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The Role of Decentralized Renewable Energy for Rural Electrification

Maharashtra case study, India

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Supervisor

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Abstract

Access to electricity is important to meet the Millennium Development Goals (MDGs). The centralized model of large thermal power stations and a central grid is a conventional system to supply electricity to consumers. This centralized model has failed to provide electricity and to achieve the rural electrification objective in developing countries. Un-electrified areas of the developing world are generally located in remote, hilly and forested regions, where grid extension is likely to be impossible for various reasons. Instead of this, decentralized renewable energy (DRE) for electricity generation has provided an avenue to electrify these remote areas and improve their social and economic conditions.

This research is an attempt to seek a balanced view between a centralized conventional source of electricity and decentralized renewable energy for rural electrification. Research has shown the various benefits of decentralized renewable energy (DRE) for rural electrification in Maharashtra, an Indian state. Maharashtra is presently experiencing serious electricity shortages, of around 4 GW. Therefore, prioritization of the distribution of electricity has led to conflict between the government and inhabitants of Maharashtra. Renewable energy (RE) has been looked at to provide electricity in remote areas of Maharashtra. However, there are around 5 554 villages that have not been electrified yet, and it would not be feasible to electrify them with centralized grid electricity.

This research concludes that there is indeed discrimination in terms of the quality of electricity supplied to rural consumers as compared to city-based domestic consumers. The way RE has been pursued in Maharashtra for rural electrification is not so impressive, and has been restricted to small-scale use and domestic lighting. The experience drawn from successful examples of DRE in other parts of India has shown that large-scale application of DRE is possible to replicate in Maharashtra. Nevertheless, this study has documented some challenges and barriers to DRE in Maharashtra.

Community perception towards RE, strong governmental policy in favour of DRE and the involvement of local government are some of the barriers. Simultaneously, development of a robust business model, a well established system for maintenance, economic viability and the sustainability of raw materials are some of the challenges. It is realized that if DRE is to provide superior benefits compared to centralized grid electricity in Maharashtra, it is of utmost importance to overcome these barriers and challenges.

Key Words: decentralized renewable energy, renewable energy, rural electrification, MDGs

Executive Summary

Electricity is an important sector for the economic development of any country. Access to electricity is a prerequisite to achieve the Millennium Development Goals (MDGs). The Indian energy sector is concentrated around a conventional system of electricity generation, which is composed of large scale thermal power plants and of a supporting infrastructure, including a grid for transmission and distribution of generated electricity.

However, this conventional system has failed to provide reliable electricity in rural parts of India. The Indian electricity sector has shown a shortfall of about -18 GW of electricity. The significance of access to easy and reliable electricity in rural parts of India has been recognized very early. Strides to reach the rural electrification target and provide electricity to everyone can be seen from the various initiatives undertaken by the government of India. However, the target of rural electrification is still incompletely met. Lack of willingness of state utilities[1] to develop the electricity infrastructure in rural areas, transmission and distribution losses, low revenue collection efficiency, highly subsidized consumers (such as farmers and poor communities) are some of the factors causing most concern.

According to section 6 of the Electricity Act 2003, the government of India decided to electrify all villages that were not yet electrified. It is thought that conventional as well as renewable energy will be used to achieve this objective; renewable energy sources would be used in a decentralized manner where conventional grid connectivity is not possible. The application of decentralized renewable energy for electricity provision and rural electrification has shown mixed results.

Decentralized renewable energy for electricity provision in Maharashtra

Maharashtra is one of the most industrialized states in India. Decentralized renewable energy has been pursued in Maharashtra in various forms and has shown mixed results. However, large scale decentralized projects are very rare; the use of decentralized systems is restricted to small scale domestic lighting sources. Conversely, successful large-scale projects have been executed in other parts of India.

In Maharashtra, 5554 villages still need to be electrified. In view of the present electricity shortage and of the debate on prioritization of the distribution of electricity in Maharashtra, it is the hour of need to initiate massive movement for renewable energy projects in a decentralized manner for rural electrification. Renewable energy is flourishing in Maharashtra; there is a huge potential for renewable energy, of around 8000 MW. Nevertheless, DRE for electricity provision in Maharashtra is found unsustainable.

Key issues identified for DRE in Maharashtra

Several issues have been identified in this research for the successful execution and long term sustainability of decentralized renewable energy projects in Maharashtra. It has been observed that for electricity provision, decentralized renewable energy cannot replace centralized conventional power generation completely. However, additional advantages associated with renewable energy make it a sensible choice as a reliable and economically feasible source of electricity in rural and remote areas, where conventional grid electricity cannot reach.

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[1] The state utilities refer to the state government undertaking companies responsible for generation, transmission and distribution of electricity in their respective states.

Issues identified for the successful implementation of decentralized renewable energy are;

1. Need for a robust business model
2. Assured supply of raw material
3. Technological issues
4. Economic viability
5. Less conducive government policies for decentralized renewable electricity projects
6. Social issues such as public perception, active involvement of local government

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1 Introduction

1.1 Background

International Energy Scenario

Access to clean, easy and affordable energy is an important factor to achieve Millennium Development Goals (MDGs) and therefore is considered as crucial for sustainable development and poverty reduction (Bhattacharyya, 2006; Takada & Charles, 2007; Takada & Fracchia, 2007). However, still after the 100 years of Edison's statement that *"we will make electricity so cheap that only rich will burn candle"* we still have 1.6-2 billion people who do not have access to electricity and 2.5 billion people still depend on traditional biomass for their domestic energy need. It is thought-provoking fact that the majority of these people are living in the developing world (Takada & Fracchia, 2007; UNDP, 2004; Zahnd & Kimber, 2009).

Nevertheless, global energy demand is increasing constantly and is mainly driven by the developing countries, since most of them are experiencing unprecedented growth. "The global electricity generation is projected to increase at an annual rate of 2.4% between the years 2004 and 2030, and will reach 30.36 trillion Kwh in year 2030" (Nath, 2008). At present the global electricity generation is around 21 trillion Kwh (EIA, 2009).

Moreover, the challenge is to keep this economic growth consistent, shun the climate change and global warming. The present electricity generation has been centered to the coal thermal power stations. Instead, the renewable energy in a decentralized manner has provided the avenue to overcome this dilemma and provide access to electricity to 1.6-2 billion people, who are living in remote areas and the villages that are not connected to the central grid. Even if connected to the central grid but does not have a reliable electricity supply. (Bhattacharjee, 2005; Takada & Charles, 2007).

Indian Energy Scenario

"India is experiencing a GDP growth rate of about 8% per annum, putting tremendous pressure on the power sector of the country" (Nath, 2008). This present growth pattern is expected to be unswerving in the future. The Indian energy sector is highly dependent on the use of fossil fuels, mainly coal. India is in the 6th position in the world energy market after the United States, Russia, China, Japan and Germany. As compared to population against the size of the economy the domestic energy production is low. "India's share of global energy production is 2.3% compared with the United States 21% and Europe 12%" (IEA, 2008).

Towards the end of the 10th five year plan the power scenario in India showed the total installed capacity of 132 GW. However, as on 30/11/2008 a slight increase can be observed and total installed capacity has been increased to the level of 147 GW. This increase in the capacity during the 11th five year plan can be seen due to the accelerated rural electrification targets and the ambitious target set by the government of India to provide electricity to everyone by the end of 2012 (IRPD, 2009). The sector-wise details can be seen in table 1.

Table 1 Installed capacity as on 30-11-2008

Sector	Hydro	Thermal				Nuclear	R.E.S. (MNRE)	Total
		Coal	Gas	Diesel	Total			
STATE	26825.7	42457.5	3912.1	602.6	46972.2	0.0	2247.7	76045.6
PRIVATE	1230.0	5241.4	4183.0	597.1	10021.5	0.0	10994.7	22246.2
CENTRAL	8592.0	29260.0	6639.0	0.0	35899.0	4120.0	0.0	48611.0
TOTAL	**36647.7**	**76958.9**	**14734.1**	**1199.8**	**92892.8**	**4120.0**	**13242.4**	**146902.8**

NOTE:- I) I.C. DOES NOT INCLUDE BENEFITS FROM PROJECTS IN BHUTAN.
II) R.E.S. INCLUDES :- SHP - 2160.48 MW , WIND - 9344.13 MW , B.P. & B.G. - 1650.43 MW ,U&I & SOLAR - 87.37 MW

Source: (IRPD, 2009)

It is worth noting here that even though operating with the full installed capacity; it has been found that at the end of the year 2008 in the month of November the Indian power sector succeeded to meet only 92 GW of demand, although the peak electricity demand was 107 GW, therefore having -15 GW of peak deficit. Again when looked at the overall peak deficit for the year 2007-08 it was -18 GW. The justification here could be the transmission and distribution losses, poor utilization of electricity at the user end and low efficiency of the power plants.

Table 2 Capacity addition during 11th plan (as per planning commission's target)

Sector	Hydro	Thermal				Nuclear	Wind	Total
		Coal	Gas	Diesel	Total			
STATE	3482.0	19985.0	3316.4	0.0	23301.4	0.0	0.0	26783.4
PRIVATE	3491.0	9515.0	2037.0	0.0	11552.0	0.0	0.0	15043.0
CENTRAL	8654.0	23350.0	1490.0	0.0	24840.0	3380.0	0.0	36874.0
TOTAL	**15627.0**	**52850.0**	**6843.4**	**0.0**	**59693.4**	**3380.0**	**0.0**	**78700.4 ***

NOTE:- * - AS PER ACTUAL ORDERS , THE CAPACITY COMES TO 78900.4 MW.

Source: (IRPD, 2009)

Energy is a vital part of development of any nation and keeps the economic growth rate consistent. The government of India therefore realized the need to expand the thermal electricity generation. In the current 11th five year plan of the government of India the net addition of 79 GW is proposed as shown in table 2. Including Hydro 16 GW, Coal 53 GW, Gas 7 GW and Nuclear 3 GW. It is important here to see that coal has the major share in this future capacity addition. This is certainly not positive news foreseeing the threat of climate change, poor quality of coal, inefficient thermal power plants.

Issues of electricity sector in India

In addition to the above discussion, the centralized conventional electricity generation and grid network has some issues that hinder the Indian electricity sector from achieving the 100% rural electrification target. The important issue is that the state-utilities had shown no interest to electrify the rural areas since there is not much economic gain in terms of monetary value as such to state-utilities; therefore there is utterly no consistency of supply of electricity in rural areas. Kalra et al (2007) author of the India's infrastructure report mentioned the fact that heavy loss of state-utilities over the years had direct implication for the poor implementation of rural electrification programs in India. (Kalra, Shekhar, & Shrivastava, 2007).

It has remained prime important for the Indian electricity sector to address this issue and find the long-term solution for sustainable development and provide easy and affordable access to electricity in rural India. Some of the reasons that exacerbate the prevailing situation are the following:

1. **Low user charges with high transmission and distribution losses**

In rural India electricity is supplied at a highly subsidized rate as compared to the city-based domestic consumers. However, the cost of transmission and distribution of electricity to these areas is very high. These areas are mainly characterized by the nature of highly scattered community therefore long and dispersed transmission and distribution lines, poor infrastructure; as a result the actual electricity delivered at the consumer end is very little. Then again low paying capacity, large number of subsidized customers aggravates this problem (Nouni et al., 2008).

2. **Low revenue collection efficiency**

The income is less in rural areas therefore the willingness to pay for electricity is low as compared to the city-based domestic consumers. As a result of this, revenue collection efficiency per unit of electricity delivered goes down. Promises of providing free electricity or subsidized electricity to the irrigation sector have always been the proclamation to grab this vote bank during elections all over the country. The actual price paid by agriculture and the irrigation sector in 2002 was around USD 0.5 cent/KWh. This was only 12.5% of the unit cost of supply. Political interference makes electricity highly subsidized in rural areas even though the state-utilities are operating under financial crunches. (IEA, 2002).

State-utilities in every state treat rural consumer shabbily. Since these rural consumers does not contribute towards monetary gain (Puri, 2006). Low revenue collected from the agricultural consumers limits the interest of state-utilities to develop transmission lines and provide quality supply of electricity in electrified villages. That sign the village can be electrified in a sense that the infrastructure would be there but not electricity anymore.

3. **Lower technical and operational efficiency**

In rural areas the awareness level for using electricity efficiently is very low. Therefore, they often operate at lower technical and operational efficiency which in a way aggravates the problem of electricity loss. Moreover, political interference, large number of unauthorized connections and power theft are some of the issues that make this situation even worst (PC, 2007-2012b).

In view of the fact that, most of the electrification will have to take place in rural and remote areas. It is of utmost important to improve the revenue generation rate if grid electricity has to be provided (IEA, 2002). Nevertheless, regular recovery is also an important issue in terms of decentralized electricity provision with large contribution from renewable to become financially sustainable. In many developing countries even if the rural areas have had a grid connectivity the supply of electricity is often interrupted and of poor quality (Chaureya, Ranganathana, & Mohanty, 2004).

In India the electricity sector has always confine to centralized electricity planning with large component of thermal power generation from fossil fuels and mainly dominated by coal. However, the evidences shown that this centralized planning has not been able to keep the balance between demand and supply at the moment (Banerjee, 2006). This centralized electricity generation has resulted in inequities, external debate, and environmental degradation, which can be seen from the fact that still near by 70% of Indian population live in rural areas and around 40% of total population live without any modern energy services (Kaundinya, Balachandra, & Ravindranath, 2009). This situation mainly arrived from the adoption of centralized energy planning, it snubbed electricity demand of rural poor community (R.B. Hiremath 2009). Centralized electricity generation with coal fired power plants all over the world has been the main culprit and major cause of climate change (Bell, 2007).

In the 11th five year plan of the government of India, the expansion of coal power generation to produce around 79 GW of electricity is expected. However, this would not be good news from the climate change point of view. If the government of India wants to meet the target of providing electricity to all by 2012, the government should think very seriously to provide electricity first to the remote areas, where the grid connectivity is not feasible. This can be done by deploying the large scale renewable energy (RE) options from the supply side and efficient energy management from the demand side. The efforts need to be in place from both sides (Reid, Simms, & Johnson, 2007).

Renewable energy in the Indian electricity sector

India has got a very high potential in the RE but still the total share of renewable in India's electricity sector is low around 6-8%. According to the estimates, RE could meet about 60% of India's total electricity supply by 2050 in a planned phased manner. But to make this happen in reality a change in the government spending pattern, concrete policy support for renewable in electricity sector is expected (Reid et al., 2007).

India is the only country that has got dedicated ministry for the renewable source of energy called Ministry for New and Renewable Energy (MNRE). It was established as a Department of Non-conventional Energy Sources in 1982 but started full fledge as an independent ministry only in 1992 as the Ministry for Non-conventional Energy Sources (MNES) but at a later stage in 2006 it has been renamed as a Ministry of New and Renewable Energy (MNRE) (MNRE, 2007-2008).

What is decentralized renewable energy for electricity generation?

What is decentralized generation (DG)? Decentralized electricity generation means "an electric power source connected directly to the distribution network or on the customer side of the meter" (Karger & Hennings, 2009). DG is also known as distributed generation. Karger and Hennings (2009) pointed out that size of the power plant may be varied from Micro-DG (below 5 kW) ,small DG (5 kW to 5 MW), medium DG (5- 50 MW), and large DG (50-300 MW) (Karger & Hennings, 2009).

MNRE is working on various fronts for the deployment of RE technology all over the country. The details of the achievement of RE targets as on 31/01/2009 can be seen in the Appendix 1.

1.2 Problem Statement in Indian Context

India is the fourth largest contributor to the greenhouse gas emission globally. India also accounts for about 4% of global Carbon-Dioxide (CO_2) emission. However the per capita emission is very little as compared to other developing countries. The main contributor to this emission has been the energy sector. The Indian electricity sector is mainly dominated by fossil fuels (mainly coal). About 60% of total electricity produced in India comes from burning of coal in the thermal power stations. On the other hand, very little contribution (around 6-8%) comes from the renewable sources in electricity sector.

There are around 80 000 to 140 000 villages in India that are not electrified yet. The government of India has an ambitious target of providing electricity to everyone by the end of 2012. The Electricity Act (EA) 2003, Integrated Energy Policy (IEP) of the government of India aims to electrify all these villages and around 23.4 million un-electrified households that are Below Poverty Line (BPL) providing up to 90% subsidy under the various schemes launched by the government. Out of these 140 000 villages around 18 000 villages are in the category of remote villages that are inaccessible through the central grid for electrification.

However, the villages that are electrified through the central grid often get low quality electricity supply, mainly ridden by blackouts. According to the EA 2003 decentralized renewable energy (DRE) sources could be used to electrify these remote villages (MoP, 2003).

The government of India is in favor of DRE for rural communities. Greenpeace is one of the most active international environmental NGO in India promoting DRE for electricity supply and has been very much active in Maharashtra on various fronts. Why would only renewable sources? There are other options which could potentially contribute and has been in practice since last several years, such as diesel generation. Nevertheless, increased oil prices, climate change, increasing greenhouse gas emission, this option has not seen as a favorable one.

1.2.1 Why Maharashtra?

For this research Maharashtra[2] has been selected as a case study. Lately Maharashtra has witnessed enormous debate on prevailing electricity shortage, extent of load-shedding (blackouts and brownouts) in urban and rural areas. Public interest organizations came forward with substitute. Greenpeace brought up this issue and wants to discuss the alternative solution at the national level platform.

The story started back in July 2008 when Congress General Secretary Mr. Rahul Gandhi[3] decided to visit the Vidarbha region. The Vidarbha has witnessed unabated suicides by farmers in 2006-2007. There are several reasons behind these suicides that includes mainly loss in agriculture output due to less rainfall, shortage of electricity that immobilize them from irrigating crop on time, harassment from money lenders, lack of health and medical facilities.

During this visit Rahul Gandhi decided to visit one village called "Jalka" located in Yavatmal district in Maharashtra. Where he met with a woman called Kalavati. Kalavati is a widow, her husband committed suicide in December 2007. She lives with 7 daughters and two sons. Jalka village were experiencing more than 12 hours of load-shedding during that period. During this

[2] It is one of the highly industrialized states and located in the central part of India.

[3] Gandhi is one of the most respected political family in India. Rahul Gandhi is a son of National congress party president Sonia Gandhi and grandson of India's first Prime Minister and freedom fighter Jawaharlal Nehru.

visit Rahul spoke to kalavati and her sons, he asked about their ambition, both said they want to become an administrative officer and businessperson respectively. Nevertheless, they do not have electricity in their house; they study after dusk under kerosene lantern. Kalavati is so poor that she could not afford to pay for electricity connection.

After this visit, in July 2008 trust voting for India-US nuclear deal had began. Rahul mentioned Kalavati's name during parliamentary speech and explained how poverty is closely related to access to electricity (Youtube, 2008). After this Kalavati became celebrity in an overnight. Now she has been offered electricity and other facilities from government. During 2009 Greenpeace has launched the campaign against upcoming power plants and prevailing electricity shortage. In March 2009 Greenpeace have donated solar panel to school building in the same village where Rahul Gandhi spoke to the woman. This village is still suffering from load-shedding. However, after installation of solar panels now students can run computer and study after dusk in the school building.

Greenpeace is promoting DRE for electricity provision in rural areas of India. This Jalka village case is just a representative case that fortunately brought up by media and got popularity after Rahul visited Jalka village. Nevertheless, there are thousands of kalavati those are waiting for electricity, proper healthcare system, educational facilities, and employment in rural parts of India. Initiative taken by Greenpeace in Maharashtra, shortfall of electricity even with biggest installed electricity generation capacity among all the states, inefficient power plants are main factors that have motivated to select Maharashtra for this research.

1.3 Aim, Objective and Research Questions

Greenpeace India strongly holds and claimed that decentralized electricity provision with large contribution from renewable is sensible option for rural electrification. DRE can provide as better as or superior benefits than traditional coal thermal electricity generation in Maharashtra.

The research intended to seek the balance view and test the hypothesis **"Decentralized solutions for electricity provision in rural areas with a large component of renewable is better and offer as better as or superior developmental, social, health and environmental performance than traditional centralized coal-thermal power generation"**. The way I test this hypothesis is seeking a triangulation and balance view from the experts working in the field of renewable energy in Maharashtra and the government officials working in the state electricity company. This research also depicts potential barriers and challenges for decentralized renewable energy; highlighting benefits of decentralized renewable energy if that would have been implemented sucessfully. The prevailing electricity condition in Maharashtra has been examined with the help of guiding research questions.

The study also investigates how and why centralized generation does not meet the objective of access to electricity, rural electrification and need of the poorest in the present scenario in Maharashtra. How prioritization of the distribution of electricity in Maharashtra often leads to situations where the poorest will be the last to get electricity and the first to have it taken away in times of shortage.

The objectives of this study will be guided by the research question **"How can decentralized renewable electricity provision be pursued in rural Maharashtra so as to yield developmental, social, health and environmental performance that is as better as or superior to traditional centralized coal-thermal power generation?**

The above mentioned research question has been the central question during this study. The sub-questions that followed the central question during interviews and the questionnaire survey are:

1. What is the present electricity scenario in Maharashtra?

2. How well do they meet it? In addition, why is their performance as it is?

3. How does prioritization of the distribution of electricity often lead to a situation where the poorest will be the last to get power and the first to have it taken away in times of shortage?

4. What is the present scenario of renewable energy sources in Maharashtra?

5. How does decentralized renewable energy contribute towards rural electrification in Maharashtra?

6. What are the barriers for decentralized renewable energy in Maharashtra?

7. What are the challenges that need to be overcome to deploy decentralized renewable energy in Maharashtra?

1.4 Scope of Thesis

The Maharashtra has led towards intentional load-shedding due to supply and demand mismatch. The concept that most of the environmental organization, public interest group mainly Greenpeace, India is in favor of; is that electricity can be provided in rural Maharashtra by deploying decentralized generation (DG) with large contribution from renewable sources. This can be connected to grid or work as an off grid.

The scope of this research is to investigate how decentralized renewable electricity be pursued in Maharashtra, what are the potential barriers and challenges and seek the balanced view on the above mentioned hypothesis in present situation. Benefits of DG in Maharashtra would be reported with the help of MDGs analytical framework. During this research decentralized electricity provision is considered as a system which generates and provides electricity on site where the consumers are located. It can be connected with central grid in some cases. However, decentralized system is seen as an independent system. Therefore, research will cover Stand-Alone (SA) and Grid-Connected (GC) systems.

However, the focus is on SA electricity generation that would not be connected with central grid and ultimately the small communities, villages and individual households will go off grid. RE is a basket of solution and technologies that have additional advantages if it is connected with central grid. Advantages being connected with central grid have been covered during discussion. Regulatory issues related to tariff for RE, renewable purchase obligation, its development and encouragement in the state of Maharashtra is not included in the study.

The geographical boundaries for this research and its applicability will purely be limited to the state of Maharashtra only. However, the same methodology and objective may be used for future study exploring the role of decentralized renewable energy for rural electrification in different parts of India. The targeted audience includes mainly the policy and decision makers at national and state level, NGOs, people living in the state of Maharashtra who does not have access to electricity, stakeholders involved in development of RE in Maharashtra.

The results of this research will also bring up suggestions that can be useful in the rural electrification initiative and will contribute to future planning to provide true, reliable, affordable and easy access to electricity in remote areas and villages in Maharashtra.

1.5 Methodology

Methodology for data collection is divided into two segments: secondary and primary sources. Secondary sources mainly consist of literature survey, peer reviewed articles and research papers, and government published documents. Data from the state department of electricity, documents published by international organizations such as World Energy Council (WEC), International Energy Agency (IEA) and World Alliance for Decentralized Energy (WADE), United Nations Development Programme (UNDP) has been used. Primary sources mainly consist of interviews and questionnaire survey with Indian and International experts (Appendix 2 and 3).

The peer reviewed articles and research papers were obtained by accessing the online library of Central European University Budapest, electronic data base and online research library of Lund University Sweden. Government published reports such as annual reports and data bases are obtained by accessing the library of Maharashtra Energy Development Agency (MEDA) and World Institute of Sustainable Energy (WISE) in Pune. Books and reports published by Ministry of New and Renewable Energy (MNRE), Central Electricity Authority (CEA), Tata Energy Research Institute (TERI) have been purchased from the publication division of the concerned institutions.

The data collected through this method is expected to provide information on the present scenario of electricity and RE sources in India and in the state of Maharashtra. This data is expected to provide information on past and current ongoing activities, available options for rural electrification with renewable energy sources, potential barriers and challenges; economical, environmental and social benefits of decentralized renewable energy in Maharashtra.

Field study was conducted during the month of February and March 2009. During this period data were collected and the structured interviews with the key persons have been carried out in Maharashtra with the above said methodology. The questionnaire was forwarded to different stakeholders, policy organizations that are analyzing the present situation, researcher in the field of decentralized RE sources. The questionnaire survey was conducted through E-mail by sending the questionnaire to the experts. The inputs from the conducted interviews and feedback received from questionnaire survey were analyzed against the actual data collected and the literature review. Based on this exercise final analysis and conclusion have been written.

To seek this information the identified informants were mainly government, public organization, research institutions, NGOs and stakeholders from electricity and RE field. The list includes prominent individuals that are heading the responsibilities for development of RE and working in the field of electricity in Maharashtra. The reason, why these people have been identified for interviews is that; some of them are senior civil servants of Indian Administrative Service (IAS) and presently heading the responsibilities of RE development in the state of Maharashtra being associated with the independent bodies establish by the government of Maharashtra as a nodal agency in the state.

In order to provide a counter balance to public servant views, structured interviews with decision makers from the State Ministry of Energy and Central Ministry of New and Renewable Energy are conducted.

1.6 Limitation and Assumption in Study

Field visit was conducted during the months of February and March 2009. The period of January until March is the closing period for the financial matters in India. During this period most of the organizations and key persons were busy with the auditing and clearing financial matters. During the field visit I could not manage to interview Central Minister for New and Renewable Energy, the government of India, since he was busy and parliamentary elections were scheduled in April 2009. Very few experts have responded to the questionnaire survey. Therefore, for further inputs the peer reviewed papers published by these experts have been used to represent their views. There are some assumptions made during the analysis of the data. That is because of the uncertainty and unavailability of the recent data on the rural electrification status in India and in the state of Maharashtra.

The intended study is to seek the balanced view on the said hypothesis. At some point reader might get impression that centralized electricity system is better than creating and installing say hundreds of decentralized renewable energy projects for electicity supply to the remote and rural areas.

1.7 Outline of the Study

The study is organized on the following lines:

Chapter 1: Set out background around central topic. Followed by problem statement in Indian context and gives you an idea why Maharashtra is selected for this study research. Further described on aim, objective, research questions, scope and methodology used for data collection and limitation and assumption made in this research.

Chapter 2: This chapter described a link between energy and Millennium Development goals (MDGs). How access to modern form of energy (electricity) is at the central part and prerequisite to achieve MDGs.

Chapter 3: This chapter will showcase the importance of decentralized renewable energy (DRE).

Chapter 4: In connection with rural electrification, this chapter gives an overview of different initiative and schemes launched by the government of India for rural electrification.

Chapter 5: This chapter addressed the research questions 1 to 5. While, set out overview of present electricity scenario in Maharashtra, status of rural electrification, prioritization of electricity distribution followed by renewable energy potential in Maharashtra.

Chapter 6: This chapter will answer the central question used in this research, followed by successful examples from other parts of India.

Chapter 7: This chapter analyzed different benefits that can occur from successful implementation of decentralized renewable energy. Identified benefits are organized with the help of MDGs analytical framework.

Chapter 8: This chapter presents the conclusion of the research study followed by some key message that is important to make decentralized RE happening in Maharashtra.

2 Theory framework: Millennium Development Goals (MDGs)

With the help of MDGs analytical framework I will showcase the potential benefits of DRE, how it can contribute to achive MDGs and what are the factors that make this concept unsustainable in present situation. MDGs framework is very useful to scrutinize the content of my research study. There is a clear link between different dimensions of poverty and access to electricity. These links explain how access to electricity is an important factor to achive MDGs. However, Millennium Development Goals (MDGs) has eight goals that need to be achived by 2015 and reflects worlds the main challenges. These are following,

Goal 1: Eradicate extreme poverty and hunger

Goal 2: Achive universal primary education

Goal 3: Promote gender equality and empower women

Goal 4: Reduce child mortality

Goal 5: Improve maternal health

Goal 6: Combat HIV/AIDS, maleria and other diseases

Goal 7: Ensure environmental sustainability

Goal 8: Develop a Global Partnership for Development

All above mentioned goals are interlinked with each other at the same time has a clear link with different dimensions of poverty. For the simplification purpose figure 1 has been used to described and explain the role of electricity in different MDGs.

The sustainable development and its importance was first time considered as a guiding principle for economic development and were incorporated in the public policy, right after the Brundtland report was published in 1987. Sustainable development is defined as "Development that meets the need of present without compromising the ability of future generation to meet their own needs" (IEA, 2001).

Energy is a driving force to foster economic, social and health conditions. Energy affect all the dimensions and supporting pillars of sustainability (IEA, 2001; Sharma, 2007). All of these supporting pillars namely Environment, Social and Economic should go hand in hand without compromising on its ability for the future generation to satisfy their own need. Poverty is considered as a major obstacle to achieve sustainable development. The clear link between poverty and access to modern form of energy i.e. electricity have been identified. This has first time realized by the international community during World Summit on Sustainable Development (WSSD) in the Johannesburg plan of implementation (Modi, McDade, Lallement, & Saghir, 2005; Zahnd & Kimber, 2009).

Poverty is not only a poor financial condition; but also can be defined as a poor social condition that reveals low educational level, poor health, nutrition condition and lack of infrastructure. Therefore, an urgent need for a long term solution to eradicate poverty has been realized. One way to overcome this dilemma could be by providing access to electricity in rural areas of developing countries (Kanagawa & Nakata, 2008; WB, 2001).

Research carried out by United Nations Development Programme (UNDP) aimed to investigate role of electricity to achieve MDGs; for instance, study conducted in Brazil, Mali and Philippines showed positive results. It has been very clear from these studies that the access to electricity will have a significant contribution in rural areas of developing countries towards poverty reduction, income generation, to raise educational level and reduce mortality (UNDP, 2005b).

There is a clear link identified between various indicators of sustainability and growth and it has been explained by Kanagawa et al (2008) and also pointed out by Modi et al (2009) that poverty in developing world is directly related to the access of reliable, easy and good quality of electricity. Therefore access to electricity plays a vital role to attain MDGs. Energy also have influence on socio-economic conditions of developing world and a strong influence on Human Development Index (HDI). Makoto and Modi further discoursed on the links that exist between energy and different components of poverty for achievement of Millennium Development Goals (MDGs) (Kanagawa & Nakata, 2008; Modi et al., 2005; Zahnd & Kimber, 2009) and can be seen from the figure 1.

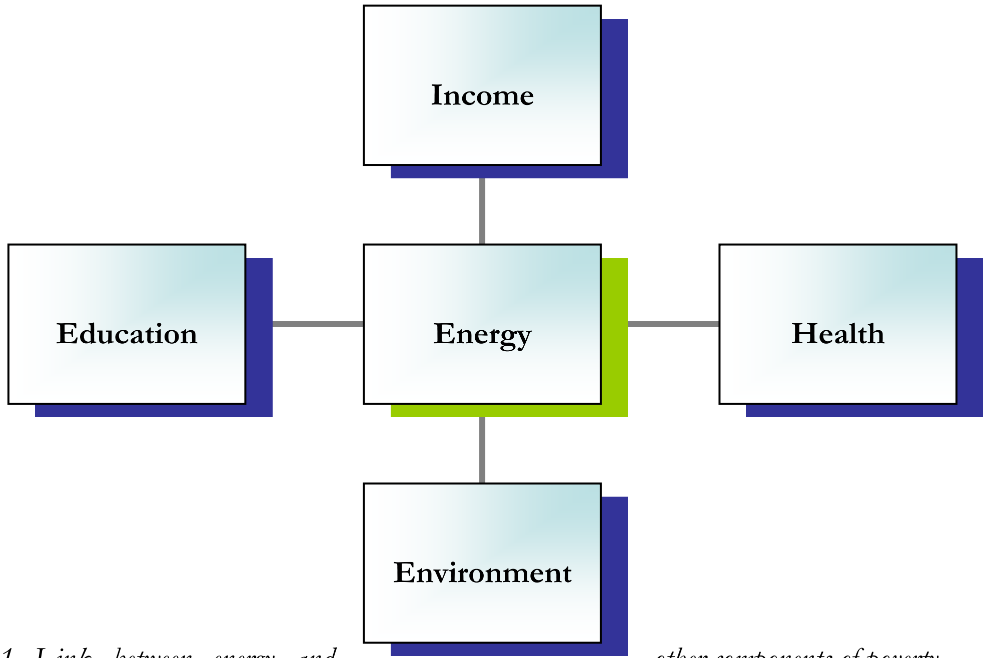

Figure 1 Link between energy and other components of poverty

Source: (Kanagawa & Nakata, 2008)

i) Energy and Income

Access to modern form of energy in rural areas plays a crucial role in income generation activities. Electricity will enable rural community to setup micro-enterprises, co-operative societies, small grocery shops, electrical appliances store. Rural electrification distribution and maintenance infrastructure will create secondary job opportunities for local community. Electricity access will revitalize local small scale business by mechanizing the activities that increases productivity of businesses.

Local small scale industry will expand while create additional business opportunity thereby increasing household income. Women co-operatives and handicraft business will mostly benefit from this. It would be possible for them to work and continue sewing after dusk which might not be possible without access to electricity (UNDP, 2004). The study conducted by UNDP in Mali region showed that mechanization of agriculture activities and micro-enterprises enabled women to increase their income almost by US $ 0.32/day (UNDP, 2005a).

ii) Energy and Health

Access to clean energy and its health benefits are well known. As mentioned before near by 2.4 billion people are still rely upon traditional biomass to fulfill their basic desires for instance heating, cooking and lighting. All of these activities pose serious chronic effect on health. Women and children are very susceptible to these health hazards. Indoor air pollution caused in order to fulfill these basic needs led to various health problems mainly diseases such as asthma, blindness, and heart diseases.

This has resulted in low life expectancy of woman and pre-mature death of infant. Access to electricity enabled to store vaccination and medicine in refrigerator. This has a vital importance particularly in the areas where medical facilities are located far from the community and entail significant time to commute incase of emergency (UNDP, 2004; Zahnd & Kimber, 2009).

iii) Energy and Environment

Use of clean energy enabled to use energy efficient appliances. This has helped to keep indoor environment clean and safe. Moreover use of RE sources will reduce the use of traditional fossil fuels avoiding deforestation. In this case agricultural biomass, cow dunk could be considered that would reduce deforestation. Natural resource depletion and climate change are other environmental benefits (UNDP, 2005a).

iv) Energy and Education

In rural areas school children do not get enough time to study. They often found busy in helping their parent with livelihood work. If they get some time after this back-breaking work they learn. Not having access to electricity in rural areas kept them away from study during night. Electricity will extend study hours after dusk when they return home from field. Mechanization of small household business will free these small children from strenuous work as a result of this available time they could use for study. Access to electricity will provide them chance to work with computer and other audio visual advanced educational materials (UNDP, 2004).

The role of electricity in sustainable development and to achieve MDGs has been realized worldwide and global efforts to provide electricity in rural areas have been increased. There are mainly two approaches for providing access to electricity in rural areas of developing countries (UNDP & GTZ, 2005).

i) This is more traditional approach, this concept will ensure access to electricity by developing centralized large infrastructure mainly power plants based on fossil fuels, central grid i.e. transmission and distribution system, and other supporting infrastructure.

ii) This is an innovative approach and active involvement of local community is needed. This concept will ensure access to electricity by developing decentralized system with large contribution of renewable sources. This goes well with local energy demand specifically energy need of the poor from developing countries, which are mainly depend on biomass and other traditional sources to meet their energy demand.

Having said that the importance of access to electricity in rural areas and its impact on socio-economic condiation; it is worthy to bring up the role of DRE could play in. Therefore, in this research MDGs analytical framework has been used for presenting and analyzing how DRE for electricity provision will contribute to achive Millennium Development Goals (MDGs) and plays a vital role in rural electrification. However, on the minus side of DRE such as the potential full cost of DRE versus the subsidised grid supply is important to address within the therotical framework.

Moreover, most of the developing countries are depend on centralized system of electricity. Centralized electricity with thermal power plants are very common and developing countries have copied this concept from developed world. Nevertheless, prevailing situation reflects that 1.6-2 billion people still live without access to electricity and majority of them live in developing world. That support to the proclamation that centralized system does not provide electricity to rural community in developing countries.

It has been observed from the literature review that energy is not mentioned in any of the MDGs. However, prerequisite through which MDGs can be achieved is access to electricity (Takada & Fracchia, 2007).

3 Decentralized renewable energy for electricity generation

In this chapter some of the key benefits of decentralizd renewable energy for electricity provision have been discussed. The MDGs analytical framework, links between different dimensions of poverty and access to electricity has been discussed in chapter 2. The discussion below is an attempt to clarify and highlight the various benefits of DRE in rural areas that contribute towards different MDGs.

Every coin has two sides. This is also true in case of DRE for electricity provision. It is very hard to convince rural communities to trust this concept, because for most of them this is something like alien. On the one hand this concept has got some potential advantages over conventional system on the other hand some potential hurdles that keep this concept to become sustainable one. Nevertheless, the factors that make DRE a better and viable option for electricity provision are, the potential of renewable sources available locally, significantely less transmission and distribution losses, economical viability of DRE in remote areas as compared to grid electricity. It is a fact that there are several issues that need to overcome. These are sensitization and capacity building of the local community, technical difficulty in maintenance and operation of say hundreds of decentralized renewable electricity generating stations, financial sustainability and business flow.

Decentralized electricity is well known in different parts of world with different names. It is known as distributed generation, on-site power, stand alone, embedded generation, captive power, backup generation, uninterruptible power, cogeneration, district energy. There are differences in names known to different parts of the world but the concept they share in common is that they generate electricity on site wherever it is needed (Bell, 2007).

Electricity is one of the strong driving force for economic development of any nation and considered as a fundamental need of human beings (Kaundinya et al., 2009). In our day to day life electricity is required for almost all activities it would not be wrong to say that every day everything begin with electricity and end up with electricity. The importance of renewable sources for generation of electricity has been increased globally. It is a proven fact that renewable source of electricity has got a potential to play a vital role in economical development of any nation and there is a clear link between access to electricity and poverty in rural areas (Camblong et al., 2009; Kaundinya et al., 2009; Zahnd & Kimber, 2009).

Access to electricity in rural areas showed a positive impact on economic and social activities of vulnerable rural community. It has a positive impact on the basic activities that contribute in a big way to overall development, for instance pumping of water for irrigation and drinking purposes, lighting that extend working and learning hours after dusk (Chaureya et al., 2004). According to the report published by UNDP "A review of Energy in National MDGs" confirmed that "energy is the fundamental prerequisite for achieving the millennium development goals(MDGs) without access to the reliable and affordable energy services specifically electricity, substantial social and economic development can not occur" (Takada & Fracchia, 2007).

Given the fact that India is an agricultural country and most of the population (around 70%) lives in rural part of India. There are still 80 000 thousand to 140 000 thousand villages in

India that have not electrified yet. Out of these, 18 000 are remote villages where grid can not reach due to geographical and economical disadvantages (Cust, Singh, & Neuhoff, 2007c; Pillai, 2005; TERI, 2007c). Therefore there is no possibility of having electricity in these villages through central grid in near future. The option that exists and most of the international environmental organization holds strongly is decentralized electricity generation with a large contribution of renewable sources. These groups have claimed that with commercial maturation, these small scale decentralized electricity provision systems are viable option and could provide most promising alternative for rural electrification (Cust, Singh, & Neuhoff, 2007a; R.B. Hiremath 2009; UNDP, 2004; WB, 2008).

Now it has been recognized worldwide that decentralized electricity generation can reduce capital investment significantly by avoiding transmission and distribution losses. Decentralized electricity system with renewable sources could provide reliable, affordable, environmentally sustainable electricity in rural areas (R.B. Hiremath 2009). In addition to that decentralized electricity generation can reduce cost of electricity per unit, it is a clean form of energy results in less pollution, less emission of green house gases, less vulnerable to extreme whether and terrorist attacks (WADE, 2003).

Rural areas will have a high advantage for decentralized generation (DG) of electricity from renewable sources. RE sources are available locally for example biomass, hydro, wind and solar. In rural areas due to large scale agriculture activities biomass is readily available, hilly areas in the country side are ideal places for harnessing wind energy and for solar large surface area is available. However, in urban region, total area for capturing solar energy is less due to high urbanization and concrete jungles. Biomass is not available locally due to agriculture business situated in rural areas. At the same time use of DG has a number of additional benefits. Fuel transportation cost and grid connection cost can be avoided, effective use of resources that are available locally. While transmission and distribution losses can be saved at a great extent. DG can provide clean, cost effective and reliable electricity.

Addition to above mentioned benefits; economical growth of rural areas can be accelerated, employment generation, support to secondary business that will generate revenue stream for local community. Researchers claimed that decentralized electricity system with renewable energy sources is essential for rural electrification in developing countries (Cust et al., 2007a; UNDP, 2004). In a view of the above situation the MoP the government of India has proposed to create Rural Electricity Distribution Backbone (REDB) and Village Electricity Infrastructure (VEI). This include distribution transformer where the grid connectivity is available. On the other hand decentralized electricity generation with large contribution from renewable sources and its distribution where grid connectivity is not economically and geographically feasible (Kalra et al., 2007).

According to the planning commission (PC), envisaged growth of economy at 9% in the 11th plan can not be achieved without significant increase in availability of electricity. The challenging task before the government of India would be, to continue this GDP growth, although provide easy, affordable and reliable access to electricity while contribute to combat climate change (PC, 2007-2012b). It is estimated that "in rural north India 30 billion hours are spent annually in gathering fuel-wood and other traditional fuels, time to gather fuels, time lost in sickness, and cost of medicine is estimated to be some INR 300 billion[4] (around

[4] 1 USD= 47.17 INR, http://www.xe.com/ucc/convert.cgi on 22 May 2009

6.6 billion USD)" (PC, 2007-2012a). It has proved that strong co-relation between access to electricity in rural areas and increased in State Domestic Product (SDP) exist.

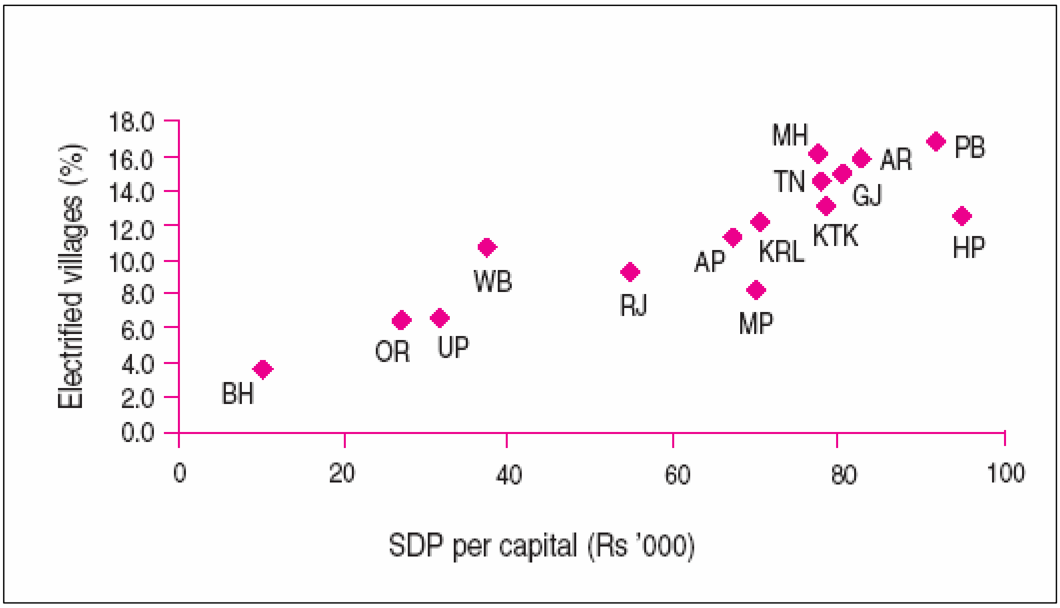

Figure 2 Domestic product and percentage of electrified villages

Source: (Kalra et al., 2007)

Figure 2 showed the relationship between state domestic product per capital on X axis versus percentage of electrified villages in the given state on Y axis. Based on the above graph it is clear that electricity provision in rural areas of different states in India had a positive impact on SDP (Kalra et al., 2007). It would not be wrong to say that electricity plays a vital role in economic development of rural areas and help to uplift living standard by providing various income generation opportunities and ultimately make a significant contribution in the overall development of rural areas.

Therefore, it is prime important for the government of India to provide electricity in rural and remote areas to maintain robust economic growth and decent standard of living in the near future. The time has come when Indian government and Indian businesses sector would need to invest in low-footprint technologies, renewable source of energy and resource efficient urban infrastructure (Godrej, 2008). Even at International level some of the countries have realized the significance of decentralized electricity infrastructure. For instance the government of Azerbaijan realized that decentralized electricity infrastructure is better than building up an centralized power stations to meet anticipated demand in future (Bell, 2007).

4 Rural electrification In India

Electricity plays an important role in rural development. Energy services in rural areas had given a prime attention. Most of the developed countries realized its importance in the nation building process and even considered seriously as a human right. This can be seen from the example of industrialized country like UK which has a people centered approach that enable the "rights-based agenda" (Tully, 2006).

Owing to the close relationship as discussed in chapter 2 between electricity and various dimensions of poverty to achieve MDGs. The government of India initiated several initiatives for rural electrification. Rural electrification has become a key objective under section 6 of EA 2003 which has brought Indian electricity policies and regulations under one umbrella (MoP, 2003).

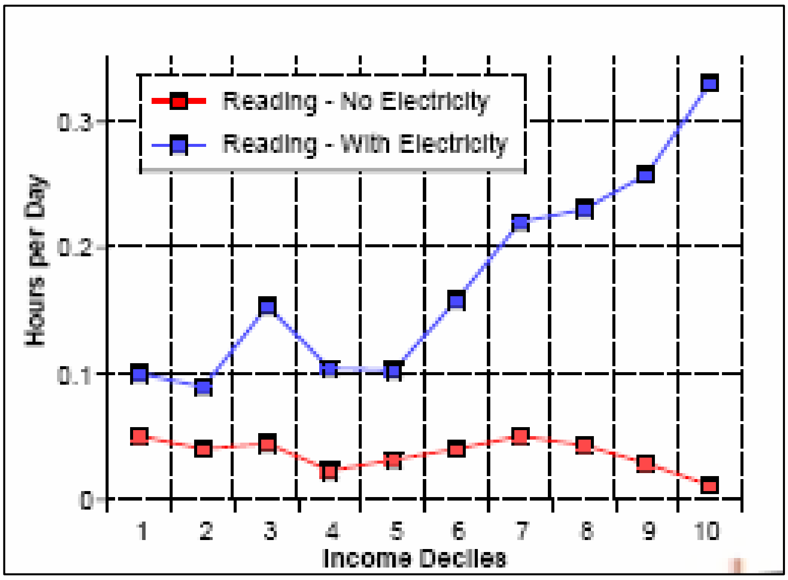

Figure 3 Women Time Use HH with and without electricity

Source: (Reiche, Covarrubias, & Martinot, 2000)

The important of access to electricity in rural areas has been justified time to time by the international organizations. The study conducted by UNDP proved that access to electricity in rural areas of India has a significant impact on social and livelihood activities of women. A figure 3 showed the relationship between income decile on X axis versus hours per day spent for reading on Y axis. It is observed that time used for reading activity has been increased significantly with electricity scenario. Contrary it has been decreased with no electricity scenario.

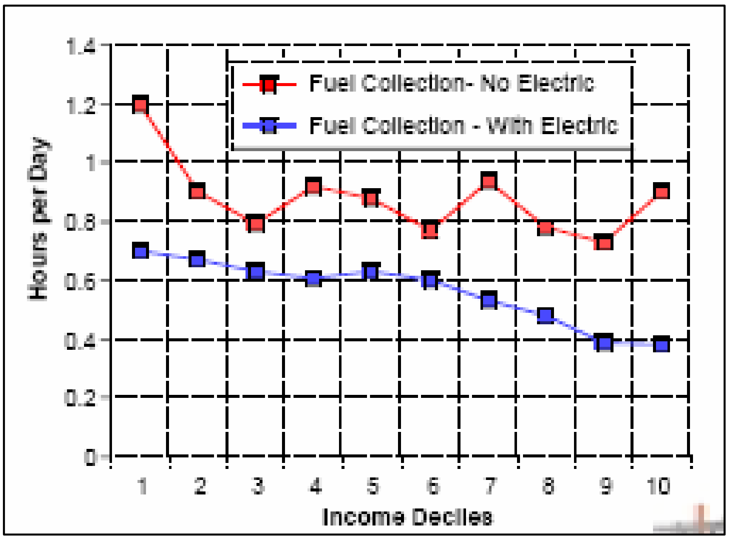

Figure 4 Women Time Use HH with and without Electricity

Source: (Reiche et al., 2000)

While figure 4 showed that women in absence of electricity will have to spend more time for collection of fuels such as cow dung, wood, agricultural residue, biomass for domestic lighting; such as cooking and heating application. However access to electricity has reduced the time spent for fuel collection.

The concept of rural electrification in India has gone through the various restructuring processes. Earlier concept of rural electrification was different and main focus were concentrated on "electrification for irrigation" to improve agriculture output. This concept was accepted until 1997 and was officially defined as " a village is deemed to be electrified if electricity is being used within its revenue area for any purpose whatsoever" (MoP, 2008).

This definition had changed in 1997 with consultation of the state-utilities and state governments and new definition was proposed " A village deemed to be electrified if-electricity is used in inhabited locality within revenue boundary of the village for any purpose whatsoever" (MoP, 2008).

Moreover, finally in 2004 definition of rural electrification has become more focused and detailed. According to this new definition formed in 2004 "A village would be declared electrified if;

1. Basic infrastructure such as distribution transformers and distribution lines are provided in the inhabited locality as well as in dalit basti[5]/ hamlet where it exists. (For electrification through Non-conventional Energy Sources a distribution transformer may not be necessary)

[5] People lives away from the main inhabited area of the village. They are so-called "untouchable"

2. Electricity has to be provided to public places like school, panchayat[6] office, health centre, dispensary, community centre, etc. and

3. The number of households electrified should be at least 10% of the total number of households in the village" (MoP, 2008).

The government of India launched various innovative programs for rural electrification. Some of them have got a remarkable success but some of them got trapped in for their own interest. The various programs run by the government of India have been discussed in the section 4.1 government initiatives in India for rural electrification.

The present status of rural electrification based on the current definition is unclear, and yet to be verified and reported by the Ministry of Power (MoP). However, some of the researchers claimed that "Officially, over 500 000 thousand of India's 600 000 thousand villages are "deemed" to be "electrified": defined as a minimum of 10% of households being connected to power supply" (R.B. Hiremath 2009).

There are still 80 000-140 000 thousand villages that need to be electrified in coming years. It is also interesting to see that the government of India has a target to electrify 100% villages by the end of the year 2007 and a 100% household electrification by the year 2012. From the above data it is clear that the target of 100% village electrification is still fragmentary (Cust et al., 2007a; TERI, 2007c). There is an uncertainty on success and achievement of rural electrification and data published, claimed, and reported by the different institutions and researchers. But the actual data according to latest definition yet to be reported by the Ministry of Power (MoP) (PC, 2007-2012b).

Moreover, for further analysis and discussion detailed data published by TERI Energy and Research Institute has been used (Appendix 4, 5 and 6). It is worthwhile to mention here that even several strides taken by the government of India for rural electrification not much progress can be seen. There are several reasons behind this slow progress. One most important reason is that in 1990s focus had shifted towards commercial operation of the state utilities this had a negative effect on progress of rural electrification programs initiated during this period (C.Bhattacharyya & LeenaSrivastava, 2008).

Government of India has been very keen to increase total share of RE sources in total electricity generation capacity of India. It has been predicted that share of RE in total electricity generation will reach up to 10% by the year 2012. On the other front the government of India is also working on decentralizing energy system at rural and semi-urban level. In this concept management and distribution of electricity systems will be taken care off by users. The efforts of setting up energy co-operatives are under way. There are some pilot projects implemented in India. Moreover, urgent need of National Renewable Energy Policy (NREP) to deal with these issues that hamper rural electrification program through decentralized renewable energy sources have been realized (Chaureya et al., 2004; R.B. Hiremath 2009).

[6] Local government

4.1 Government Initiatives in India for rural electrification

4.1.1 Rural electrification under Minimum Needs Programme (MNP)

This program has been launched during 5th five year plan; rural electrification was added as one of the component in this programme. The fund was provided to the state governments under this programme in the form of partly loan and partly grant. The area which was proposed to electrify under this programme were remote and difficult villages with low load potential. Unfortunately this scheme was discontinued in 2004 and further got merged in Rajiv Gandhi Gramin Vidyutikaran Yojna. Details of Rajiv Gandhi Gramin Vidyutikaran Yojna are mentioned in the section 4.1.6 (MoP, 2008).

4.1.2 Pradhan Mantri Gramodayan Yojana (PMGY[7])

This scheme was launched in 2000-2001 and the component of rural electrification was added in the later part of 2001-2002. Under this scheme grant were issued by central government to the state governments on a normal pattern of the government of India, which includes 90% grant and 10% loan for special category of states and 30% grant and 70% loan for other states. In this scheme State Board of Electricity/Electricity Department/Power Utilities were given responsibility to implement the scheme. This scheme was discontinued from 2005-2006 (MoP, 2008).

4.1.3 Kutir Jyoti Scheme (KJC[8])

This programme was launched in 1988-89. The aim of this programme was to provide single point light connection to households that are below poverty line (BPL) and this included harijans[9] and adivasi[10] families. Under this scheme about 6 million households were connected to electricity in 15 years (Kalra et al., 2007). The prime important was given to the states having higher rural population and low village electrification level. Further this scheme was merged in Rajiv Gandhi Gramin Vidyutikaran Yojna (MoP, 2008).

4.1.4 Accelerated Rural Electrification Programme (AREP)

AREP was launched in 2003-2004 and was restricted to the electrification of non-electrified villages/electrification of hamlets/dalit bastis/tribal villages and electrification of households in the villages through conventional and non-conventional source of energy. Interest subsidy through the state-utilities to implement this programme was provided (MoP, 2008).

4.1.5 Accelerated Electrification of one hundred villages and 10 million households

This scheme was introduced by the government of India in 2004-05 by merging interest subsidy scheme AREP and Kutir Jyoti programme. The 40% capital subsidy was provided for rural electrification projects and balance amount as a soft term loan through Rural

[7] Prime Minister Village Development Scheme

[8] Cottage light Scheme

[9] So-called untouchable

[10] Tribal

Electrification Corporation (REC). This scheme is now merged in Rajiv Gandhi Gramin Vidyutikaran Yojna (RGGVY) (MoP, 2008).

4.1.6 Rajiv Gandhi Grameen Vidyutikaran Yojana (RGGVY)

According to the Ministry of Power, RGGVY has been launched in April 2005 to achieve National Common Minimum Programme objective, to provide electricity to all households within four years (MoP, 2008). The objectives of this programme are;

1. to achieve 100% electrification of all villages and habitations in India
2. to provide electricity access to all households
3. to provide free-of-cost electricity connection to BPL households

To achieve these aforementioned objectives under RGGVY the government of India envisioned of creating;

1. Rural Electricity Distribution Backbone (REDB) with at least 33/11 KV (or 66/11 KV) substation in each block.
2. Village Electrification Infrastructure (VEI) with at least one distribution transformer in each village/habitation
3. Decentralized Distribution Generation (DDG) system where the grid is not cost effective or feasible.

Under the RGGVY scheme, until 45 602 villages have been electrified and 25 087 villages electrified intensively between April 2005 and January 2008. Moreover, 228 7016 rural households that included around 187 6216 BPL households given free of cost connection (MoP, 2008).

4.1.7 Rural Electrification via Renewable Energy Sources

At the end of 10th five year plan of the government of India renewable energy sources succeeded to meet only 1% of rural energy need; therefore, in the subsequent plan i.e. 11th five year plan, there are two programs introduced based on renewable energy. Namely, Remote Village Renewable Energy Programme (RVREP) and Grid-connected Village Renewable Energy Programme (GVREP). Each of these programs further has two sub-components as described below (McKenzie & WISE, 2008).

4.1.7.1 Remote Village Renewable Energy Programme (RVREP)

4.1.7.1.1 Village Energy Security Programme (VESP)

VESP meant to electrify and ensure energy security of un-electrified villages and its hamlets by deploying decentralized renewable electricity systems. This scheme also ensured to provide 90% of actual cost of the system or INR 2.25 million[11] (around 47 000 USD) per system per village of 100 households whichever is less. Physical target for this programme in the 11th five year plan is 1 000 remote villages/hamlets.

4.1.7.1.2 Remote Village Solar Lighting Programme (RVSLP)

RVSLP aimed to distribute single light solar lighting system for remote villages and its hamlets. Under this scheme subsidy to cover 90% of actual cost of a system is given or INR 7 200[12]/system/household (around 153 USD) which ever is less. The target under this scheme for current 11th plan is allocation of 9 000 systems.

4.1.7.2 Grid-connected Village Renewable Energy Programme (GVREP)

4.1.7.2.1 Solar Thermal Systems

Under this programme, it is expected to allocate solar flat plate collector for hot water. The physical target of 1 million m^2 has been decided during current 11th five year plan. For cooking and drying application solar plate collector with physical target 0.5 million m^2, concentrating type cooker application with physical target 2 million m^2 has been decided.

4.1.7.2.2 Biogas Plants

Mainly consist of family type of biogas plants for cooking application purpose with physical target 2 million m^3 to be achieved during current 11th five year plan.

[11] 1 USD= 47.17 INR, http://www.xe.com/ucc/convert.cgi on 22 May 2009

[12] 1 USD= 47.17 INR, http://www.xe.com/ucc/convert.cgi on 22 May 2009

5 Maharashtra case study

5.1 Electricity scenario in Maharashtra

Maharashtra is one of the most developed states in India with a population of around 96 million. It has a key position in political and economical development of India and account almost for 9% of India's population. The total land area is 308 thousand km^2 (DES, 2008; Nath, 2008).

Mumbai is the financial capital of the country and capital of the state of Maharashtra. Geographically Mumbai is situated on the Western coast of the state facing to the Arabian Sea. The total population of Mumbai is around 12 million and is one of the biggest city in India (DES, 2008; Nath, 2008). The Maharashtra state is having the biggest installed electricity generation capacity in among all the states in India (MoP, 2008). The present electricity scenario in Maharashtra shown in table 3

Table 3 Demand, availability and shortfall in the month of March 09 in MW (Mega Watt)

Peak demand of MSEDCL[13]	14 200 to 15 332 MW
Availability	10 000 to 11 536 MW
Shortfall	3 796 to 4 200 MW
Tata Power Company Limited (TPCL) + Reliance Energy Limited (REL)	2 400 MW
Peak demand of Maharashtra	16 600 to 17 732 MW
Availability	12 400 to 13 936 MW
Shortfall	3 796 to 4 200 MW

Source: (Er.Mohod, 2009)

The data above showed that overall electricity generation in Maharashtra does not meet total requirement. According to Pimparkhedkar (2009) nearly decade and half ago, Maharashtra was an electricity surplus state. However, the capacity addition is not realized as envisaged in the last two five year plans. In 2006-07 the installed capacity in the state increased marginally by 348 MW which comes through renewable energy sources.

In order to improve the scenario the government of Maharashtra have signed memorandum of understanding (MoU) with 8 private sector companies in 2005-06 under public private partnership for total capacity addition of 12 500 MW. Most of these proposed projects are Ultra-Mega thermal power projects. Nevertheless, progress in this regard is very slow no project has been commissioned yet; reasons being fuel linkage, high cost of generation and

[13] Maharashtra State Electricity Distribution Company Limited.

depletion of conventional energy sources of energy (Pimparkhedkar, 2009). Present average availability of electricity in Maharashtra is shown in table 4

Table 4 Present average availability of electricity in the state of Maharashtra

Sr. No.	Name of the project	Installed Capacity in (MW)	Average Peak availability in (MW)
01	Mahagenco Thermal	6 800	4 900
02	Mahagenco Hydro	2 344	1 400
03	Mahagenco Gas	852	600
04	Central Sector	3 382	2 600
05	Ratnagiri Gas and Power Ltd. (RGPPL)	740	610
06	Tarapur	160	150
07	Sardar Sarovar	392	110
08	Pench Hydro	53	10
09	Ghatghar Hydro	250	100
10	Independent Power Producer	0	0
11	Ultra Mega Project	0	0
	Total Installed Capacity	14 973	10 480

Source: (Er.Mohod, 2009)

5.2 Status of rural electrification in Maharashtra

Rural electrification has been the vital part of energy planning in India and in Maharashtra. The important of rural electrification recognized very early and therefore given special attention in the energy planning documents. The analysis published by MEDA in 2004, it has been observed that there are near about 333 remote villages in Maharashtra that have not electrified yet and will not be possible to electrify them in future through central grid (MEDA, 2004).

The following map of Maharashtra showed the location of those 333 remote villages. Most of them are clustered in specific areas (Nandurbar district, Melghat region, Gadchiroli district). These areas are mainly thick forest region and hard to reach (5 to 20 km) from nearest grid line. Therefore, these villages are categorized as remote villages where grid extension is not feasible economically and geographically. The circular spots shown in the map represents those 333 remote villages (MEDA, 2004)

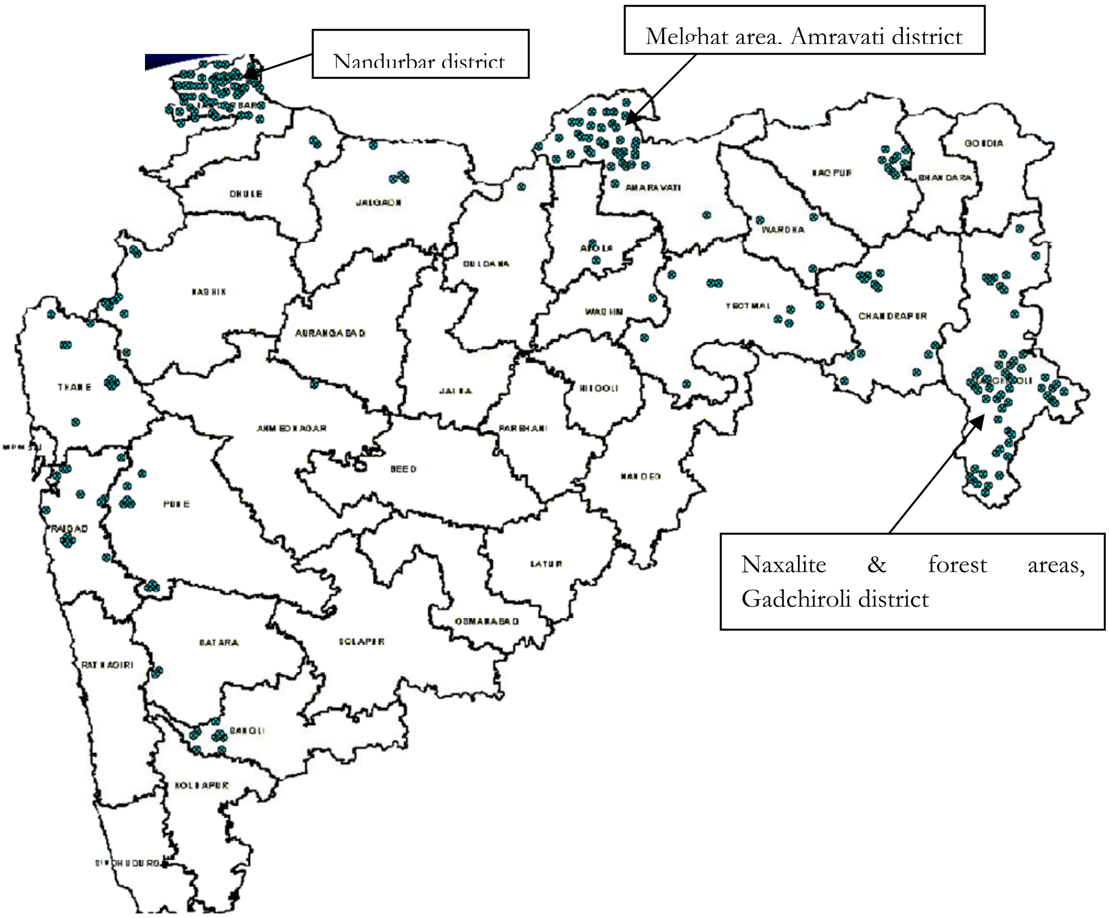

Figure 5 Non-electrified remote villages in Maharashtra

Source: (MEDA, 2004)

Contrary the data published by TERI in 2007, Maharashtra has 87% of village electrification rate as on 31st March 2006. According to TERI there are still 5 554 villages in Maharashtra (Appendix 4) that have not electrified yet, but it has not been clarified that whether this data include both category of villages remote as well as villages that are not considered as electrified based on new definition of village electrification. However, primary sources for this data used by TERI are government organizations such as MoP, CEA and MNRE.

Therefore, for further analysis and discussion it has been realized that data published by TERI is more reliable, accurate and complete as compared to data published by MEDA. It has been assumed that figure 5 554 include both categories of villages; remote as well as villages that are not deemed as electrified as per new definition of village electrification. However, accurate and updated data on the achievement of rural electrification and remote villages yet to be reported by the Ministry of Power (PC, 2007-2012b; TERI, 2007c).

"The criteria upon which State Electricity Boards (SEBs) identify these 'remote' villages are largely based on physical constraints such as hard-to-reach locations, rather than an optimization of the economically appropriate mix between grid and off-grid solutions. In these 'notified' regions it is the responsibility of the MNRE's state nodal agencies for instance in the state of Maharashtra this is the responsibility of Maharashtra Energy

Development Agency (MEDA) to implement renewable energy projects in order to meet central government targets" (Cust et al., 2007a).

Moreover, total pump-sets energized in Maharashtra during 1997 was 188 3152 numbers which has been increased upto the level of 262 3272 numbers as on March 2006 (Appendix 5). It should be noted that Maharashtra has largest pump-sets energization rate among all the other states in India; followed by Andhra Pradesh with total 244 0823 numbers of pump-sets (TERI, 2007a). This can be justified by the first definition of village electrification which was more focused on to increase agriculture out put by electrifying pump-sets. Contrary there are more than 10 million households in Maharashtra. Household electrification rate is around 65% and still there are around 35% households that need to electrify (Appendix 6).

Nevertheless, if we observe this situation of ambiguity of data, one thing is clear that no matter given data is based on an old definition or new, but still there is a plenty of scope for rural electrification. However, it is also worth mentioning that in response to one of the question that has been asked to MSEDCL officer; what is the present rural electrification status in Maharashtra? he replied saying that 100% electrification has been achieved (Er.Mohod, 2009). It reflect itself a reluctance of state-utility to except this fact that they failed to attain rural electrification target.

Further more in remote areas for instance area of Melghat[14] where majority of population is Below Poverty Level (BPL) and belong to tribal community. Under RGGVY government is entitled to provide subsidized electricity connection. However, it has been claimed that people are not willing to take electricity connection. Justification given is that they preferred to stay in dark and not willing to pay for electricity (Er.Mohod, 2009).

Given the fact of load-shedding and incomplete rural electrification target; the government of Maharashtra has decided to go for a capacity addition in thermal power generation from coal. According to MSEDCL, it has been claimed that this future capacity addition will help to meet the target of rural electrification and will provide electricity to all people living in Maharashtra. Nevertheless, the issue of electrifying remote villages would not be solved considering the fact that grid connectivity is not possible in some villages.

In response to one of the question during questionnaire survey Pimparkhedkar and Prof. Ghotge pointed out that centralized new capacity addition would not help to achieve rural electrification. It is a fact that fossil fuel is the only source for centralized new capacity addition. Dependence on fossil fuel is not sensible due to fuel linkage risk, energy security and climate change related problems. High transmission and distribution loss is another factor which needs to be considered in mind. State-utility (MSEDCL) have not been able to reduce losses to the acceptable limit over a period of time. It is worth mentioning that according to IEA coal is going to play a major role in Indian electricity sector until 2030 (Ghotge, 2009; Pimparkhedkar, 2009). The expected year wise capacity addition in Maharashtra is furnished in table 5, 6 ,7 & 8

[14] Melghat is one of the dense forest area located north-east of Maharashtra. Surrounded by the hilly areas of Satpuda mountains.

Table 5 Capacity addition in 2008-09 (1277 MW)

MAHAGENCO[15]	Central Sector	Private
Ghatgar 250	Sipat 258	TPC[16] 250
	Khalgaon 98.7	
	RGPPL[17] 670	
Total 250	Total 1 026	Total 250**

Note: ** TPC generation not considered in capacity addition

Source: (Er.Mohod, 2009)

Table 6 Capacity addition in 2009-2010 (1629 MW)

MAHAGENCO	**Central Sector**	**Private**
New Parli unit-2- 250	Sipat Stage-1 340	
Paras Exp-2	RGPPL 740	
	Khalgaon 49.3	
Total 500	Total 1 129	Total 0

Source: (Er.Mohod, 2009)

Table 7 Capacity addition in 2010-2011 (2070 MW)

MAHAGENCO	Central Sector	Private
Khaparkheda Exp. 500	Sipat 170	JSWL[18] (expected) 300***
Bhusawal Exp-1 500	Barh (3×33) 100	
Bhusawal Exp-2 500		
Total 1 500	Total 270	Total 300

Note: *** Draft PPA has been initiated but yet to be approve by MSEDCL Board, Government of Maharashtra, and Maharashtra Electricity Regulatory Commission (MERC).

Source: (Er.Mohod, 2009)

15 Maharashtra State Power Generation Company Limited

16 Tata Power Company

17 Ratnagiri Gas and Power Private Limited

18 Jindal South West Limited

Table 8 Capacity addition in 2011-2012 (3943 MW)

MAHAGENCO	**Central Sector**	**Private**
Chandrapur Exp.-1 500	N. Nanakpura 33	Adani case-1 660
Chandrapur Exp-2 500	Mundra Ultra-Mega Power Project (Sep-11) 800 (March-12) 800 320	Lanco Teesta 500
Parli replacement 210		
Urban Gas B-1 814*		
Urban gas B-2 406*		
Total 2 430	Total 353	Total 1 160

Note: * Generation depends on sufficient gas availability at reasonable rate.

Source: (Er.Mohod, 2009)

5.3 Current shortage of electricity and prioritization of electricity distribution in Maharashtra

Present demand for electricity in Maharashtra is more than total electricity supplied. As mentioned earlier total peak demand of Maharashtra include peak demand of MSEDCL + peak demand of TPCL + REL. This peak demand is 17 to 18 GW. However, supply is 13 to 14 GW only. Therefore, Maharashtra is experiencing shortfall of around 4 GW. Due to this demand and supply gap state is currently going through the planned load-shedding.

Some organizations and public interest groups in Maharashtra and India claimed that centralized generation in Maharashtra and altogether in India does not meet the objective of rural electrification. Access to reliable and quality of electricity remains a dream for majority of population in present scenario. These groups also argued that prioritization in distribution of electricity often leads to the situations where poorest will be the last to get electricity and the first to have it taken away in times of shortage. From the above supply and demand data provided by MSEDCL, it is very clear that present traditional large centralized coal plant does not meet objective of easy, reliable, uninterrupted access to electricity for people living in Maharashtra.

However, it is observed that alarm raised by these public interest groups; that currently there is a prioritization while distribution of electricity and that led to the situation of poor and rich discrimination. This is not absolutely true, but partially this is actually the situation that can be seen in rural areas.

It has been emphasized by the MSEDCL that due to shortfall of electricity in Maharashtra there is a planned load-shedding all over the state. There is no deliberate prioritization in distribution of electricity during shortage. There is no poor and rich for MSEDCL. For justification of this statement, statistical analysis that had been carried out for calculation of transmission and distribution losses has been presented. It has been confirmed from the statistical analysis that extent of load-shedding in particular region is basically depend on the revenue collection efficiency against the units of electricity supplied to that region. In other words, if revenue collection efficiency is less as compared to total units of electricity supplied and transmission and distribution losses are more in that case load-shedding hours will be more in that region.

Even the government of India under its RGGVY programme for rural electrification recognized revenue sustainability issue for rural electrification and explicitly mentioned that "electricity supplied must be paid for" (Kalra et al., 2007). This fact also pointed out by Dr. Sunil Deshmukh Honorable Minister of Finance, Planning and Energy for the State of Maharashtra (Deshmukh, 2009; Er.Mohod, 2009). In support of this, data presented by MSEDCL is given in table 9.

Table 9 Demand supply (MSEDCL) scenario in MW at the time of peak demand

	2002-03	**2003-04**	**2004-05**	**2005-06**	**2006-07**	**2007-08**	**2008-09** **Upto 23.03.09**
Demand	11425	11357	12749	14061	14825	15689	15656
Availability	9004	9315	9704	9856	10298	10412	10715
Shortfall	2421	2042	3045	4205	4527	5277	4941

Source: (Er.Mohod, 2009)

From table 9 it has been observed that though demand is growing substantially availability of electricity have not increased in that proportion.

Table 10 Present load shedding protocol of MSEDCL

	Other region		**Agricultural Dominated Area**	
Group	**Distribution collection losses**	**Load-shedding hours**	**Distribution collection losses**	**Load-shedding hours**
A	0% to 18%	2.45	0% to 21%	10.00
B	› 18% to 26%	3.30	› 21% to 29%	10.30
C	› 26% to 34%	4.15	› 29% to 37%	11.00
D	› 34% to 42%	5.00	› 37% to 45%	11.30
E	› 42% to 50%	5.45	› 45% to 53%	12.00
F	› 50%	6.30	› 53%	12.00

Source: (MSEDCL, 2009)

Table 10 is based on the principle and protocol of load-shedding given by MERC and output of statistical study conducted in Maharashtra for calculation of transmission and distribution losses. Presently, this protocol is in force for load-shedding throughout Maharashtra. Load-shedding protocol is based on division wise distribution loss and collection efficiency i.e. units of electricity supplied to the division and revenue collection efficiency from it as explained before. This data proved that there is no poor or rich distinction while distribution of electricity in Maharashtra. However, this is because of economic drivers and revenue sustainability. This protocol is effective from 14.01.2009 (MSEDCL, 2009).

Even though, data provided above defeat the proclamation that there is a deliberate prioritization while distribution of electricity in Maharashtra. However, the fact can not be ruled out that the actual extent of load-shedding is usually more than it ought to be based on MSEDCL protocol. Even, careful observation of the way electricity is being distributed in Maharashtra, we might find that people living in the villages actually get electricity at a higher subsidy as compared to city based domestic consumers; although, this is because of the political interference. It is a general notion that providing free or subsidized electricity has always been the proclamation to grab this vote bank during elections all over the country. However, when it comes to powercuts, village people face maximum power cuts.

In Maharashtra, consumers from Mumbai get assured un-interrupted electricity supply for which they have to pay additional charges. In other words, people living in cities have higher paying capacity and are provided with the better services than people living in villages. Therefore, there is indeed discrimination in terms of service quality. It is worth mentioning here the comments passed by Zagade during interview; that out of total electricity generated in India around 43% is consumed by industry sector and contribute 28% towards total Gross Domestic Product (GDP) and provide employment to 3.5% workforce. However, rural areas consume 15% electricity and employ 56% population (Zagade, 2009).

This is a fact that India is an agricultural country and strength of Indian economy is mostly in villages. Rural activities provide employment to about 56% population as mentioned before therefore should get a quality of electricity (Zagade, 2009). Public interest groups also claimed that bigger city as Mumbai receive un-interrupted power at the cost of other regions. There are numbers of logical reasons that can be considered while distribution of electricity. This seems to be obvious given the fact that Mumbai is a capital of Maharashtra and also financial capital of India. Most of the big corporate, multinational companies are also located in this region.

According to Dr. Deshmukh, Mumbai should get un-interrupted power because the government of Maharashtra will not be in a position to deal with financial losses that might occur due to electricity shortage in Mumbai (Deshmukh, 2009). In addition, the fact needs to be considered that Mumbai has got dedicated power utilities from private sector (Tata Power Company Limited and Reliance Energy). These utilities are well in position to purchase power from other states or other state utilities incase of power shortage or whenever it is needed. That purchased power will be served to Mumbai city and people are ready to pay for it. Actually they can afford it and willing to pay is higher in Mumbai (Pillai, 2009; Rao, 2009). Moreover, it has been observed from Rural Electrification Policy (REP) and EA 2003, that if consumers are ready to pay a decided tariff then they should get 24 hours un-interrupted and quality of electricity (MoP, 2003, 2006).

5.4 Renewable energy scenario in Maharashtra

With the prevailing shortage of electricity from conventional sources there has been an increased awareness of RE in Maharashtra. Table 11 shows RE potential in Maharashtra and achievement until 30th June 2008.

Table 11 Renewable energy potential in Maharashtra and achievement until 30th June 2008

Sr. No.	Renewable Sources	Potential in India	Potential in maharashtra	Achievement (MW)
1	Wind	45 000	4 584	1 775
2	Small Hydro	10 324	600	211
3	Biomass / agro waste	16 000	781	52
4	Bagasse based co-generation	5 000	1 250	262
5	Urban waste	1 700	287	NA
6	Industrial waste	1 700	350	6.125
	Total	79 724	7 852	2 306.445

Source: (Pimparkhedkar, 2009)

As we can see from the table 11 achivement of wind energy is more as compared to other renewable energy sources. The government of India, MEDA and promoters of RE believed that the wind energy is a quick addition to the power supply. In one year it is possible to add say 1 000 MW which is not happening and not practically possible in conventional sector (Pillai, 2009). It takes 10 years for a conventional electricity generation project to come on stream, although wind energy is modular, quick addition is possible, policies are in favor of grid connected wind energy in Maharashtra.

As far as cogeneration is concerned in Maharashtra it has not seen as a stand alone system it has always been associated with industry sector mainly Sugar, since Bagasse[19] is the main waste coming out of sugar industry and potentially finds its way for co-generation.

The government of Maharashtra forecasted RE addition in Maharashtra. According to the data wind energy will have significant contribution in future addition of RE in Maharashtra. Following co-generation based on Bagasse waste from sugar industry. The data in table 12 shows the forcasted addition of RE in Maharashtra

[19] The dry dusty pulp that remains after juice is extracted from sugar cane.

Table 12 Forecasted addition to RE generation 2007-2012 in Maharashtra

RE SOURCES	FORECAST 2007-08 (MW)	FORECAST 2008-09 (MW)	FORECAST 2009-10 (MW)	FORECAST 2010-11 (MW)	FORECAST 2011-12 (MW)
Wind	600	600	600	600	600
Small Hydro	25	40	40	70	75
Co-Gen	100	150	200	250	300
Biomass	100	150	158	165	177
MSW Liquid & Industrial Waste	75	100	125	150	187
Solar PV	0.30	0.50	0.75	0.95	1.00
TOTAL	900.30	100.50	1123.75	1235.95	1340.0

Source: (McKenzie & WISE, 2008)

As we can see from table 12, wind energy is growing, in a way that every year capacity addition of wind energy is more as compared to other renewable sources in Maharashtra. The reason behind this is that potential of wind energy in Maharashtra is high as compared to other RE sources.

6 How can decentralized renewable energy be pursued in rural Maharashtra

From the evidences provided in chapter 5 it is most likely that present centralized electricity system in Maharashtra does not seems to be providing reliable, uninterrupted and quality of electricity in rural areas. In this section of study, attempt has been made to answer the central question **"How can decentralized renewable electricity provision be pursued in rural Maharashtra so as to yield developmental, social, health and environmental performance that is as better as or superior to traditional centralized coal-thermal power generation?.** This is simply not the issue of whether villages or communities have been connected with central grid. Nevertheless, the issue is whether access to reliable and quality of electricity with any sort of generation medium is available.

According to TERI there are around 5 554 villages in Maharashtra that have not electrified yet. Some of them are not deemed to be electrified due to less than 10% household's electrification rate and remaining villages are categorized as remote villages and difficult to reach. Grid extension is not feasible economically and geographically. Remote villages are located in forest area where clearance from forest ministry is needed.

In order to overcome this dilemma there is a strong need for alternative technology that could provide electricity to these remote areas and villages where grid electricity supply is ridden off due to load-shedding. It has been very clear from literature review that decentralized electricity provision DRE can potentially provide easy and reliable electricity to these areas. Even government is thinking for decentralized renewable energy as an alternate option for rural electrification. Steps taken towards this realization have been shown from various initiatives undertaken by government. (Camblong et al., 2009).

Table 13 Actual additions to RE generation in Maharashtra 2007-2008

RE SOURCES	CUMULATIVE ACHIEVEMENT UP TO 31 MARCH 2007	ACHIEVEMENT IN 2007-8	CUMULATIVE ACHIEVEMENT UP TO 31 MARCH 2008
Solar PV Systems			
SPV Lantern (No.s)	11,231	3423	14,654
SPV Street Lights (No.s)	2933	2351	5102
SPV Domestic Lights (No.s)	1567	1134	2701
SPV Pumps (No.s)	228	0	228
Total Solar PV Systems	15,959	6908	22,685
Solar thermal systems (No.s)	48,765	12	48,777
Biogas program (No.s of plants)	459	0	459
Biomass program (No.s of improved crematoria and chulha)	433,475	0	433,475
Wind (No.s of monitoring stations)	112	50	162

Source: (McKenzie & WISE, 2008)

As shown in table 13 various initiatives in Maharashtra decentralized systems of solar and biomass had contributed in a significant way as compared to wind. The reason behind could be wind energy is site specific and depend on wind speed which varies through out the year. Uncertainty in electricity production and consumption is another reason that limits decentralized wind energy projects in Maharashtra. However there are very few decentralized small wind parks that provide energy to nearby community for instance in Melghat area; but not much and visible progress can be seen. Wind energy promoters are more focused on grid interactive wind parks rather than decentralized manner.

There were some initiatives by MNRE the government of India to electrify remote villages in Maharashtra through decentralized renewable energy sources. These initiatives failed to showcase desired results; because of numerous factors, such as lack of community engagement, lack of maintenance and expertise, payment recovery (financial sustainability) and so on. Contrary to this, some of the studies conducted in other parts of India showed that consumers were willing to pay even more premium for uninterrupted and quality supply of electricity. Even experience and study showed that off-grid consumers were willing to pay even more premium for electricity connection that would be either from diesel generator or depend on renewable source of electricity (Cust, Singh, & Neuhoff, 2007b).

These are two exactly opposite situations exist in India. It can be argued that some factors were missing during implementation of these initiates in tribal areas. Those are, lack of sensitization and capacity development among community and lack of active participation (PC, 2007-2012c). There were some complaints from consumers that SPV lantern does not function well. This reflects that the communities were not well trained to operate SPV lantern, though it is found very simple to operate them. Nevertheless, possibility of low quality of equipments supplied to consumers can not be ruled out.

Country like the one India has been gifted with an abundant sunshine, all in that central part of India wherein Maharashtra is located is blessed with direct sunlight. "Most part of India get 300 days of sunshine a year. India receive solar energy equivalent to over 5 000 trillion kWh/year, which is far more than the total energy consumption of the country"(Varun & Singal, 2007). Ground water is the main source for drinking water and also the main source for irrigation in Maharashtra. Ground water contributes around 50% in terms of area under irrigation.

On the other hand 80% domestic need of water is met by ground water. Farmers are highly subsidized; dispersed nature of water pumps and hard to reach locations further aggravated the transmission and distribution losses as mentioned before. These are the reasons that contribute and decrease the willingness of the state-utility to provide proper supply of electricity in rural areas. This situation has renewed the interest to deploy SPV water pumping system in rural parts of India and particularly in Maharashtra. It has a significant importance in case of Vidarbha region that has witnessed debated suicides of farmers.

Study conducted by Purohit and Michaelowa (2008) showed that progress made by India in SPV water pumping sector is very slow as compared to theoretical potential despite of government subsidy. The reason behind this according to these researchers is that, high capital cost involved in these systems; although the Clean Development Mechanism (CDM) has opened new rout to finance these schemes through international funding. Nevertheless, present low value of Carbon Emission Reduction (CER) less than 15 € make financing a bit difficult. Whereas mitigation of 1 tones of CO_2 with this system is around 24-242 € only (Purohit & Michaelowa, 2008). Moreover, high transaction cost and capital cost to start with renewable technology projects, intermittency in the cost of conventional supply of electricity and electricity provided by renewable sources are other reasons that make this situation more difficult.

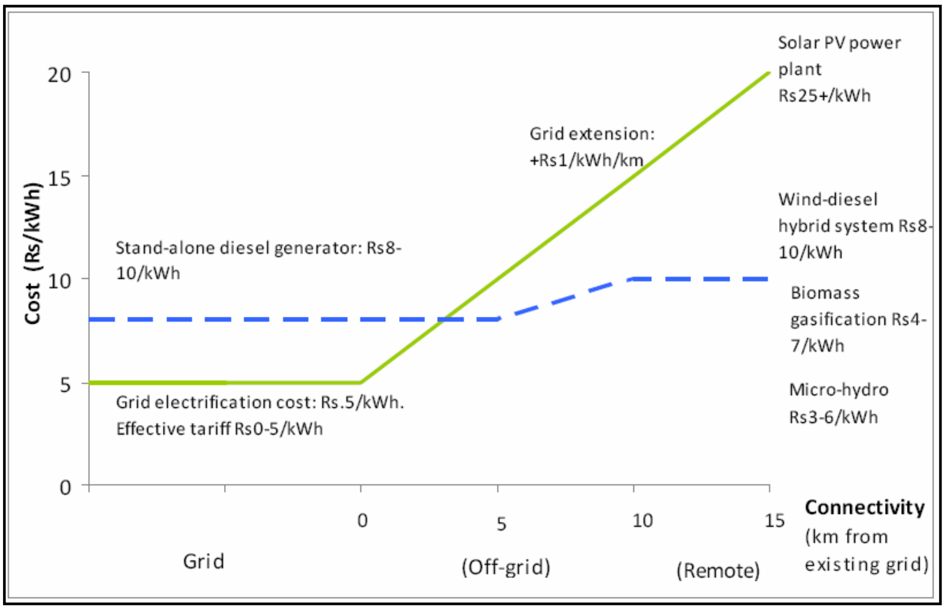

Figure 6 Cost comparision of conventional and renewable technology for electricity provision in rural areas

Source: (Cust et al., 2007a)

In 1999-2000 MNRE refined the calculations and compared SPV electricity sector with electricity from distant power plants for remote areas. According to this study the SPV option could be feasible and found to be cheaper on a net present value for the villages beyond 3 km from the grid in hilly and forest areas and beyond 7 km in plain areas. One more study conducted by Cust et al (2007) shown in figure 6 depicts the comparision of vaious DRE options for electrification aginst the centralized grid electricity. The comparision is based on the distance of unelectrified areas from the nearest grid access. The factors that have been considered while comparision are grid extension cost, generation cost and transmission and distribution losses. Micro-hydro and biomass gasification are found the cheapest option for rural electrification in remote areas rather than extending grid. In a conventional grid electricity price increases by INR Rs1/kWh/km for grid extention. When all these options of DRE were compared with conventional grid electricity on the basis of distance, cost of grid extension, delivered electricity including generation, transmission and distribution losses. DRE is found cheaper than extending grid to these remote areas.

6.1 Lesson for Maharashtra

However, there are several successful examples in other parts of India and world that has been the milestone in the era of decentralized electricity generation at remote places. Lesson can learn from these examples and such model can be replicate in Maharashtra as well. Begin with the ideal and widely cited example of Sunderban Islands India, how sustainable decentralized electricity provision with large contribution from renewable can be pursuit that can have as better advantage as grid electricity.

Sunderban is located in West Bengal. Sunderban is a bunch of small islands located where the river Ganga, Brahmaputra and Meghana converge on the Bengal basin. The total area of Sunderban is 9 629 km^2 and has 19 blocks and become home for around 4.5 million population. Sunderban is one of the ideal example in the field of decentralized electricity provision with large contribution from RE. In Sunderban first solar thermal power station was commissioned in 1993 at Sagar Island. This small solar power plant had capacity of 2-kW which was further enhanced up to 4-kW (Chaudhuri, 2007a).

It is worth noting that this first decentralized solar power plant still working with its full capacity. It was 1995 when the first 25-kW solar power station was setup at Kamalpur village of Sagar Island. 4-km supply line was also constructed to provide electricity to local consumers for instance hamlets and dalit bastis. It is worth mentioning here that initially the villagers of the Sagar Island were hesitant to use non-conventional energy but after initial resistance, presently 30 000 villagers in Sagar Island are depend on solar power (Chaudhuri, 2007b). Table 14 below shows the details of PV power plants in various villages in Sagar Island.

Table 14 Villages electrified with solar PV power in Sagar Island

Sr. no.	**Village**	**Capacity**
01	Kamalpur	25 kW
02	Mritunjaynagar	26 kW
03	Khashmahal	25 kW
04	Mahendraganj	25 kW
05	Uttar Haradhanpur	30 kW
06	Mandirtala	28 kW
07	Natendrapur	28 kW
08	Gayenbazar	25 kw
09	Koyalapara*	120 kW
10	Sagar hospital	20 kW
11	Muriganga	80 kW (under construction)
12	Gobindapur	80 kW (under construction)

*Largest off-grid solar power plant in India

Source: (Chaudhuri, 2007a)

Presently, 50 persons are working towards the maintenance of the plant and distribution line. There are also 11 shops in the Island selling solar power equipments. With the help of solar power, villagers can carry out their businesses after dusk. Women too can carry out their stitching and tailoring work at night. Most important development has been the rapid decrease in snakebite cases in those virgin hamlets of Sagar Island. Even supply of drinking water has been improved. A wind-diesel-biomass hybrid plant has been setup in Sagar Island. It is important to mention here that this plant is unique and one of its kind in Asia. The biomass plant has the capacity of 150 kW this plant is mostly used to generate electricity in winter and non-windy days. Therefore, this plant has become the most efficient non-conventional power plant in the country and unique in the world (Chaudhuri, 2007a; Hiremath, Kumar, Balachandra, Ravindranath, & Raghunandan, 2009).

Second Island that had been electrified is Gosaba. This island is very well known for poisonous snakes. Today 1 200 people of Gosaba are depend on biomass gasifier plant for electricity. The socio-economic conditions have been improved massively. Antivenom serum, the main injection to counter the death by snakebite, could not be preserved earlier due to lack of electricity but now it is possible. In Chotto Mollakhali Island which is one of the remote island of Sunderban it was only because of initiative and support of villagers that West Bengal Renewable Energy Development Agency (WBREDA) could manage to complete the installation of 4× 125 kW biomass gasifier power plants. To assure sustainable supply of fuel to these projects 60 000 fast growing trees were planted. It is worth mentioning here that Sunderban is a home for largest number of decentralized systems for electricity generation based on renewable sources in the world (Chaudhuri, 2007b).

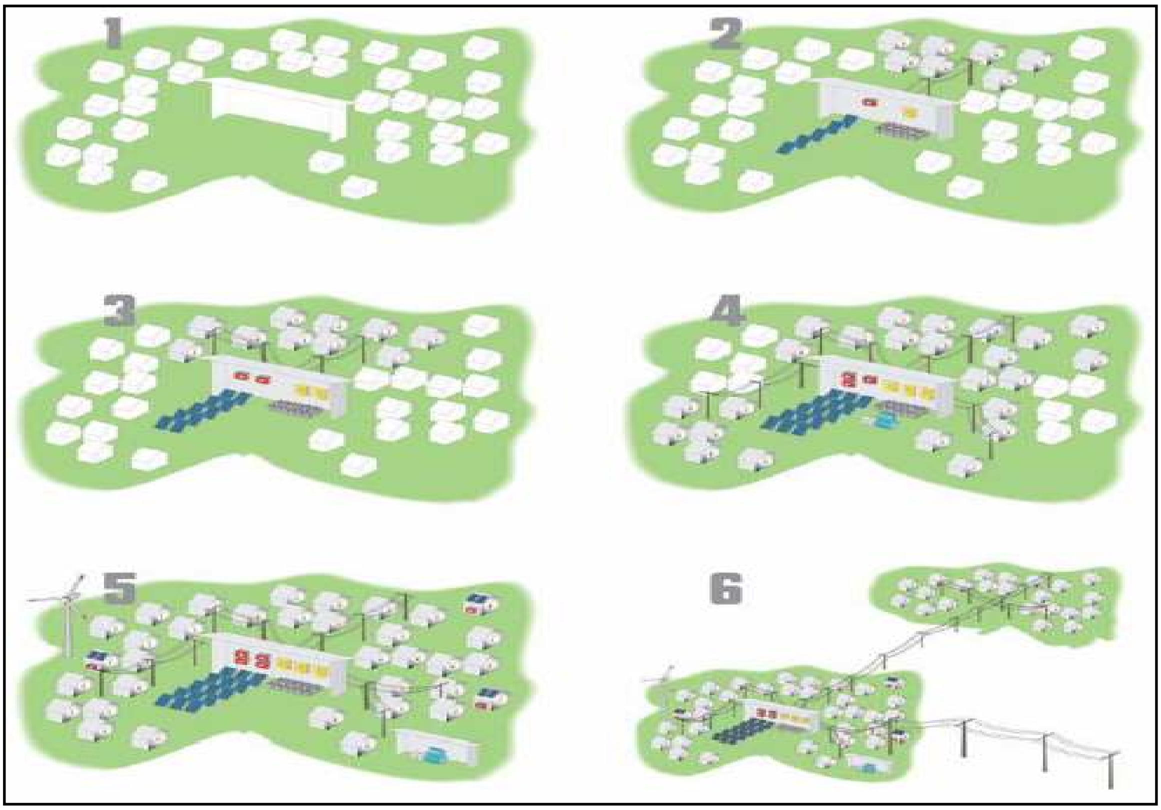

Figure 7 AC-coupled hybrid system extending with increasing electricity demand

Source:(Cramer, Ibrahim, & Kleinkauf, 2004)

Figure 7 depict the same trend which was followed in Sunderban Island very systematically. Mix of various renewable sources was used in parallel to meet the increase demand for electricity and finally becomes an independent grid.

Some other examples are Mundanmudy villages in the state of Kerala; where near about 393 villages were electrified with solar panels. A Salepada village in the state of Orissa is one of the best example with active involvement of local community at every stage of the project. Hosahalli and Hanumanthanagara villages in the state of Karnataka is another such successful example (Hiremath et al., 2009).

Small decentralized system based on Solar Photovoltaic (SPV) Water Pumping (SPVWP) can be deployed in remote location to withdraw water from underground. Study conducted by Meah et al (2008) showed that SPV is now proven technology for water pumping at remote locations and cost effective where abundant sunshine is available. In this study Meah presented the case of Wyoming Governor Dave Freudenthals solar water pumping initiative to alleviate draught impact. Under this initiative total 88 numbers of solar water pumping systems was installed. Out of this at present total 75 systems are in operation and these all systems are found cost effective when compared to extend central grid at these places (Meah, Fletcher, & Ula, 2008).

Decentralized electricity provision with diesel generator in remote areas is a strong competitor to SPV systems. However, diesel system is associated with some distinct disadvantages. Mainly diesel systems are noisy; maintenance is high as compared to SPV system. Fuel transport cost from nearest depot is another factor that makes these systems costly. Nevertheless, when compared on the grounds of capital cost; SPV has a high capital cost. Foreseeing these complications, researchers suggested that hybrid system of SPV with diesel generation as a backup power again supplemented with wind hybrid system at remote locations could be sensible option. SPV generate electricity during day time only. But, when SPV system does not generate electricity diesel generation would be used to compensate demand and supply (Phuangpornpitak & Kumar, 2007).

Discussion of whether decentralized system should connect with central grid or should work as an independent grid called micro-grid or mini-grid. Researcher Jiayi et al (2008) claimed that decentralized solution might create problem if it is connected with central grid. The best way to utilize its potential is having a sub-system called as "Micro-Grid". Micro-grid is independent distribution network within locality. According to Jiayi micro-grid is not suitable to connect directly to central grid due to varying load factor and the way electricity is generated and distributed in either cases. Study conducted by Kirubi and Jacobson (2009) demonstrated that micro-grid can play a vital role in the socio-economic development of rural community (Kirubi & Jacobson, 2009). Therefore, it would not be wrong to say that decentralized solution for electricity would perform better with its own transmission and distribution network (Jiayi, Chuanwen, & Rong, 2008).

However, there are some advantages of grid connected system; that are improvement in tail-end voltage, reliability of power in case of load-shedding. On the other hand advantages of decentralized system without grid connectivity are reductions in distribution losses since electricity do not have to transmit for a long distance, last but not least improving system reliability that is missing in centralized generation. Therefore, decentralized energy with a large contribution of renewable sources in rural areas could be a sensible option (Kaundinya et al., 2009).

Pillai (2009) is of opinion that there is a misconception that renewable would only be decentralized. Some states in India mainly Rajasthan and Gujarat; these two states has got 215 000 km^2 of desert area. These are potential solar electricity generation sites. Even Rajasthan government has sanctioned some projects in deserts of Rajasthan. Therefore, again that could be centralized in a sense of electricity generation. These two states can not absorb that much electricity. Generated electricity have to transfer to other parts of the country may be in Northern grid. Therefore, it is misconception that RE could be only decentralized way. However, we should look RE as a basket of solution and try how to decrease load from central grid and pump excess electricity back into central grid (Pillai, 2009).

Study conducted by Nouni et al. (2009) shows that cost of electricity supply to villages located at a distance of 5 to 25 km. is vary from $ .05 cents to $ 5.5/kWh. Nouni considered cost of electricity generated by centralized thermal power station based on coal and cost of electricity distribution and transmission to remote areas. Study also conclude that micro-hydro, dual fuel biomass gasifier systems, small wind electric generators and photovoltaic systems could be financially attractive as compared to grid extension for providing access to electricity in small remote villages in India (Nouni, Mullick, & Kandpal, 2009).

Study conducted by Rajvanshi (2002) in one of the taluka[20] in the state of Maharashtra called Phaltan taluka. Showed that biomass generated in Phaltan can make a significant contribution to provide electricity and able to fulfill total need of electricity of Phaltan. Rajvanshi proved, that taluka in Maharashtra has a significant amount of potential in terms of biomass residue. Biomass can be use for electricity production. Study concluded that it is possible to create employment opportunities, as well as to accelerate economical activities in rural areas. Near about 30 000 jobs can be created. It is worth mentioning that this study has been later used by the government of India and became the basis for the national policy on self-sufficient taluka and was adopted by the government of India in 1996. Nevertheless, remarkable progress can not be seen after this study (Rajvanshi, 2002).

According to Cust et al (2007) electric power demand in a typical Indian village ranges somewhere between 20 kW to 100 kW and the biomass available locally is found sufficient to fulfill this demand. Potential for large scale biomass gasification projects in India is estimated to be around 20 000 MW (Cust et al., 2007b). Issue of sustainability for decentralized electricity generation projects has been debated for a long time among the researchers. The scientific community and researcher believe that decentralization of electricity generation can not be rated as clearly positive or negative (Alanne & Saari, 2006; Karger & Hennings, 2009). The success of this concept is largely depend on local conditions, institutional factors and micro-economic conditions. Moreover, several factors that hinder the growth of decentralized RE projects in rural Maharashtra have been discussed in the next chapter.

[20] A taluka is an administrative block generally comprising about 90–100 contiguous villages, with a small town as its headquarters.

6.2 Barriers and challenges to pursuit decentralized renewable energy for electricity provision in Maharashtra

However, specific barriers and challenges are identified to deploy DRE in Maharashtra. From the above successful examples it has been observed that the key factors for success of these projects were initiative and active participation, support that had come from community side. Following are some of the barriers and challenges that have been identified in rural Maharashtra.

6.2.1 Barriers for DRE in Maharashtra

6.2.1.1 Public awareness, mind set/community perception

Public awareness to except this fact that decentralized electricity from renewable sources can provide benefit is very less. Still rural communities are not very well aware of the benefits and usufulness of renewable energy. There is a misconception that coal reserves are plenty and India can continue to export coal. According to Pillai (2009) and Chand (2008) the author of "The Coal Dilemma" Indian coal is low in quality and Indian coal reserves can be expected to last for next 45 years (Chand, 2008; Pillai, 2009). Mind set of the rural community that this is the duty of government to provide electricity is seems to be the dominant factor that keeps them away to realize community participation in the DRE projects.

6.2.1.2 Lack of local government (Panchayat Raj) involvement

Panchayat raj represents the huge mass of rural areas. Active involvement of panchayat raj, co-operative societies and youth groups are very crucial for successful implementation of government schemes in rural areas. It has been observed that understanding between villagers and officers of the implementing agency in Maharashtra is not so obliging each other, which has created negative impact during planning and execution of the project (Pimparkhedkar, 2009). Moreover, lack of know how, little involvement of rural development organization at grassroots level makes it difficult (Rio, 2007). On the other hand this has been overcome in the case of Sundarban Island. In sundarban public participation and active involvement of panchayat raj were the key factors for the successful execution and sustainable operation and maintainance of DRE projects.

6.2.1.3 Less conducive government policies/support/incentives

Maharashtra has been very fortunate in terms of policy support for RE. However policies has been concentrated around grid interactive wind energy and not been able to address and finance other source of RE projects in Maharashtra (Pillai, 2009; Pimparkhedkar, 2009). Foreseeing the high capital cost of SPV system incentives from government is needed to finance these initiatives (Nouni, Mullick, & Kandpal, 2006). Need of better coordination between national and state level implementation agencies is needed (Urmee, Harries, & Schlapfer, 2009). Situation in melghat area is even wrost, electricity access in melghat area does not show the intention of household electrification, but merely the extention of power lines extended to the remote villages.

6.2.2 Challenges for DRE in Maharashtra

6.2.2.1 Need of robust business model/ Lack of professionalism

Need of robust business model to design and execute DRE projects have been realized. It has been observed that there is no standardization during planning, implementation and operation of these projects in Maharashtra (Kumar, Mohanty, Palit, & Chaurey, 2009; Pillai, 2009). The business model and strategy which has been followed in sundarbans by West Bangal Energy Development Agency (WBEDA) can be replicate in Maharashtra.

6.2.2.2 Economic viability

The private entities are not interested in generation and distribution business in decentralized mode because of uncertainties of revenue collection, strong competition with conventional source of electricity that is highly subsidized for rural communities (Pillai, 2009; Pimparkhedkar, 2009; Rio, 2007). Subsidized electricity in rural areas is mainly because of the political benefit. It would not be wrong to say that political intentions is some how responsible for this situation. This is the chief reason why DRE projects are not successful and not visible progress is shown in this area. Therotically it has been proved that DRE is economically viable option for remote village electrification. But it is important in Maharashtra to prove it on the grounds of practicalities.

6.2.2.3 Quick dispersal of technology

Although RE technology is flourishing worldwide and so in India. Nevertheless, its quick dispersal in a decentralized manner for rural electrification in Maharashtra is necessary. Not only its dispersal but also awareness and capacity building is very important. Considering the lack of awerness it is felt that the strong mechanisum should be establish in the state; therefore, District Advisory Committees (DACs) on "Renewable Energy" are formed under the chairmainship of the respective District Collectors. The responsibilities includes identification of beneficieries, monitoring of projects under implementation, suggesting measures for popularization of renewable energy in the district and required to meet once at least every quarter in the district. However, as far as author's knowledge goes not visible progress can be seen in Melghat area of Amravati district which has more number of people living without any form of electricity.

6.2.2.4 Storage facility and efficiency improvement

Storage facility is a vital element in DRE. Generally the electricity demand of rural community is very little. The typical load pattern in rural areas found very high during morning and evening. Most of the people go out for work during day time and therefore the load varies considerably during this time. Presently batteries are used for storage of electricity produced by SPV systems during day time when there is high rate of electricity generation. This stored electricity then supplied to consumers. There is a need to increase storage efficiency of SPV systems. Since RE can not operate at high plant load factor (PLF) as conventional plant could be. Therefore energy efficiency in DRE systems are very much important (Pillai, 2009). Lack of storage facility limits the growth of large wind farms in DRE sector for rural electrification.

6.2.2.5 Sustainability of raw material (biomass)

Under section 7 of EA 2003, electricity production and distribution is a free activity, anyone interested to produce and distribute energy no matter from which sources (renewable or non-renewable) entitled to get permission from the government and can do so. This type of provision may create competition among different energy co-operative societies for biomass. Sustainability issue of raw material is always been crucial for decentralized biomass projects. Potential for biomass energy in Maharashtra is plenty. However there is no proper collection system. It has been realized from the past experience that taluka level or village level biomass collection network is needed (Zagade, 2009). This developed network will work parallel to the local energy co-operatives and local government and will assure sustainable supply of raw material.

6.2.2.6 System for maintenance

DRE projects in rural areas are mostly based on the concept of community owned. Therefore community should have to take care of maintenance during its operation period (Pillai, 2009). During project operation proper maintenance and management is necessary. It would not be financially feasible to hire external vendor to take care of the system.

Educated youth from the community can be trained so that they get employment and system will also be taken care off efficiently. In some cases for example in Sunderban yearly maintenance is responsibility of equipment supplier. Similarly proper allocation of responsibility and monitoring is also necessary for successful project management. The success of any rural electrification project is very much depend upon the technical competency of the local community i.e. user. Social factors such as income, background knowledge of the system is very much important (Gölz, 2005).

7 Benefits of DRE in Maharashtra for rural electrification within the MDGs analytical framework

In this part of my research I will discuss potential benefits from sustainable and successful implementation of DRE. Discussion in chapter 5 showed that the present electricity scenario in Maharashtra is not impressive at all. The huge demand and supply gap led Maharashtra towards conflict and riots against the state-utility company, situation that reflects a picture that is close to discrimination between rich and poor. Therefore, it is very clear from the discussion that the present situation is not healthy for economic, social and environmental development of Maharashtra.

In order to present various advantages that would occur from decentralized electricity in Maharashtra; MDGs analytical framework has been used. Going back to chapter 2 titled "Theory framework", we have discussed how electricity can play a vital role in the overall development of the rural communities and become a prerequisite to attain MDGs in developing countries. Throughout the following discussion, I will link decentralized renewable energy with different components of poverty (see figure 1) that have been included in the MDGs. I will showcase how decentralized RE for electricity provision in rural areas can contribute toward different component of MDGs.

7.1 Income, employment and economic benefits

The study conducted by Decentralized Energy System India (DESI) proved that a 100 kW project of Independent Rural Power Producer (IRPP) in rural areas can directly employ 11 persons and would create another 56 downstream jobs in small scale industries by making electricity available in rural areas (Banerjee, 2006). In addition to these advantages agricultural output would be increased, availability of electricity in rural households will lead to eradication of poverty, generation of employment and raised living standard of rural people (Jain & N.K.Roy, 2002).

Liming (2009) claimed that the centralized utility model is not always feasible and cost effective for providing electricity and therefore not always a cost effective channel to provide electricity in rural areas. He also claimed that the price of generating electricity from SPV dropped by around 60% between 1990 and 2007 at the same time efficiency has gone up to 24%. "The cost of generating electricity from SPV has fallen from $ 300 per watt in 1954 to $ 4.5 per watt now"(Liming, 2009). The most important economic benefits would be transmission and distribution losses will be saved to a great extent that would not be possible in the centralized model at present.

Most of the unelectrified areas for instance Melghat and Gadchiroli in Maharashtra belong to the low income and tribal's community. It is observed that only during monsoon season these communities get full time employment in the agriculture sector and found busy in farming activity. After monsoon they migrate to other places for employement. DRE will create employment opportunities and economic benefits in these areas. These communities can start small cottage business with the help of their traditional knowledge for instance processing of forest products at household level, handicraft business which has a great value in the urban market.

7.2 Environmental benefits

At environmental side several studies have been conducted to identify Carbon-dioxide (CO_2) emission from use of renewable energy sources. One such study conducted by Varun et al (2009) concluded that renewable energy sources for electricity also contribute to emission of CO_2. In this study researchers have analyzed several renewable energy sources which can be used for electricity generation mainly SPV, Biomass system and Hydro power. Furthermore comparison of CO_2 emission from these sources with conventional electricity generation from coal thermal power stations has been carried out and it is observed that renewable sources emit less CO_2.

Nevertheless, they have compared the best option among renewable sources and it has been found that small-hydro projects tend to be more attractive; but very much site dependent. It is pointed out that SPV can produce significant amount of lifecycle carbon emission but it is worth noting that as compared to conventional power plants based on fossil fuels it is very little (Varun, Bhat, & Prakash, 2009). Fuel wood can be saved, resulting in decrease in deforestation and resource depletion. Indoor pollution can reduce significantly as compared to kerosene lantern scenario.

7.3 Educational and social benefits

A number of social benefits can be achieved through implementation of community based DRE projects. Maharashtra has got a long history of co-operative movement. Use of decentralized RE will provide extra hours for children to study after dusk. Electricity in schools can enable students to run computers.

Women and small children will not have to spend hours to collect fuel wood, saved time can be utilized for study or other livelihood work. With decentralized RE people would use TV and other audiovisuals. They would listen to the news channels and TV shows. Hotels and cafeterias will turn into a social gathering point; where people can enjoy music and watch sport matches. In Melghat area there are some villages where there is no communication facility available due to unelectrification; DRE would help to develop communication infrastructure for example telephone and mobile towers. Due to this awareness level will be increased and that will have a positive impact on health benefits and income generation activities.

7.4 Health benefits

It is a fact that most of the government doctors are very reluctant to go and live in rural areas; for instance area of Melghat in Amravati district, Naxalite and forest area of Gadchiroli district. Reasons are poor facilities, lack of infrastructure, lack of electricity and poor quality of life in remote areas. However, decentralized RE in these remote areas would encourage them to provide services even to this poor section of the community. Melghat is having the highest cases of death of children due to malnutrition. In September 2008 according to the sources there were around 36 788 children, of these about 23 087 are suffering from malnutrition (Nadar, 2008).

The main reasons are lack of infrastructure, poverty and poor medical facilities. Electricity from RE enables doctors to preserve pulse polio, snake venom and other important vaccines. In summer when the temperature goes up to 42-43^0 C cooling of water and cold drinks would be possible. Due to less use of kerosene for in-house lighting the risk of various health problems mainly diseases such as asthma, blindness, and heart diseases would reduce significantly. This will result in increased life expectancy of woman and infants.

8 Conclusion

Under section 6 of EA 2003 rural electrification is the key objective of the government of India. Fuel linkage problem, heavy transmission and distribution losses and low revenue collection efficiency, low quality of coal, increased Co_2 emission, climate change, and fossil fuel depletion prompted the policy makers to adopt new technologies for rural electrification.

Referring to section 1.3 describing aims, objectives and research questions, it would be necessary to reveal that throughout the discussion of case study beginning from chapter 5 until chapter 7 all of the research questions were addressed. In this part I conclude and summarize my research findings with the help of designed research questions. The following discussion will summarize my research findings in connection with sub-questions 1,2,3,4 and 5.

Sub-questions one and two have been discussed in section 5.1 and section 5.2. It has been observed from the data provided that the present peak demand of Maharashtra is around 17 to 18 GW, however the supply is only 13 to 14 GW, therefore there is a total shortfall of 4 GW in the present situation. Furthermore addressing sub question two, low quality of coal, transportation and logistical issues involved in coal supply, transmission and distribution losses, have been responsible for the poor performance of the electricity sector in Maharashtra.

Transmission and distribution losses were aggravated to such an extent that for two units of electricity generated at power station only one unit is billed at consumer end. It is a pity that considered as one of the most developed state with largest installed generating capacity Maharashtra still has around 5 554 villages that are not electrified yet. Therefore, it is very clear from the discussion that the present electricity sector in Maharashtra does not meet the total demand. However, RE sources could potentially fulfill this gap between demand and supply in Maharashtra.

Section 5.3 addressed research question three. The study has also intended to clarify the present proclamation of prioritization of electricity distribution between rich and poor in Maharashtra. Based on the interview conducted with the state minister for energy, finance and planning Dr. Deshmukh and sub-regional officer from MSEDCL, it is clear that the present load-shedding in Maharashtra due to shortage of supply is based on the protocol of MSEDCL. This protocol is based on transmission and distribution losses and revenue collection from a given region. Referring to table 10 in section 5.3 more the distribution and collection losses (DCL) in a particular region more will be the extent of load-shedding in that region.

Nevertheless, careful observation of the way electricity is supplied and the prevailing load-shedding situation in rural Maharashtra. It can be concluded that villages actually get electricity at a higher subsidy compared to city based domestic consumers; although, this is because of the political interference. Providing free or subsidized electricity has always been the proclamation to grab this vote bank during elections all over the country. However, when it comes to powercuts, village people face maximum load-shedding. In Maharashtra, consumers from Mumbai get assured un-interrupted power supply for which they have to pay additional charges. In other words, people living in cities have higher paying capacity and are provided with better services than people living in villages. Therefore, there is indeed discrimination in terms of service quality.

Section 5.4 addressed the research question number four. It can be concluded that renewable energy sources are available in plenty in Maharashtra. Specifically wind, small-hydro and biomass. Around 6 000 MW of potential is available including these three sources. Wind is on first place with achievement with around 1 775 MW in Maharashtra. The reasons are policy support, financial backup, and involvement of private wind energy promoters in Maharashtra to generate electricity and supply it to the state utility. The RE purchase obligation in Maharashtra also showed a positive effect on wind energy development in Maharashtra.

Chapter 6 addressed the question number five, a central question how can decentralized RE be pursued in Maharashtra. It is important to mention here that the central question has a direct link with the hypothesis and potentially gives the idea to the reader which side the hypothesis favors. The way decentralized RE has been pursued in Maharashtra is mainly restricted to the provision of domestic and street lighting. Decentralized systems that are widely used in Maharashtra are SPV lanterns, SPV domestic lighting systems, SPV street lightings. Biomass sources and biogas have been used to provide cooking fuel, thereby replacing the use of traditional biomass like fuel wood and kerosene.

The intention behind this was to improve indoor environmental conditions. The close observation showed that still most of the remote areas have not benefited from these programs. The areas which have somehow benefited, though SPV systems are not working properly or solar plates have been stolen. On the other side lack of biomass collection facility made biomass gasification projects out of use. Large scale application of SPV systems, biomass gasification and hybrid solar-wind-diesel system in a decentralized manner for rural electrification are very rare in Maharashtra.

These systems exist and have been sustainably working for the last 10 years in other parts of India as already discussed in section 6.1 titled lesson for Maharashtra; then why not in Maharashtra. Section 6.2 has discussed some of the barriers and challenges for large scale dispersal of decentralized RE in Maharashtra. It can be concluded that public perception towards RE, institutional factors, lack of finance, lack of involvement of local government are some of the main barriers and challenges in Maharashtra.

It is certainly not the case that decentralized electricity provision with large contribution of renewable sources will completely replace the centralized grid system. Nevertheless, foreseeing various advantages in terms of social, environmental and economic gain by deploying the decentralized option indeed makes us think, and consider it as an alternative and viable choice for rural electrification. Rural electrification would be intensified by using decentralized renewable source of electricity available locally, for instance biomass, wind, solar etc. this will certainly lead to the economic development of Maharashtra and will put a check on rural urban migration.

Recommendations

MEDA as a nodal agency in the state has a crucial role in the overall process. Below are some recommendations I would like to propose for further improvement and large scale deployment of DRE in Maharashtra

1. There is an urgent need of development of robust business model, MEDA should take a lead and discuss this initiative with local community and policy makers

2. MEDA should engage and nominate local grassroots level NGOs for capacity building and training of local community

3. Detailed assessment of all renewable energy sources should be carried out, specifically in un-electrified areas as a priority

4. Rather improving the numbers of projects, implementation agencies should think for long term sustainability of decentralized electricity projects in rural areas and villages to improve the socio-economic conditions and to accomplish the true objective of electricity for everyone by 2012.

"India lives in its villages" Mahatma Gandhi

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Er.Mohod. (2009, March), Maharashtra State Electricity Distribution Company Limited, Amravati, India

Deshmukh, D. S. (2009, March), State Minister for Finance planning and Conventional Source of Energy, Government of Maharashtra, Amravati, India

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Abbreviations

AREP	:	Accelerated Rural Electrification Programme
BPL	:	Below Poverty Line
CEA	:	Central Electricity Authority
DDG	:	Decentralized Distribution Generation
DG	:	Decentralized Generation
DRE	:	Decentralized Renewable Energy
EA	:	Electricity Act
GDP	:	Gross Domestic Product
GW	:	Giga watt
GC	:	Grid Connected
GVREP	:	Grid Connected Village Renewable Energy Programme
HDI	:	Human Development Index
IEA	:	International Energy Agency
IRPD	:	Integrated Resource Planning Division
IEP	:	Integrated Energy Policy
IAS	:	Indian administrative Service
KWh	:	Kilo watt hours
kW	:	kilowatt
kWp	:	kilowatt peak
Km^2	:	Kilometres square
KJC	:	Kutir Jyoti Scheme
MDGs	:	Millennium Development Goals
MW	:	Mega watt
MWeq.	:	Megawatt equivalent
MNRE	:	Ministry of New and Renewable Energy
MNES	:	Ministry of New Energy Sources
MSEDCL	:	Maharashtra State Electricity Distribution Company Limited
MNP	:	Minimum Needs Programme
MEDA	:	Maharashtra Energy Development Agency
NREP	:	National Renewable Energy Policy
NGOs	:	Non Governmental Organizations
PC	:	Planning Commission
PMGY	:	Pradhan Mantri Gramodayan Yojana
RE	:	Renewable Energy
REDB	:	Rural Electricity Distribution Backbone
REL	:	Reliance Energy Limited

RGGVY	:	Rajiv Gandhi Gramin Vidyutikaran Yojana
RVSLP	:	Remote Village Solar Lighting Programme
SA	:	Stand Alone
SDP	:	State Domestic Product
SPV	:	Solar Photo Voltaic
sq. m.	:	Square meter
TERI	:	The Energy and Resource Institute
TPCL	:	Tata power Company Limited
UNDP	:	United Nations Development Programme
VEI	:	Village Electricity Infrastructure
VESP	:	Village Energy Security Programme
WADE	:	World Alliance for Decentralized Energy
WEC	:	World Energy Council
WISE	:	World Institute for Sustainable Energy
WSSD	:	World Summit on Sustainable Development

9 Appendix

Appendix 1 Renewable Energy- Estimated potential and cumulative achievement as on 31-01-2009

No.	Sources / Systems	Achievements during 2008-09 (upto 31.01.2009)	Cumulative Achievements
I. Power From Renewables			
A. Grid-interactive renewable power			
1.	Biomass Power (Agro residues)	77.50 MW	683.30 MW
2.	Wind Power	998.85 MW	9755.85 MW
3.	Small Hydro Power (up to 25 MW)	163.83 MW	2344.67 MW
4.	Cogeneration-bagasse	232.90 MW	1033.73 MW
5.	Waste to Energy	3.66 MW	58.91 MW
6.	Solar Power		2.12 MW
	Sub Total (in MW) (A)	1,476.74 MW	13,878.58 MW
B. Off-grid/Distributed Renewable Power (including Captive/CHP plants)			
7	Biomass Power / Cogen.(non-bagasse)	60.92 MW	150.92 MW
8.	Biomass Gasifier	8.98 MWeq.	160.31 MWeq
9.	Waste-to- Energy	4.36 MWeq.	31.06 MWeq
10.	Solar PV Power Plants and Street Lights	0.07 MWp	3.00 MWp
11.	Aero-Generators/Hybrid Systems	0.09MW	0.89 MW
	Sub Total (B)	74.42 MWeq	346.18 MWeq
	Total (A + B)	1551.46 MW	14,224.76 MW
II.	Remote Village Electrification	300/NIL villages/Hamlets	4254 villages + 1156 hamlets
III. Decentralized Energy Systems			
12.	Family Type Biogas Plants	0.66 lakh	40.90 lakh
13.	Home Lighting System	31,754 nos.	4,34,692 nos.
14.	Solar Lantern	27,360 nos.	6,97,419 nos.
15.	SPV Pumps		7,148 nos.
16.	Solar Water Heating - Collector Area	0.03 Mln. sq.m.	2.60 Mln. sq.m.
17.	Solar Cookers		6.37 lakh
18.	Wind Pumps	80 nos.	1347 nos.
IV. Other Programmes			
19.	Energy Parks	26 nos.	504 nos.
20.	Akshay Urja Shops	15 nos.	289 nos.
Note: 10 Lakh= 1 million			

Source: (MNRE, 2009)

Appendix 2 List of the people interviewed

1) Mr. Mahesh Zagade
IAS, Director General
Maharashtra Energy Development Agency (MEDA)
Pune, India

2) Mr. G. M. Pillai
IAS, Director General
World Institute of Sustainable Energy (WISE)
Pune, India

3) Dr. Sunil Deshmukh
State Minister of finance and planning and Conventional Energy
Government of Maharashtra, India

4) Mr. G. Srinivas Rao
Reliance Energy Ltd. Mumbai

5) Mr. Mohod
Sub-regional Officer MSEDCL, Amravati

Appendix 3 List of the people for questionnaire survey

Mr. Rangan Banerjee rangan@me.iitb.ac.in	Mr. R. B. Hiremath rahul@aero.iisc.ernet.in
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Mr. Ravindra M. Moharil, rmm_ycce_ep@yahoo.com	Mr. Prakash S. Kulkarni, pskulkarni_vnit@yahoo.co.in
Mr. Dinesh C. Sharma dineshcsharma@gmail.com	Dr. B. Sudhakar Reddy sreddy@igidr.ac.in
Mr. Pradeep Chaturvedi Pradeepc@vsnl.com	Mr. Anil K. Rajvanshi anilrajvanshi@vsnl.com
Mr. Surendra Pimparkhedkar cpsr@wisein.org	Prof. Sanjeev Ghotge wiseinfo@wisein.org

Appendix 4 Villages electrified in India as on 31st March 2006

Region/state/union territory	Total number of villages	Villages electrfied	Percentage electrified
Chandigarh	23	23	100.0
Delhi	158	158	100.0
Haryana	6 764	6 764	100.0
Himachal Pradesh	17 495	16 915	96.7
Jammu and Kashmir	6 417	6 304	98.2
Punjab	12 278	12 278	100.0
Rajasthan	39 753	25 845	65.0
Uttar Pradesh	97 942	66 879	68.3
Uttarakhand	15 761	14 737	93.5
Subtotal (northern region)	196 591	149 903	76.3
Chhattisgarh	19 744	16 456	83.3
Dadra and Nagar Haveli	70	70	100.0
Daman and Diu	23	23	100.0
Goa	347	347	100.0
Gujarat	18 066	17 908	99.1
Madhya Pradesh	52 117	50 213	96.3
Maharashtra	41 095	35 541	86.5
Subtotal (western region)	131 462	120 558	91.7
Andhra Pradesh	26 613	26 565	99.8
Karnataka	27 481	27 125	98.7
Kerala	1 364	1 364	100.0
Lakshadweep	8	8	100.0
Puducherry	92	92	100.0
Tamil Nadu	15 400	15 400	100.0
Subtotal (southern region)	70 958	70 554	99.4
Andaman and Nicobar Islands	501	321	64.1
Bihar	39 015	20 610	52.8
Jharkhand	29 354	8 923	30.4
Orissa	47 529	26 235	55.2
Sikkim	450	425	94.4
West Bengal	37 945	32 861	86.6
Subtotal (eastern region)	154 794	89 375	57.7
Arunachal Pradesh	3 863	2 195	56.8
Assam	25 124	19 660	78.3
Manipur	2 315	1 930	83.4
Meghalaya	5 782	3 428	59.3
Mizoram	707	570	80.6
Nagaland	1 278	822	64.3
Tripura	858	491	57.2
Subtotal (north-eastern region)	39 927	29 096	72.9
All-India	593 732	459 486	77.4

Source: (TERI, 2007c)

Appendix 5 Energization of pump sets in India: March 1995 to March 2006

State / union territory	March 1995 (cumulative)	March 1996 (cumulative)	March 1997 (cumulative)	March 1998 (cumulative)	March 1999 (cumulative)	March 2000 (cumulative)	March 2001 (cumulative)	March 2002 (cumulative)	March 2003 (cumulative)	March 2004 (cumulative)	March 2005 (cumulative)	March 2006 (cumulative)
State												
Andhra Pradesh	1 605 807	1 642 993	1 821 291	1 824 689	1 884 571	1 918 712	1 924 542	1 934 389	2 249 894	2 309 605	2 374 365	2 440 823
Assam	0	3 675	3 675	3 675	3 675	3 675	3 675	3 675	3 675	3 675	3 675	3 675
Bihar	264 755	267 371	269 345	270 277	271 090	272 629	274 911	275 785	277 085	278 399	270 392	271 169
Chhattisgarh	—	—	—	—	—	—	73 984	74 065	90 519	98 035	106 749	130 259
Goa	5 441	5 732	6 063	6 454	6 590	6 658	6 867	6 867	7 206	7 332	7 485	7 485
Gujarat	551 551	568 858	591 564	617 495	643 757	670 422	694 163	733 000	764 564	794 148	807 681	825 262
Haryana	404 107	406 612	408 461	409 404	410 224	411 022	420 472	427 422	435 537	450 617	462 635	467 973
Himachal Pradesh	4 141	4 441	4 780	5 098	5 392	5 762	6 167	6 611	7 389	8 114	9 196	10 259
Jammu and Kashmir	3 586	4 716	5 088	5 621	5 621	5 621	5 621	5 621	9 123	9 529	9 714	9 714
Jharkhand	—	—	—	—	—	—	—	—	—	—	8 735	9 453
Karnataka	973 288	1 014 918	1 049 465	1 082 150	1 141 824	1 181 963	1 263 859	1 291 124	1 402 209	1 416 164	1 434 060	1 509 025
Kerala	289 866	304 904	314 632	329 355	353 405	373 862	392 295	405 900	417 640	430 449	446 366	460 470
Madhya Pradesh	1 087 404	1 131 435	1 176 317	1 229 016	1 274 873	1 298 108	1 236 737	1 244 719	1 320 923	1 325 092	1 329 388	1 340 123
Maharashtra	1 883 152	2 025 973	2 091 718	2 151 191	2 208 738	2 275 531	2 327 716	2 345 405	2 417 075	2 491 521	2 572 815	2 623 272
Manipur	45	45	45	45	45	45	45	45	45	45	45	45
Meghalaya	65	65	65	65	65	65	65	65	65	65	65	65
Mizoram	0	0	0	0	0	0	0	0	0	0	0	0
Nagaland	176	176	176	176	176	176	176	176	176	176	194	194
Orissa	65 145	69 184	70 144	72 047	73 359	74 526	74 625	74 625	74 625	74 625	74 625	74 625
Punjab	681 432	709 916	726 221	735 162	744 972	755 141	77 854	811 252	835 651	880 902	912 889	930 311
Rajasthan	488 770	514 758	539 762	565 068	590 119	613 061	639 131	654 182	678 466	701 283	741 124	783 703
Sikkim	0	0	0	0	0	0	0	0	0	0	0	0
Tamil Nadu	1 487 654	1 528 807	1 567 322	1 609 242	1 643 915	1 680 312	1 723 778	1 764 085	1 793 948	1 821 432	1 854 471	1 886 147
Tripura	1 738	1 764	1 764	1 764	1 764	2 094	2 904	2 094	2 757	2 940	3 095	3 273
Uttar Pradesh	727 937	761 272	778 512	790 157	806 270	817 673	808 238	815 498	835 642	841 951	844 964	844 964
Uttrakhand	—	—	—	—	—	—	17 521	17 521	17 007	17 508	17 719	18 408
West Bengal	98 329	101 232	102 773	104 383	107 238	109 291	110 793	111 513	112 322	112 815	113 563	113 888
Total	10 585 006	11 068 847	11 529 183	11 812 534	12 177 683	12 476 349	12 785 330	13 005 639	13 753 543	14 076 422	14 406 010	14 764 585
Union territory												
Chandigarh											623	623
Dadar and Nagar Haveli											953	953
Daman and Diu											1 006	1 006
Delhi											25 883	25 883
Puducherry											10 538	10 597
Andaman and Nicobar Islands											1	1
Total	34 578	35 243	36 159	36 872	37 453	37 895	38 150	38 287	38 884	38 951	39 004	39 063
Grand total	10 619 584	11 104 090	11 565 342	11 849 406	12 215 136	12 514 244	12 823 480	13 043 926	13 792 427	14 115 373	14 445 014	14 803 648

Source: (TERI, 2007a)

Appendix 6 Electrification of rural households as on 31st March 2006

State/union territory	*Total number of rural households*	*Total number of electrified households*	*Electrified households (%)*	*Total number of unelectrified households*	*Unelectrified households (%)*
Andaman and Nicobar Islands	49 653	33 807	68	15 846	32
Andhra Pradesh	12 676 218	7 561 733	60	5 114 485	40
Arunachal Pradesh	164 501	73 250	45	91 251	55
Assam	4 220 173	697 842	17	3 522 331	83
Bihar	12 660 007	649 503	5	12 010 504	95
Chandigarh	21 302	20 750	97	552	3
Chhattisgarh	3 359 078	1 548 926	46	1 810 152	54
Dadra and Nagar Haveli	32 783	27 088	83	5 695	17
Daman and Diu	22 091	21 529	97	562	3
Delhi	169 528	144 948	86	24 580	14
Goa	140 755	130 105	92	10 650	8
Gujarat	5 885 961	4 244 758	72	1 641 203	28
Haryana	2 454 463	1 926 814	79	527 649	21
Himachal Pradesh	1 097 520	1 036 969	94	60 551	6
Jammu and Kashmir	1 161 357	868 341	75	293 016	25
Jharkhand	3 802 412	379 987	10	3 422 425	90
Karnataka	6 675 173	4 816 913	72	1 858 260	28
Kerala	4 942 550	3 238 899	66	1 703 651	34
Lakshwadeep	5 351	5 337	100	14	0
Madhya Pradesh	8 124 795	5 063 424	62	3 061 371	38
Maharashtra	10 993 623	7 164 057	65	3 829 566	35
Manipur	296 354	155 679	53	140 675	47
Meghalaya	329 678	99 762	30	229 916	70
Mizoram	79 362	35 028	44	44 334	56
Nagaland	265 334	150 929	57	114 405	43
Orissa	6 782 879	1 312 744	19	5 470 135	81
Puducherry	72 199	58 486	81	13 713	19
Punjab	2 775 462	2 482 925	89	292 537	11
Rajasthan	7 156 703	3 150 556	44	4 006 147	56
Sikkim	91 723	68 808	75	22 915	25
Tamil Nadu	8 274 790	5 890 371	71	2 384 419	29
Tripura	539 680	171 357	32	368 323	68
Uttar Pradesh	20 590 074	4 084 288	20	16 505 786	80
Uttarakhand	1 196 157	602 255	50	593 902	50
West Bengal	11 161 870	2 262 517	20	8 899 353	80
Total/average	138 271 559	60 180 685	44	78 090 874	56

Source: (TERI, 2007d)