the dome. The mixture of dung and water in the digester produced biogas under appropriate temperature condition. The production of biogas depends upon the temperature. The gas formed is collected in the dome. The gas produced then can be used for two purposes- (a) through the gas pipe the gas produced is fed to the specially designed stove used for cooking, and (b) the gas can be fed to the internal combustion engine to produce electricity (c) the gas is also used for lighting (at least 10% of 122,654 biogas plants are equipped with biogas based lamps).

5.3.4. A typical 4 cum biogas plant which is used for cooking requires 20-30kg of dung and 20-30 litres of water per day and the stove runs for 3 hours. The typical size of the biogas power plant is in the range of 4 cum to 20 cum. Though the biogas plants have a life span of 20-30 years, continuous availability of dung and water at the plant site for biogas power plant is a challenging job and needs community participation for sustaining the operation of the biogas plant.

5.3.5. Many RETs, such as microhydro, biogas and solar PV home systems are matured and are at the different stage of commercialization where as other technologies are in the different stages of development. The Table 5.2 briefly summarizes the status of various RETs.

5.3.6. Micro-hydropower Technology in Nepal- Hydropower plants of capacity up to 100 kW are referred to as Micro-Hydropower

(MH) plants in Nepal. Plants of up to this capacity have been fully de-licensed by His Majesty's Government of Nepal. This technology was introduced in Nepal in early 60s. Recently published Micro-hydro data of Nepal shows that there are 1956 micro-hydro plants capable of generating 13,064 kW of power (50% electrical and 50% mechanical) already installed in Nepal. There is a considerable capability in project survey / design and manufacturing / installation of Micro-hydro related parts and micro-hydro projects in Nepal. Now there are a number of MH manufacturing and installation companies, consultancy firms and NGOs working in MH sector in Nepal.

Table 5.2 Stages of Development of RETs

Technology	Stage of Development									
	Fundamental R&D	Resource Data	Adaptive R&D	Demonstration	Dissemination	End-use Diversification	Commercialization	Needs Financing Assistance	Needs HRD	Needs to Develop Quality Control & Monitoring Mechanism
Microhydro		✓			✓	✓	✓	✓	✓	✓
Solar PV		✓	✓	✓	✓		✓	✓	✓	✓
Solar Thermal		✓	✓	✓	✓				✓	✓
Passive Solar Building		✓	✓	✓						
Biogas	✓		✓		✓	✓		✓	✓	✓
Liquid Biofuel		✓	✓	✓						
Solid Biomass		✓	✓	✓						
Improved Cooking Stove	✓		✓	✓	✓			✓	✓	
Wind Energy		✓	✓	✓						
Geothermal	✓	✓	✓	✓						

Note: Represents present stage of activity and needs for technology adoption in near term

Table 5.3 Suitability of Different RETs by Topographical Region

RETs	Topographical Region		
	Terai	Hill	Mountain
Microhydro		✓	✓
Solar PV	✓	✓	✓
Solar Thermal	✓	✓	✓
Passive Solar Building	✓	✓	✓
Biogas	✓	✓	
Liquid Biofuel	✓	✓	✓
Solid Biomass	✓	✓	✓
Improved Cooking Stove	✓	✓	✓
Wind Energy	✓	✓	✓
Geothermal		✓	✓

5.5. Assessment of capacities[1]

5.5.1. The exploitation of various sources of alternative and renewable energy like: biogas, small and micro hydropower, solar energy (Photovoltaic and Thermal), improved cook stove, wind energy, etc has great potential in Nepal. His Majesty Government has created the Alternative Energy Promotion Center (AEPC) with the objective of developing and promoting different sources of renewable energy, considering the fact that the maximum utilization of these renewable energy resources could contribute to environmental protection and sustainable rural development. Even though HMG had already provided subsidy to encourage the use of RETs for exploiting renewable energy resources, it is desirable to make necessary adjustment in the existing system of subsidy for extensive use of RETs. HMG/N has approved and implemented the new subsidy policy for Renewable Energy to achieve the following objectives

- To Protect environment by encouraging the use of renewable energy resources and RETs in the rural areas and to provide opportunity to low income rural households to use RETs.
- To support rural electrification as well as gradually reduce the growing gap of electricity supply, consumption, etc. between rural and urban areas.
- To make the use of grant assistance provided by donors, existing and forthcoming more effective and objective oriented and thereby attract the donors and other investor in RETs sectors.
- To support development and extension of RET market by attracting private sector entrepreneurs.
- To support to the envisaged targets of RETS program of the long term plan.

5.5.2. Energy Sector Assistance Programme- On the 26th of March 1999 an agreement on an Energy Sector Assistance Programme (ESAP) was signed between HMG/N and GKD with a total budget of 154 million DKK. The total ESAP period is expected to be 15-20 years. The Alternative Energy Promotion Centre (AEPC) and Nepal Electricity Authority (NEA) are the national agencies for the programme. The components are executed by private commercial sector operators and by NGOs.

The development objective of the ESAP is to improve the living conditions of the rural population by easing its access to energy technologies with better performance in terms of productivity, use versatility and environmental impacts. The immediate objective is to improve the availability, productivity and sustainability of the public and commercial infrastructure

[1] http://www.aepcnepal.org/gen/se.php

for the planning, the promotion, the maintenance and the financing of renewable energy sources.
For the initial five years phase, the ESAP consists of five components:

- Support to AEPC
- Promotion to Improved Cooking Stoves
- Support to Micro-Hydro Development
- Promotion of Solar Energy
- Financial Assistance to Rural Energy Investments Component including rural electrification of Kanchanpur and Kailali Districts

The Alternative Energy Promotion Centre (AEPC) and Nepal Electricity Authority (NEA) are the national agencies for the programme. The components are executed by NEA, private commercial sector operators and by (I) NGOs.

5.5.3. AEPC is carrying out various activities for the implementation, development and promotion of biogas technology with BSP and its Related Organizations. The Biogas Support Programme(BSP) was initiated in July 1992 to develop and promote the use of biogas in Nepal. Subsidy has been given to biogas plants to benefit the rural households under biogas programme since a long time back.

Farmers who want to install biogas plant have to have adequate number of cattle in their farm. Since dung needs to be mixed in plentiful of water for proper processing, regular water supply has to be maintained and the water needs to be near the biogas plant. further information can be obtained from a bank, biogas company, or BSP.

From the inception of the programme in July 1992 to 15 July 2004, the programme has constructed 122,654 biogas plants.

5.5.4. AEPC has been carrying various activities of which the Solar Energy Support Program (SSP) is the major. SSP has installed 50,294 (42,494 ESAP/AEPC managed and 7800 government subsidized) SHS and a number of community-based institutional systems equivalents to more than 0.8 MWp by the July 2004 on a demand driven basis. With the financial support from Danida/ESAP, SETS was established in the year 2001 with Royal Nepal Academy of Science & Technology (RONAST). It is a part of the Solar energy Support Program of AEPC/ESAP. For the promotion of SHS systems and PV industry, an Interim Rural Energy Fund (IREF) has been set up to administer the subsidy.

5.6. Identification of niches

5.6.1. At present, 30,000 rural households are being connected to national grid every year. In contrast distributed energy system supply 45,000 new households every year with access to biogas, micro hydro or SHS, which shows a high potential and penetration of renewable energy in Nepal[1]. The tenth plan of the government also recognizes the importance of solar energy and aims to generate 3.7MW of solar energy benefiting 52 districts with 52,000 solar energy systems distributions. Again in case of biogas plant it is roughly estimated that total dry dung produced in Nepal is about 11m tonnes. If the available dry dung is used for biogas, the potential biogas production is estimated to be around 1200mcum/year.

[1] Source: Energy synopsis report ,94/95 WECS, Kathmandu

CHAPTER 6 Key findings and recommendation with suggestions for future actions

These recommendations are a synthesis of discussions in chapters 4 and 5.

The countries in the south east region have common requirements for promoting RETs. These are related to energy security issues at one end, and servicing their large rural population on the other. Most of local governments have made commitments towards developing the RE sector, though their implementation are at various levels of effectiveness. The study has highlighted barriers related to technology, policy, and institutional levels; below is a list of key findings:

- Need for an national RE policy integrating targets and visions of various departments/ institutions and an effective institutional mechanism based on public-partnerships to implement the policy at all levels
- Focus on technology and product R&D that are in tune with the local energy requirements and can be adopted easily by the socio-economic character of the target communities
- Need to enhance technical manpower in the country for resource assessment; technology and product customisation; planning, developing and implementing a project among others
- Efforts in improving the techno-commercial understanding of RETs among non-RET community, in order to provide a conducive environment of growth to the sector

Future actions

- Each of the above recommendations need specific action plan for their implementation. These action plan need to be developed with clearly identified roles and responsibilities of various stakeholders
- While this current study has provided important insights into the RE sector as a whole, it would be meaningful for country governments and regional fora if the above action plans (or policy implementation plans) are developed for specifically identified niches for RETs that have potential for large scale impact
- Further, a well strategised dissemination phase of the above would induce cooperation among countries on sharing of technology and know-how, joint projects, exchange of resources etc.

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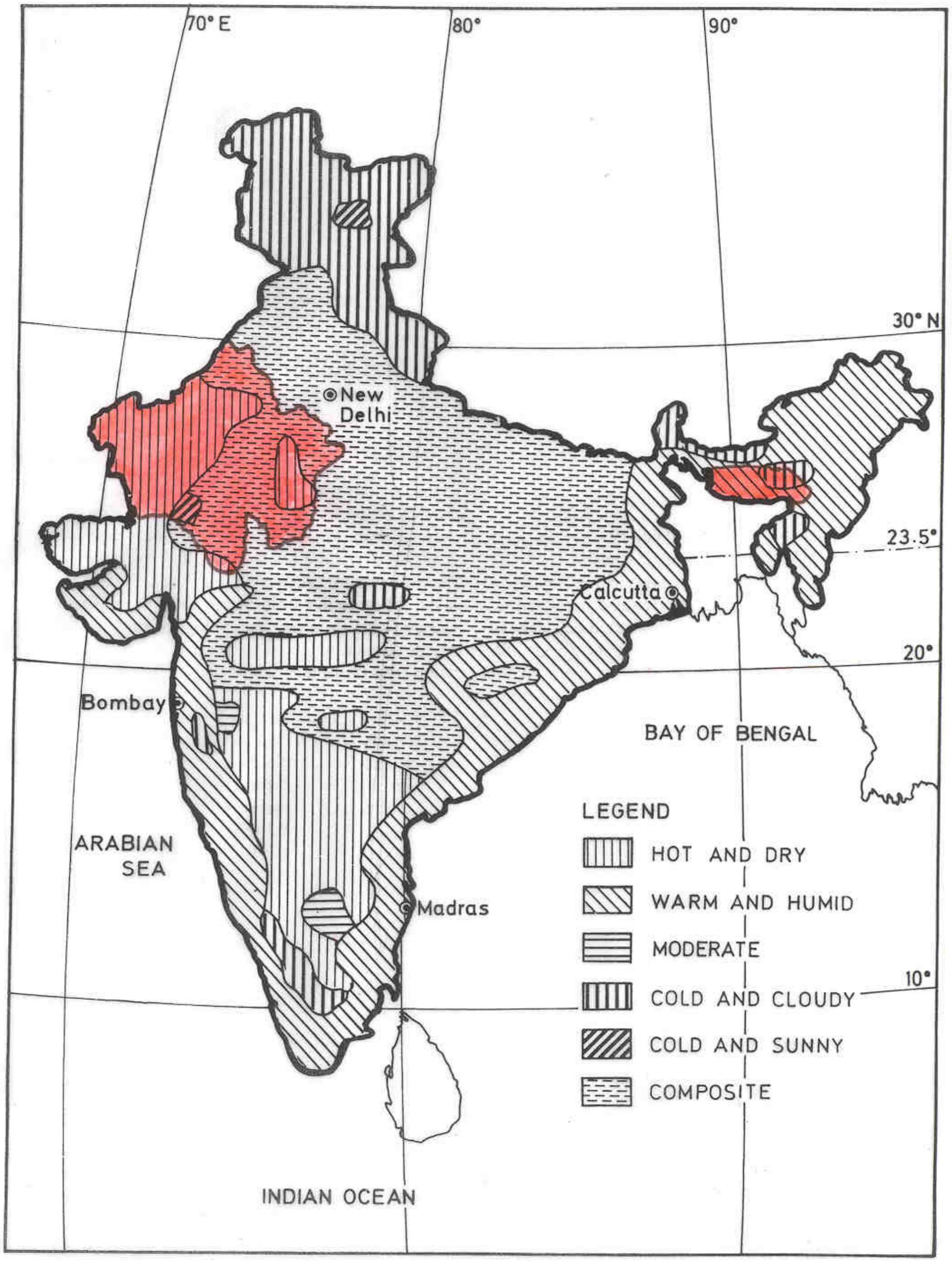
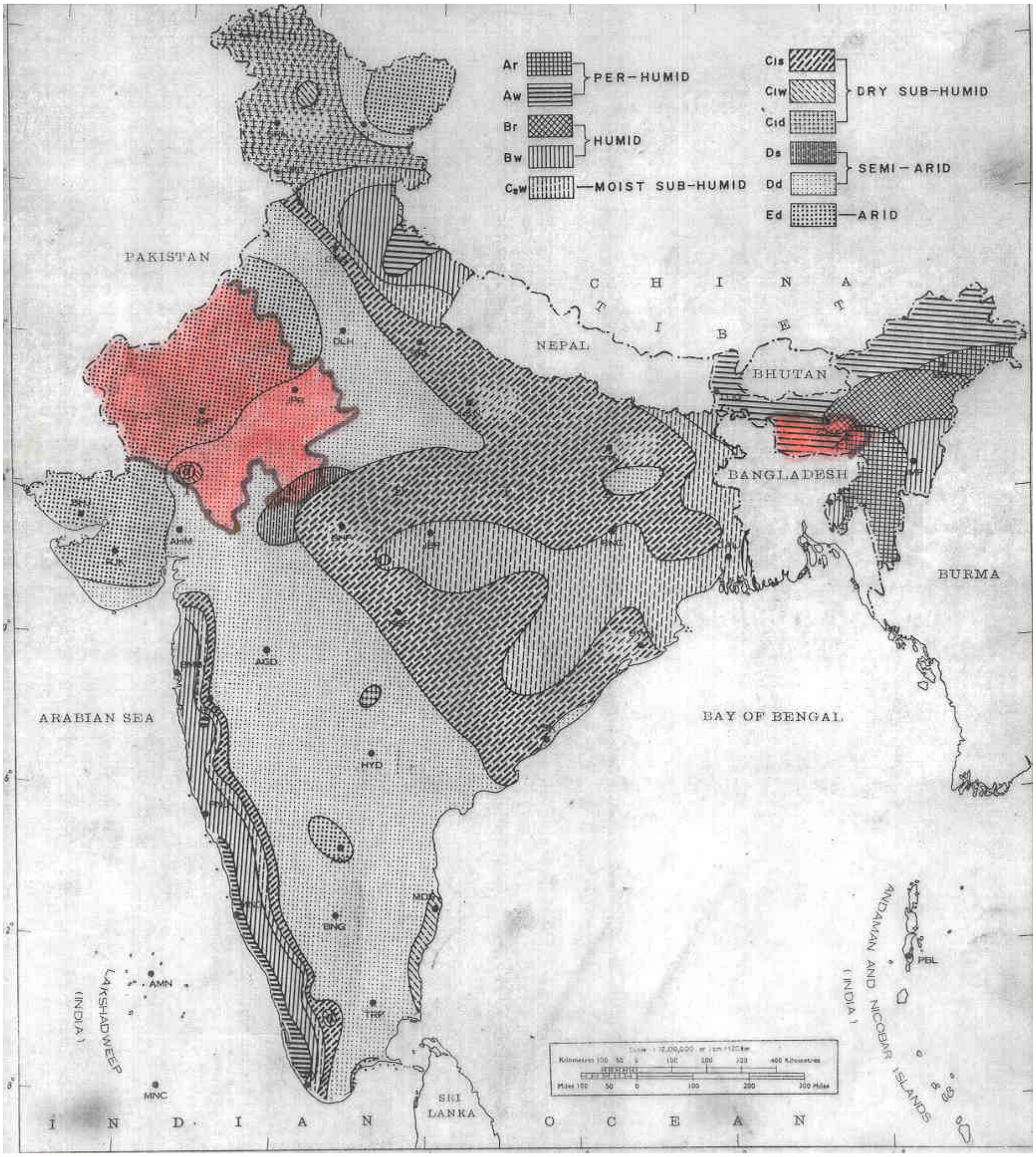


Agro-climatic map of India



Climatic map of India

Appendix-3

Table-1 Per 1000 distribution of households by MPCE class, and average MPCE separately for each primary source of energy used for lighting

MPCE Class	Primary source of energy used for lighting								No. of HHs	
	Kerosene	Other oil	Gas	Candle	Electricity	Others	No lighting arrangement	All	Estimated (00)	Sample
1	2	3	4	5	6	7	8	9	10	11
Rajasthan rural										
0-225	13	106	-	-	2	-	0	8	530	29
225-255	17	22	-	-	3	-	5	10	622	34
255-300	60	93	-	-	16	-	64	38	2444	107
300-340	61	53	-	-	39	-	32	49	3146	142
340-380	77	108	-	-	43	-	70	61	3896	194
380-420	95	66	-	-	72	-	50	83	5281	252
420-470	128	1	-	-	104	-	76	115	7305	333
470-525	121	160	-	-	125	-	68	123	7833	368
525-615	155	244	-	-	155	-	206	156	9912	498
615-775	159	126	-	-	218	-	110	187	11900	601
775-950	63	21	-	-	104	-	222	84	5369	322
950-more	51	0	-	-	119	-	96	85	5418	349
not recorded	0	0	-	-	0	-	0	0	0	0
all classes	1000	1000	-	-	1000	-	1000	1000	63656	3229
av.MPCE(Rs)	500	408	-	-	595	-	580	549	X	X
Estd.No.of hhs (00)	31279	392	-	-	31230	-	505	63656	X	X
No.of sample hhs.	1501	24	-	-	1667	-	26	3229	X	X

Table 2 Per 1000 distribution of households by MPCE class, and average MPCE separately for each primary source of energy used for lighting

MPCE Class	Primary source of energy used for lighting								No. of HHs	
	Kerosene	Other oil	Gas	Candle	Electricity	Others	No lighting arrangement	All	Estimated (00)	Sample
1	2	3	4	5	6	7	8	9	10	11
Rajasthan Urban										
0-300	35	-	-	-	10	-	-	12	236	30
300-350	78	-	-	-	23	-	-	27	543	47
350-425	142	-	-	-	54	-	-	61	1227	132
425-500	225	-	-	-	89	-	-	100	2000	175
500-575	134	-	-	-	105	-	-	108	2173	210
575-665	155	-	-	-	125	-	-	127	2551	225
665-775	90	-	-	-	102	-	-	101	2036	224
775-915	73	-	-	-	120	-	-	116	2330	226
915-1120	38	-	-	-	123	-	-	116	2330	227
1120-1500	18	-	-	-	113	-	-	105	2112	210
1500-1925	13	-	-	-	79	-	-	74	1479	153
1925-more	0	-	-	-	58	-	-	53	1063	126
Not recorded	0	-	-	-	0	-	-	0	0	0
All classes	1000	-	-	-	1000	-	-	1000	20080	1985
Av.MPCE(Rs.)	521	-	-	-	818	-	-	796	X	X
Estd.no.of his (00)	1610	-	-	-	18369	-	-	20080	X	X
No.of sample hhs	130	-	-	-	1844	-	-	1985	X	X

Table-3 Per 1000 distribution of households by MPCE class, and average MPCE separately for each primary source of energy used for lighting

MPCE Class	Primary source of energy used for lighting: Kerosene	Other oil	Gas	Candle	Electricity	Others	No lighting arrangement	All	No. of HHs: Estimated (00)	Sample
1	2	3	4	5	6	7	8	9	10	11
Meghalaya Rural										
0-225	0	-	-	-	0	-	-	0	0	1
225-255	0	-	-	-	0	-	-	0	0	0
255-300	9	-	-	-	1	-	-	5	15	4
300-340	28	-	-	-	10	-	-	19	55	21
340-380	53	-	-	-	32	-	-	43	122	45
380-420	91	-	-	-	44	-	-	68	195	69
420-470	148	-	-	-	90	-	-	120	345	117
470-525	154	-	-	-	156	-	-	158	456	151
525-615	268	-	-	-	222	-	-	245	706	209
615-775	151	-	-	-	291	-	-	219	630	202
775-950	65	-	-	-	63	-	-	64	184	54
950-more	34	-	-	-	90	-	-	60	174	59
notrecorded	0	-	-	-	0	-	-	0	0	0
all classes	1000	-	-	-	1000	-	-	1000	2881	932
av.MPCE(Rs.)	524	-	-	-	1371	-	-	563	x	x
estd.no.of hhs(00)	1493	-	-	-	1371	-	-	2881	x	x
no.of sample hhs	506	-	-	-	422	-	-	932	x	x

Table 4 Per 1000 distribution of households by MPCE class, and average MPCE separately for each primary source of energy used for lighting

MPCE Class	Primary source of energy used for lighting: Kerosene	Other oil	Gas	Candle	Electricity	Others	No lighting arrangement	All	No. of HHs: Estimated (00)	Sample
1	2	3	4	5	6	7	8	9	10	11
Meghalaya Urban										
0-300	-	-	-	-	0	-	-	0	0	0
300-350	-	-	-	-	0	-	-	0	0	0
350-425	-	-	-	-	0	-	-	4	3	1
425-500	-	-	-	-	6	-	-	11	8	5
500-575	-	-	-	-	38	-	-	44	31	16
575-665	-	-	-	-	69	-	-	64	46	23
665-775	-	-	-	-	166	-	-	158	114	49
775-915	-	-	-	-	269	-	-	248	179	67
915-1120	-	-	-	-	144	-	-	138	99	66
1120-1500	-	-	-	-	181	-	-	168	122	93
1500-1925	-	-	-	-	90	-	-	85	61	41
1925-more	-	-	-	-	37	-	-	82	59	23
Not recorded	-	-	-	-	0	-	-	0	0	0
All classes	-	-	-	-	1000	-	-	1000	722	384
Av.MPCE(Rs.)	-	-	-	-	697	-	-	972	x	x
Estd.no.of his (00)	-	-	-	-	660	-	-	722	x	x
No.of sample hhs	-	-	-	-	359	-	-	384	x	x

Table 5 Distribution of households by source of lighting in Rajasthan

Source of lighting	Total	Rural	Urban
Electricity	5,109,018	3,150,556	1,958,462
Kerosene	4,122,172	3,912,541	209,631
Solar energy	31,584	29,112	2,472
Other oil	19,443	17,179	2,264
Any other	12,720	8,780	3,940
No Lighting	47,357	38,535	8,822
Total number of households	9,342,294	7,156,703	2,185,591

Table 6 Distribution of households by source of lighting in Meghalaya

Source of lighting	Total	Rural	Urban
Electricity	179,597	99,762	79,835
Kerosene	234,716	224,878	9,838
Solar energy	1,114	968	146
Other oil	991	794	197
Any other	914	777	137
No Lighting	2,914	2,499	415
Total number of households	420,246	329,678	90,568

Table 7 Land holding in Rajasthan by size

Type of land holding	# of holdings in lakhs	% of total	Area (in lakh hectares)	% of the total
Marginal holding (up to 1 ha)	16.11	30.1	7.80	3.7
Small holding (1-2 ha)	10.85	20.2	15.66	7.4
Small-medium holding (2-4 ha)	11.17	22.8	31.85	15.0
Medium holding (4-10 ha)	10.64	19.8	66.17	31.1
Large holdings (more than 10 ha)	4.87	9.1	91.02	42.8

Source: Government of Rajasthan (1996), “Agriculture Census of Rajasthan 1995-96”. Directorate of Agriculture. Jaipur

Table 8 Distribution of households by type of fuel used for cooking in Rajasthan

Type of fuel used for cooking	Total	Rural	Urban
Total	9,342,294	7156703	2185591
Firewood	6,121,671	5499961	621710
Crop residue	969,981	916330	53651
Cowdung cake	383,830	339682	44148
Coal, Lignite, Charcoal	9,123	2939	6184
Kerosene	370,389	85715	284674
LPG	1,437,023	282926	154097
Electricity	7,280	5958	1322
Biogas	19,025	10134	8891
Any other	5,778	3690	2088

Table 9 Distribution of households by type of fuel used for cooking in Meghalaya

Type of fuel used for cooking	Total	Rural	Urban
Total	420246	329678	90568
Firewood	338600	310373	28227
Crop residue	5482	4623	859
Cowdung cake	254	148	106
Coal, Lignite, Charcoal	11309	2067	9242
Kerosene	23114	4194	18920
LPG	32520	3551	28969
Electricity	6211	2754	3457
Biogas	570	392	178
Any other	501	253	248

Appendix 6

Human poverty across eco-development region, 2000 (Nepal = 39.2)