Assessment of Demand Side Management (DSM) Potential and Implementation Strategies in Rajasthan Power sector

THESIS

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By

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CERTIFICATE

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This is to certify that the thesis entitled **"Assessment of Demand Side Management (DSM) Potential and Implementation Strategies in Rajasthan Power sector"** and submitted by **Sanjay Vashishtha** ID No 1999PHXF408 for award of Ph.D. Degree of the Institute, embodies original work done by him under my supervision.

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ABSTRACT

Electricity utilities in India are facing severe energy shortages over the last decade. There are many factors responsible for this situation, such as, high T&D losses, faster growth in domestic and agriculture consumers, lack of capacity addition, poor end-use efficiency, etc. It is expected that the gap between the energy demand and supply will further increase in near future. Application of DSM could be a good way for easing the imminent energy crises. DSM has been highly beneficial in the utilities of developed and a few developing countries. Despite the large energy saving potential and clear economic benefits, DSM is yet to be implemented in Indian utilities.

The present study assesses the potential benefits of DSM in the context of Rajasthan power sector, an electricity utility in northern India. DSM programmes in different consumer categories are proposed for implementation. A reference scenario (base case) and four alternative scenarios are projected using an end-use forecasting model, LEAP. The alternative scenarios present a combination of different technological options, such as, DSM, T&D loss reduction, renewable energy power generation, etc. A comparison of these alternative scenarios with reference scenario is carried out to show the savings in terms of energy, peak demand and environmental emissions. The results indicate significant energy, peak demand and environmental

emission savings through these options and suggest that all these options need to be attempted simultaneously.

There are number of technological and policy related barriers in DSM implementation. The study attempts to identify these barriers through a series of in-depth interviews with top utility officials and experts involved in DSM implementation.

The financial impact of DSM activities on the utility is analysed in the short run and long run perspective. Two different types of electricity industry structures, namely unbundled electricity distribution company (Discom) purchasing electricity from power pool and a vertically integrated electricity utility generating its own power, having its own transmission network and its own distribution network are considered for the analysis.

A questionnaire based survey was also conducted involving utility officials, regulators and consultants to assess a range of DSM implementation strategies. These strategies have been evaluated from a multi-criteria perspective with varying implications in effectiveness, economic feasibility, compliance flexibility, legal feasibility, potential for market transformation and stakeholder acceptance. The results indicate that an integrated approach is required by creating dedicated funds and providing technical support to the end-users for effective implementation of DSM programmes.

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LIST OF ABBREVIATIONS AND ACRONYMS

ADB	Asian D evelopment Bank
AEC	Ahemdabad Electricity Company
AHP	Analytical Hierarchy Process
ASSOCHEM	Association of Chambers of Commerce
BEE	Bureau of Energy Efficiency
BSES	Bombay Suburban Electric Supply Company
BU	Billion Units
CCGT	Combined Cycle Gas Turbine
CEA	Central Electricity Authority
CERI	Canadian Energy Research Institute
CESC	Calcutta Electricity Supply Company
CFL	Compact Fluorescent Lamp
CII	Confederation of Indian Industry
CMIE	Centre for Monitoring Indian Economy
Discom	Distribution Company
DPL	Durgapur Projects Limited
DSM	Demand Side Management
EE	Energy Efficiency
EEAC	Energy Efficient Air-conditioner
EEB	Energy Efficient Ballast

EEF	Energy Efficient Fan
EEL	Energy Efficient Lighting
EEM	Energy Efficient Motor
EEP	Energy Efficient Pump
EER	Energy Efficient Refrigerator
EMC	Energy Management Centre
EPC	Energy Performance Contracting
ESCO	Energy Service Company
GEDA	Gujrat Energy Development Agency
GEF	Global Energy Fund
Genco	Generation Company
GHG	Green house gas
GOR	Government of Rajasthan
GWh	Gega Watt hour
HPGC	Haryana Power Generation Company
HT	High Tension
IDBI	Industrial Development Bank of India
IEA	International Energy Agency
IGCC	Integrated Gas Combined Cycle
IGIDR	Indra Gandhi Institute of Developmental Research
IIE	International Institute of Education
IPP	Independent Power Producers
IREDA	Indian Renewable Energy Development Agency
IRP	Integrated Resource Planning

ISCC	Integrated Solar Combined Cycle
JVVN	Jaipur Vidyut Vitran Nigam
kWh	Kilowatt hours
LM	Load Management
LNG	Liquefied Natural Gas
LT	Low Tension
MOP	Ministry of Power
MPUVN	Madhya Pradesh Urja Vikas Nigam
MT	Medium Tension
MTOE	Million tones of oil equivalent
MU	Million units
MW	Mega Watt
NHPC	National Hydro Electric Power Corporation
NLC	Neyvely Lignite Corporation
NPC	National Productivity Council
NTPC	National Thermal Power Corporation
PFBC	Pressurized Fluidized Bed Combustion
PFC	Power Finance Corporation
REDA	Rajasthan Energy Development Agency
RERC	Rajasthan Electricity Regulatory Commission
RET	Renewable Energy Technologies
RSEB	Rajasthan State Electricity Board
RSPCL	Rajasthan State Power Corporation Ltd.
RVPN	Rajasthan Vidyut Prasaran Nigam

RVUN	Rajasthan Vidyut Utpadan Nigam
T&D	Transmission and Distribution
TERI	The Energy and Resources Institute
TPEC	Total Primary Energy Consumption
TPEP	Total Primary Energy Production
Transco	Transmission Company
TWh	Tera Watt hour
USAID	United States Agency for International Development
WBPDC	West Bengal Power Development Corporation

Chapter 1

RATIONALE AND STRUCTURE OF THE THESIS

1.1 INTRODUCTION

Electricity is a critical input for the economic development of a country. Developing countries such as India are facing severe electricity crisis. The widespread shortages of electricity supply have been detrimental to economic growth. According to various reports, the situations for electricity demand and supply in the next decade do not seem to be any better (Planning Commission, 1998; DOE,2003). Efforts to expand the generating capacity are hampered by resource constrains. Carbon dioxide (CO_2) emissions stemming from electricity generation forms an additional dimension to the problem. In the light of these problems, Demand Side Management (DSM) becomes attractive in attempting to meet the growing energy needs. The present study focuses on assessing potential of DSM programmes and its implementation strategies in the context of Rajasthan power sector, a recently unbundled electricity utility in northern India.

1.2 ENERGY SCENARIO IN INDIA

India is world's sixth largest energy consumer and world's third largest producer of coal. The country relies on coal for more than half of its energy needs. Oil accounts for about 30 % of the total energy consumption (Ansari, 2001). As far as reserves of fossil fuels are concerned, India has 79,106 million tonnes (MT) of proven reserves of coal, 660 MT of crude oil and 648 billion cubic meters of natural gas reserves (CMIE, 2000). The total energy consumption is about 294 million tonnes of oil equivalent (MTOE), this is only 12 % of the energy consumed by the largest energy consumer, i.e. USA (2,278 MTOE) (World Bank, 2002). Table 1.1 shows India's Total Primary Energy Production (TPEP) and Total Primary Energy Consumption (TPEC) over the last decade. The gap between TPEP and TPEC has been continuously increasing over the last decade. In year 2001, the TPEP was 9.37 Quads and TPEC was 12.8 Quads. Thus the Indian economy's dependence on the imported petroleum is increasing over time. Serious steps to improve energy efficiency and conservation of energy are required urgently.

Table 1.1 Total primary energy production and consumption in India (Quads)

	1991	*1992*	*1993*	*1994*	*1995*	*1996*	*1997*	*1998*	*1999*	*2000*	*2001*
TPEP	6.86	7.17	7.37	7.63	9.01	8.75	8.96	9.01	9.06	9.34	9.37
TPEC	8.06	8.71	9.10	9.59	11.10	11.17	11.47	11.76	12.16	12.67	12.80

Source: DOE,2003

According to the demand and supply forecasts made in the ninth five year plan (Planning Commission,1998) for coal, oil, natural gas indicate that there will be a deficit of 220 MT of coal by year 2012, which represents 25 % of total demand (Table 1.2). The demand for crude oil, which was 2.1 million barrel per day in year 2001, is expected to increase to about 4.06 million barrel per day by year 2012. With 0.9 million barrels per day of indigenous production, it represents a deficit of about 79 % in total crude oil demand by year 2012 (Table 1.3). The natural gas demand in the country is expected to increase from current demand of 117 million cubic meters per day to 216.4 million cubic meters per day by the year 2012. This represents a shortage of 172.6 million cubic meters per day (80 %) against the total natural gas demand (Table 1.4). Several efforts are underway to explore the possibility of importing the natural gas either in the form of LNG (liquefied natural gas) from eastern and western boarder of India. In sum, the gap between energy demand and domestic production is likely to widen if the present trends continue, leading to a growing dependence on energy imports even in the short run.

Table 1.2 Coal demand and supply forecasts for India (million tonnes)

	1997-98	*2001-02*	*2006-07*	*2011-12*
Demand	323	400	576	872
Domestic supply	298	360	484	652
Deficit	25	40	92	220

Source: Planning Commission, 1998

Table 1.3 Oil demand and supply in India (million barrels per day)

Year	*Crude production*	*Crude imports*	*Petroleum products demand*	*Self reliance (%)*
1997-98	0.69	0.62	1.68	39
2001-02	0.74	1.57	2.10	33
2006-07	0.80	2.20	2.89	26
2011-12	0.90	3.31	4.06	21

Source: Planning Commission, 1998

Table 1.4 Natural gas demand and supply in India (million cubic metres per day)

	1996-97	*2001-02*	*2006-07*	*2011-12*
Demand	52.1	117.8	167.1	216.4
Production	49.3	71.2	57.5	43.8
Gap	2.8	46.6	109.6	172.6

Source: Planning Commission, 1998

1.3 POWER SCENARIO IN INDIA

Over the last decade, the electricity demand in India has been increasing at an annual compounded growth rate of about 9 %, which ranks among the highest in the world (CEA, 1997). With the current trends in economic growth, it is expected that the demand for power would continue growing at a rapid pace in the future. The total installed generation capacity was 1,12,058.42 MW as on 31/3/2004 consisting of 29500.23 MW hydro, 77968.53 MW thermal and 2720 MW nuclear and 1869.66 MW wind. (MOP, 2004). During the Eighth Plan (1992-93 to 1996-97), 16,422.6 MW were added to the installed capacity against the target of 30,538 MW. Thus, the achievement was only 53.8 % of the target. The Ninth Plan envisaged a capacity addition of 40,245 MW. As against this the achievement in the Ninth Plan was 19,015.1 MW (Planning Commission, 2002a). Again the achievement was 21,230 MW short of target.

The total energy shortage during 2003–04 was 39,866 GWh, amounting to 7.1 %, while the peak shortage was 9,508 MW, translating to 11.2 % of peak demand (MOP, 2004). The high energy and peak demand shortages are also attributed to inadequate Transmission and Distribution (T&D) capacity. Currently, the T&D losses are of the order of 20-25 % (CEA, 2002), although the unofficial figure is believed to be around 40 % (Sant, 1997).

As per the projections of Sixteenth Electric Power Survey of India conducted by the Central Electricity Authority of India (CEA, 2002), India's peak demand would be 1,57,107 MW with energy requirement of 975 TWh by the year 2012 (Figure 1.1 & 1.2). The total investment inclusive of transmission and distribution, in the year 2012, is estimated to be US $200 billion (MOP, 2003a). The management of funds of this magnitude is beyond the capacity of Central and State governments.

The financial performance of the State Electricity Boards (SEBs) has been below par. The commercial losses of all the SEBs were Rs. 41,170 million in March 1992; and increased further to Rs. 1,50,881 million by March 2002 (MOP, 2003a; Planning Commission, 2002b). A large portion of these losses is accounted for by the sale of power to agriculture and domestic consumers at a cost lower than the cost of production. Due to high level of subsidy, the rate of return in these SEBs has reached a negative figure of -19.8 % in 2001-02 (Planning Commission, 2002b). International funding organizations such as International Monetary Fund (IMF) and the World Bank have been pushing governments to reduce subsidies and restructure the SEBs to function in a purely commercial manner. Although some of the states (i.e., Orissa, Haryana, Andhra Pradesh and Rajasthan) have initiated the restructuring processes with the principles of corporatisation and unbundling of the vertically integrated structure with an independent regulatory authority, there has not been considerable improvement so far.

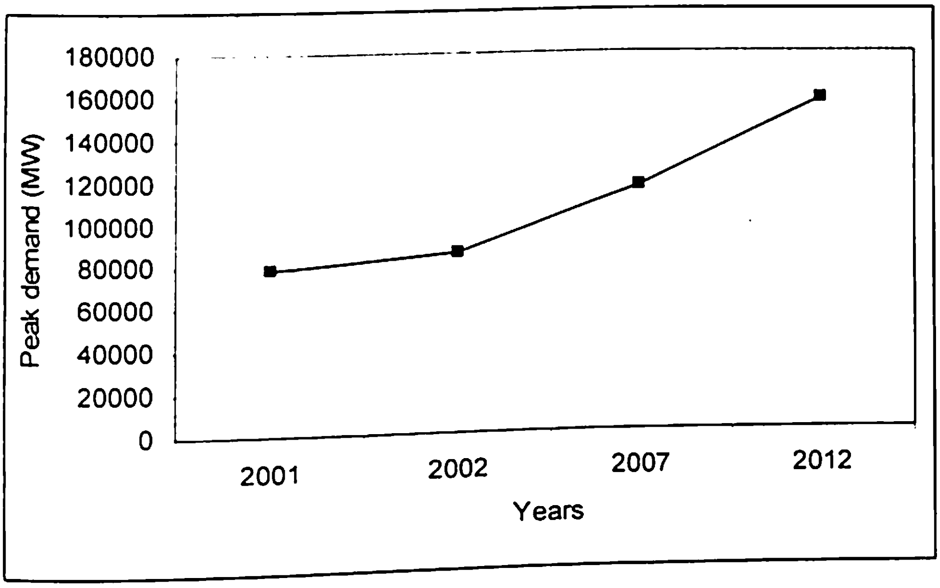

Figure 1.1 Peak demand in India

Source: CEA, 2002

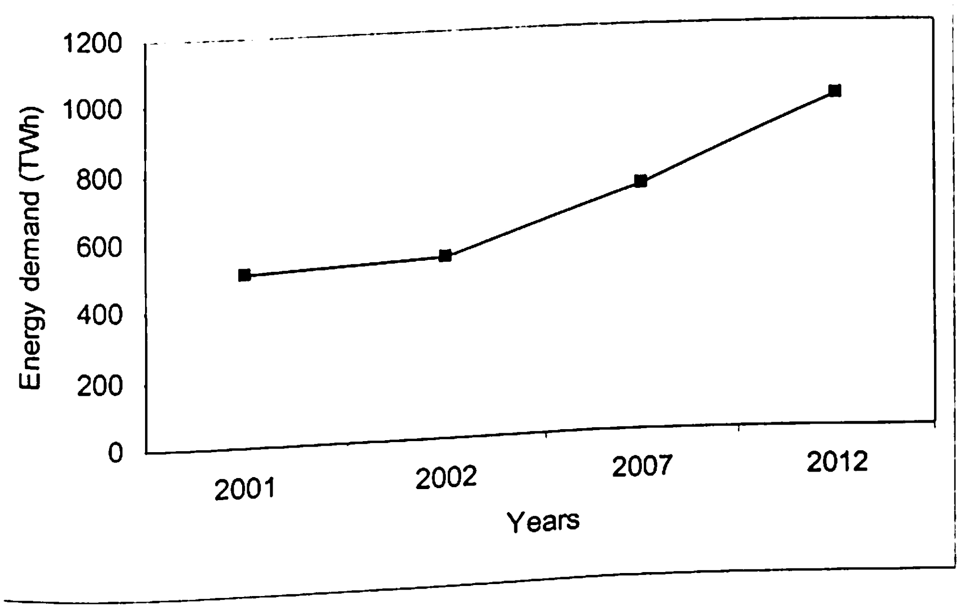

Figure 1.2 Energy demand in India

Source: CEA, 2002

1.4 NEED FOR DSM

In view of the fact that the addition of new capacity takes a relatively long time and huge capital investments, utility planners are focusing on innovative planning strategies to bridge growing capacity shortages. Recently government of India has initiated a major energy conservation and efficiency improvement programme as a part of the ongoing reform programme (MOP, 2003b). DSM is being considered as an important component under this programme. DSM is either implemented directly through utility sponsored programmes or through market intermediaries like ESCOs (Energy Service Companies). The importance of DSM is well recognized in developed countries (Gellings and Chamberlin, 1993; Kreith, 1993; Eto et al., 1995; IEA, 2000). However in the context of developing countries, its benefits are yet to be tested. The feasibility study conducted by World Bank (Ramachandran, 1998), says that, DSM has the potential to mitigate India's endemic problem of energy and peak capacity shortages and capital mobilisation for supply expansion. The study ranked different Indian SEBs based on DSM potential and opportunities. According to this study, Rajasthan is one of the promising states to tap the DSM potential. DSM can be highly beneficial in the agricultural sector, because of the subsidized prices and high costs of supply resulting from technical and commercial losses (Padmanabhan and Sarkar, 2001). Despite the large energy saving potential and clear economic benefits, decision makers in the utilities are hesitating in widespread implementation of these programmes. The most common barriers for implementing DSM include non scientific tariff, lack of incentives, lack of information, and absence of integrated planning approach, etc. (Parikh et al., 1996a; Painuly and Reddy, 1996).

The existence of untapped energy savings potential indicates that current market conditions do not favour the implementation of DSM programmes in Indian utilities. There is a need to increase understanding of the implementation issues of DSM by government, regulators and utility officials for designing appropriate policies. In order to address these issues, present study focuses on assessing potential of DSM and its implementation in the context of Rajasthan power sector.

1.5 OBJECTIVES OF THE STUDY

Following are the main objectives of the study:

1. To assess the technical and financial performance of the Rajasthan power sector and highlight the feasibility of DSM under the current utility framework.
2. To estimate the energy and environmental savings through DSM under a series of scenarios. These scenarios include a range of planning options such as: Energy Efficiency (EE), T&D loss reduction and Renewable Energy Technologies (RETs).
3. To identify the major barriers for DSM implementation and suggest suitable policy measures to overcome these barriers under the current utility framework
4. To assess the techno-economic feasibility of DSM programmes under different market conditions and its impact on different market actors.
5. To evaluate the DSM implementation strategies from the perspective of different stakeholders.

1.6 METHODOLOGY

Following study tasks were successfully completed to achieve the objectives of the study.

1. Examination of the trends of electricity demand and supply, institutional structure, cost structure, tariff structure, T&D losses etc.
2. A comparative analysis of technical and financial performance of Rajasthan power sector vis-a-vis the other utilities in India.

3. An analysis of the various planning options available to meet the electricity demand until the year 2012. Important planning options that are evaluated include: (i) DSM strategies (ii) renewable energy power generation (iii) reduction in T&D losses.

The important questions that have been addressed in evaluating various planning options for Rajasthan power sector include the following:

- How much new capacity additions required to meet electricity demand of Rajasthan over the next decade?
- What will be the implications of electricity generation on the greenhouse gas (GHG) emissions?
- What is the extent of resources required to fully meet projected electricity demand?
- What impact could energy efficiency, renewable energy technologies and T&D loss reduction offer for meeting the electricity demand and reducing environmental emissions?

4. A series of in-depth interviews with the top utility officials and experts in Rajasthan, to identify the major barriers in implementation of DSM programmes under the current utility framework.
5. A questionnaire based survey to evaluate a range of DSM implementation strategies from the perspectives of different stakeholders.

The important questions that have been addressed in evaluating various policy options for DSM implementation include the following:

- Who should be responsible for planning and implementation of DSM under the current structure?
- What are the pros and cons for implementing DSM programmes through existing utility framework?
- Are tariff reforms necessary for implementing DSM?
- Who should carryout IRP under the current framework of the utility?
- What are the disincentives for utility to implement DSM?
- What are the barriers for end-users in adopting DSM measures?
- What mechanisms the regulators should adopt to maximize a utilities DSM results?

7. The statistical methods used in the thesis are: tables, pie charts, graphs, matrices, forecasting tools, etc.

1.7 SCOPE OF THE STUDY

In this study, options for reduction of electricity demand and environmental emissions from power generation are identified. In view of the inadequacy of the available data, the thesis makes the critical assumptions and uses the estimated data such as energy consumption at end use level, market penetration of DSM options, savings through DSM options, etc.

1.8 PLAN OF THE THESIS

Chapter 1 gives the rationale and structure of the thesis covering the Indian energy scenario, the current electricity crisis and the need for DSM. The chapter also includes the aims, objectives, the methodology and the thesis plan.

Chapter 2 presents a review of DSM and its integration in electric utility planning process. This chapter also reviews the worldwide and Indian experiences on DSM implementation.

Chapter 3 presents the current status of Rajasthan power sector. It also examines the technical and financial performance of Rajasthan power sector vis-à-vis other utilities in India.

Chapter 4 assesses the impact of DSM upon energy, peak demand and environmental emissions. A number of alternative scenarios are forecasted to show the impact of different technological options.

Chapter 5 identifies the major barriers for DSM implementation under the current institutional framework in Rajasthan power sector and suggests suitable measures to overcome these barriers.

Chapter 6 assesses the role of different market actors in DSM implementation. The chapter also analyse the techno-economic feasibility of certain hypothetical DSM programmes implemented through different market actors.

Chapter 7 evaluates a range of alternative DSM implementation strategies from the point of view of different stakeholders, namely: utility, regulators and consumers.

Chapter 8 presents the conclusions and recommendations from the study.

Chapter 2

DEMAND SIDE MANAGEMENT (DSM) AS AN ALTERNATIVE SOLUTION: REVIEW OF GLOBAL EXPERIENCES

2.1 INTRODUCTION

The concerns of utilities about meeting energy demand and the interest of the customers in energy efficiency have resulted in development of DSM. This chapter reviews the theoretical aspects of DSM and its integration in electric utility planning process. Section 2.2 attempts to give an overview of DSM and its application in electric utility planning process. Section 2.3 discusses the worldwide experiences on DSM implementation. Section 2.4 highlights the experiences in Indian context. Finally section 2.5 identifies the research gaps for the problem.

2.2 ELECTRIC UTILITY PLANNING AND DSM

The content of electric utility resource planning is broad and covers all the studies related to both the long-term and the short-term planning methods. Its main aim is to seek an optimal supply capacity to meet the projected demand economically, subject to the reliability and the environmental constraints (Sanghavi, 1991). In the traditional utility planning process, growing electricity demands are met though increasing power supply options and improving the transmission and distribution network (Kleinpeter, 1995). This supply led planning gives little consideration to alternative methods of meeting energy needs, such as investment in energy efficiency and conservation measures.

In the US, in the early 1970s, the traditional planning approach came under increasing criticism. There were a number of problems - demand became more difficult to accurately forecast, construction lead times were more unpredictable and there was public opposition to new power stations, rising energy prices, unmet energy needs and the declining environmental quality (Sant, 1984).

In response, an alternative method of meeting energy needs was developed based on Least Cost Planning (LCP) which is now used in some form by most of the utilities in developed countries. Compared to the traditional planning, LCP develops a range of supply and demand options, encompasses broader objectives and involves the participation of wider interests. The central goal of LCP is to provide energy services at minimum cost using both demand and supply options while paying attention to the broader economic, environmental and social effects of different options (Swisher et al., 1997).

Integrating the demand side options in utility planning is known as Demand Side Management (DSM). In terms of power system planning, DSM programmes play an important role for long term operation, and when these options are integrated with the supply side options to meet the forecasted electricity demand, it is known as Integrated Resource Planning (IRP). DSM has gone a long way since its beginning in the wake of the oil crisis in 1970s. Over the years programmes have changed dramatically in scope, intensity and sophistication. The early programmes emphasized increasing awareness of energy conservation issues and available conservation options. By the 1980s, the interest by utilities in DSM activities of utilities was widespread (Gellings and Chamberlin, 1993). There has been a significant shift of interest towards ways to influence how electricity is used by the consumers, and to reduce the burden on creating additional supply side resources.

The relevance of DSM as a cost effective tool for utility capacity expansion planning has been well recognized in electricity utilities of developed countries. Gellings and Chamberlin (1993), Swisher et al. (1997), Hill et al. (1992) and Chernick and Wallach (1996) have considered the integration of both supply side and DSM options for electric utility planning. Most of these studies discuss the DSM implementation in the context of developed countries. Only a few studies have concentrated on the issue of the developing countries. For example, Faruqui (1989) assessed the relevance of DSM in power planning in Pakistan, and Shrestha and Bhattarai, (1993) in the context of Nepal. These studies have demonstrated the economic and environmental benefits of DSM in their respective countries. In Indian context, Parikh et al. (1997) assessed the possible benefits of implementing DSM in high tension industries in Maharastra state. They provided a detailed plan for the number of adoptions, energy savings and demand savings that can be obtained using different DSM options.

2.2.1 DSM Planning Process

DSM planning process comprises four basic steps namely, establishment of base case, identification of DSM opportunities, develop DSM programmes, and implementation of DSM programmes (Gellings and Chamberlin, 1993). A DSM plan is a group of options combined the needs of a specific category of consumers. Generally DSM options are combined with a specific financial package (Reddy, 1995). DSM programme thus developed are integrated with supply side options to develop a coherent resource plan.

As DSM programmes are different in cost, size and expectation, a careful evaluation of these programmes becomes very important. Utilities use typically two types of evaluations, namely process evaluation and impact evaluation (Gellings and Chamberlin, 1993). Process evaluation examines programme operations to identify how well the programme is implemented and to suggest ways to programme delivery, while impact evaluation examines the effects of the programme on energy and peak load reduction.

It is also important to quantify the economic benefits of DSM programmes from the perspective of different actors involved in DSM implementation. According to Hirst and Reed (1991) the cost and benefits of DSM programmes can be assessed in several perspectives. Key perspectives include participants, non-participants (ratepayer impact) test, the utility impact (revenue requirements), and the society (total resource cost test). The screening and selection of individual resource option can be based on different criteria, such as minimization of cost requirements, total resource costs, societal costs, or average electricity prices, and so on.

In assessing alternative resources, three approaches are commonly used by the utilities (Hill,1993; Chattopadhyay et al., 1994). These approaches are sequential demand approach; sequential supply approach; and simultaneous approach. In sequential demand approach, DSM resources are selected first, then are the supply side resources, while in case of sequential supply approach, the supply resources are selected first to meet the projected electricity demand. In case of simultaneous approach, both resources (DSM and supply) are selected at the same time to satisfy the load requirements using some measure of cost effectiveness as a guide.

There are various models available to assess the economic and environmental benefits of different supply side and demand side options in utility planning. The most widely used utility planning models include: Wien Automation System Planning Package version IV (WASP-IV) (Jerasorn et al., 2001); Modular Energy System Analysis and Planning (MEASP) Tomsic (2003); Market Allocation (MARKAL) model (Mathur et al., 2003); and Long Range Energy Alternatives Planning (LEAP) model (SEIB, 2000). Of these available models, LEAP has been most widely used to quantify the long-term implications of energy policy alternatives. The LEAP model has been used in many studies, especially carbon abatement studies (Dhakal, 2003; Islas et al., 2003; Tanatvanit, et al., 2003). The main strength of these studies is the detailed specification of energy and environment options.

2.2.2 DSM Implementation

Saidel and Alves (2003) classify the policy framework used for implementing DSM in to five basic categories: (1) restrictive regulations; (2) information to the public; (3) creation of market asymmetries; (4) funding/loans programmes; and (5) state capital/private capital partnerships. A number of researchers have assessed the effectiveness of these policies in the context of different market economies. For example, Vine et al. (2001) assessed the impact of appliance efficiency standards in US (United States), Dulleck and Kaufmann, (2004) evaluated the effectiveness of information programmes in the context of UK (United Kingdom). Varone and Aebischer (2001) conducted a comparative analysis of different energy efficiency policies implemented in

Canada, Denmark, the United States, Sweden and Switzerland. Wikler (2000) assessed the DSM implementation policies adopted in Thailand, Australia, UK and US. The study suggests how the experience of these countries on DSM can be replicated in south Asian countries.

Electricity market in most of the developing countries is currently under the transition phase. There is a gradual shifting from the monopoly market to the competitive market. A number of authors has advocated for modification of the existing planning approaches for DSM implementation under the competitive market. According to Sioshansi (1996), in future, traditional approaches will become outdated and DSM and environmental factors will play an important role in utility planning process. According to Mills (1999), in future, integration of demand side and supply side resources will not be done only on the basis of least cost criteria; environmental cost and social impact of these resource options play an important role while selecting the resources for future electricity demand. He says the integration of demand side and supply side resources should be assessed from a multi-criteria perspective. Chamberlin and Herman (1996) illustrates the characteristic differences between the utility DSM of the past and DSM of the future. They say, "With the advent of competition, DSM in the future will be considered 'good' if a service provider can offer more customer value (at a profit) than its competitors.

It is also important to assess the financial incentives and disincentives of DSM to different market actors. Vine et al. (2001) assessed incentives and disincentives of DSM implementation to different market actors under different generic models utilities.

According to him utilities are expected to undertake only those DSM programmes, which are likely to increase their net revenue.

2.2.3 Barriers for DSM Implementation

Although DSM has a substantial potential for electricity savings but, due to a wide range of barriers, this potential has not been fully exploited. Brown (2001) classified these barriers in to two categories, one concern with the utilities barriers to use DSM, and the second refers to the consumer's related barriers to implement DSM programmes. Some of the researchers have attempted to identify the consumer related barriers. For example, Thiruchelv et al. (2003), identified consumer related barriers in adopting energy efficiency technologies in the context of south Asian countries such as, China, India, Sri Lanka and Vietnam. Jochem et al. (2000) assessed the barriers for DSM programmes in developing countries. According to this study, lack of awareness of potential benefits; lack of effective energy policy at national level; energy supply constraints; inappropriate energy pricing and cross-subsidies; lack of trained staff, operators and maintenance workers; lack of capital and import of inefficient/used plants; and proliferation of inefficient equipment and the desire to minimise initial costs, are the major barriers for adopting DSM programmes.

Parikh et al. (1996a) conducted a survey to determine the barriers and the role of policies about DSM options in the Indian industry. They showed that the major barriers for the implementation of DSM programmes are the prices of the DSM technologies and the most preferred type of incentive by the industries was a one-time cash rebate. Painuly et al. (1996) also assessed these barriers in Indian context. The major barriers identified include: technical; institutional; financial; managerial; pricing policies; and information diffusion. Cooperation among the utilities, the government, the consumers and the equipment manufacturers are also seen as necessary measures to speed up the implementation of DSM programmes (Sandrine et al., 2001).

Sarkar (2004) classify the strategies to overcome these barriers for DSM in to two categories, namely Market push strategies and Market pull strategies. The market push strategies include regulatory command and control policies, mandatory energy audits, building energy efficiency codes and utility obligation for conducting IRP. The market pull strategies include, appliance labelling, ESCO development, performance contracts etc. Strategies have also been formulated for promoting specific energy efficiency technology. For example, Kumar et al. (2003) assessed policy options for promoting compact fluorescent lamps (CFLs) in India. The study recommended EDucation, POlicy support, STAandards, Demonstrations and INdustry involvement (EDPOSTADIN) for popularising CFLs in India.

2.3 WORLD WIDE EXPERIENCES WITH DSM

DSM was initiated in electricity utilities of North America in the early 1980s. Since 1990s, DSM is being applied widely in electricity utilities all over the world, e.g. US, Canada, Brazil, Australia, Mexico, India, Thailand, Korea, France, Germany, etc.

In US, energy efficiency initiatives are promoted through a public goods charge applied to all customer classes. In return, electricity customers are eligible to participate in various programmes that promote market transformation of energy efficiency products and services (Convery, 1998). In California, the government has created an independent quasi-public agency known as the California Board for Energy Efficiency (CBEE) which manages the fund collected through the public goods charges. ESCOs have also played an important role in delivering energy efficiency in US electricity market. (Painuly et al., 2002). The lessons learned from DSM experience of electricity utilities in North America are described in a joint publication of TERI and CERI (1995). These lessons include: utility commitment; utility staffing; customer acceptance; ownership and organizational arrangements; programme targeting; capturing lost opportunities; targeting of delivery approach; marketing efforts; assistance of trade allies; credibility with customers; financial incentives; providing services; comprehensive measures; high efficiency technologies; programme procedures and materials; customer choice; minimizing risk; developing customer relationship; education, consistent regulation/ policy; regulatory incentives and penalty; information associations/ conferences.

In case of European countries, environmental consideration played an important role in implementing DSM programmes. They introduced a levy to raise finance to fund DSM programmes costs. The electricity regulators introduced a special revenue allowance for electricity companies to achieve end-use energy savings on behalf of their customers (OFGEM, 2002). Similar experiences are available for Australia (Didden, 2003; Crosslay, 1996) where DSM was implemented through regulatory interventions.

In Thailand, Government collects an environmental surcharge on the sale of oil products. The funds collected through this surcharge are used to promote energy efficiency and renewable energy technologies. Examples of DSM initiatives in Thailand include market transformation programmes, energy efficiency product labeling efforts, consumer education initiatives, and private-sector partnerships through ESCOs (Singh and Carol, 2000).

The experience with energy efficiency funds is however mixed with success as well as failure stories. Some of the funds created in developing countries include Energy Saving Fund (ESF) in Czech Republic (Painuly et al., 2003), Indian Renewable Energy Development Agency (IREDA) Energy Efficiency Fund (Bhakthavatsalam, 2001). Similar funds are in different stages of development in Brazil, Romania, and Thailand to support energy efficiency initiatives (Singh and Mulholl, 2000).

Energy Efficiency standards and labelling has also resulted in considerable savings. For example, in Thailand, over 3.6 million EE labeled refrigerators saved 235 GWh /yr energy savings and 14 MW peak demand savings. Similarly, about 400,000 EE labeled air-conditioners resulted in 173 GWh /yr energy savings and 1.4 MW peak demand savings (Sarkar, 2004). More examples of successful DSM policies and programme are available in the INDEEP database under the framework of the IEA DSM implementing agreement, Task I (IEA, 2000).

2.4 DSM IN INDIAN CONTEXT

DSM has the potential to mitigate India's endemic problem of energy and peak demand shortages and capital mobilization for supply expansion. According to a joint study conducted by Tata Energy Research Institute (TERI) and Canadian Energy Research Institute (CERI), electricity savings of the order of 10.3 % in domestic sector, 10.8 % in commercial sector, 12.4 % in agriculture sector and 5.4 % in industrial sector can be realised by implementing energy efficiency measures in these sectors by the year 2010 (TERI and CERI, 1995). Another study conducted by Indian Renewable Energy Development Agency (IREDA) estimates that the required capacity addition can be reduced by almost 25% by improving energy conservation measures and through DSM, and thereby enable a reduction in the capital investment to US $ 140 Billion (Bhakthavatsalam, 2001).

A number of researchers have discussed the feasibility of DSM in Indian context. Kumar and Suri (1997) highlighted the significant benefits of DSM in the context of Indian Industrial sector. Banerjee (1998) assessed the benefits of load management in Indian power sector. According to Padmanabhan and Sarkar (2001) DSM is a strategic tool to overcome the problems of poor voltage and end-use efficiency in the context of agriculture sector in India. They stress on the need of developing innovating financial mechanisms to implement DSM. Sharma et al. (2003) identifies DSM as an immediate short-term measure to overcome the current electricity crisis in Kerala power sector. Wisbrod and Tribble (1999) assess the implementation of the first DSM pilot programme in Ahemdabad Electricity Company (AEC). The study highlights the natural implementation of DSM programme in Indian situation without any subsidy from the government.

Multilateral and bilateral agencies (e.g. World Bank, USAID, ADB) have also played an important role in promoting DSM in Indian utilities. DSM cells in Discoms (Distribution companies) have been created with the aid of World Bank as part of the state power sector reforms programmes. In April, 2000, government of India initiated the Energy Conservation and Commercialisation (ECO) project with the assistance of USAID (Brian, 2003). USAID also supported the first pilot programme for DSM in India in Ahmedabad Electric Company (AEC) in 1994. ESCOs played an important role in the success of the programme (Weisbroad et al.,1998).

Government of India introduced certain policy initiatives to promote energy efficiency and DSM in Indian power sector. For example in 1998, the Electricity Regulatory Commission Act, 1998 was also introduced to encourage more efficiency and transparency in working of state electricity utilities. This led to the restructuring of Indian electricity utilities. This was followed by Energy Conservation Act, 2001. Bureau of Energy Efficiency (BEE) was created under this act (MOP, 2001), which is responsible for taking up both promotional and regulatory functions required for implementation of energy efficiency programmes. Recently government has introduced the Indian Electricity Act, 2003 (MOP, 2003c). The Act embodies the features of reforms as well as allows competition at retail level. Introduction of this act is being considered as a move towards creating a market-based regime in the Indian power sector that consolidates the laws relating to generation, transmission, distribution, trading and use of electricity (Thakur et al., 2004).

2.5 RESEARCH GAPS

- Although there is a considerable literature on DSM, not many case studies are available in the context of developing countries, particularly in the Indian context. As DSM implementation in Indian utilities is yet to take off, there is a need of assessing its potential and feasibility in individual utility.
- As most of electricity utilities are going through the restructuring phase, some barriers inhibiting investment in energy efficiency would be identified and removed, while others may remain unaffected. Actual implementation of DSM programmes has variety of technical, policy, institutional, financial and

information related barriers, which needs to be assessed in the context of Indian utilities.

- Successful DSM implementation depends on its varying implications in effectiveness, cost, feasibility, efficiency and stakeholder acceptance (Metty and Beckwith, 2002; Clarke, 1994). This necessitates a critical analysis of DSM implementation strategies from specific stakeholder point of view.

Chapter 3

RAJASTHAN POWER SECTOR-CURRENT STATUS

3.1 INTRODUCTION

This chapter briefly discusses the current status of Rajasthan power sector and highlights the key factors affecting its performance. The chapter begins with an overview of Rajasthan power sector. This is followed by a discussion on the technical and financial performance of Rajasthan power sector. Finally options to improve its performance are suggested.

3.2 RAJASTHAN POWER SECTOR: AN OVERVIEW

3.2.1 Evolution of Rajasthan power sector

At the time of the formation of Rajasthan State in 1949 the installed generation capacity was a meagre 13.27 MW and electricity supply was limited to the princely states and few towns. The power sector in Rajasthan received impetus after the formation of Rajasthan State Electricity Board (RSEB) in 1957 and planned growth in installed capacity, transmission network and rural electrification took place with the state investing 28-30% of its plan outlay in the initial years in the power sector. RSEB was an autonomous corporate body, under state ownership. Responsibility of the state was to ensure supply of essential products and services to its citizens at affordable prices, particularly because the majority of the population was poor. Currently the state power system covers a large geographical area of 342,000 Sq. Kms through its transmission and distribution network and serves over 5 million consumers from different categories. Demand for electricity has been growing at an annual average of 11%.The unserved demand is significant, as evident by a backlog of over 0.6 million applications for service connections (Jain, 1999). The annual per capita electricity consumption is 334.5 kWh, which is lower than India's average of 354.75 kWh (MOP, 2004).

3.2.2 Institutional Structure

Rajasthan power sector has undergone significant changes in recent years, and the institutional framework evolved to supply electricity had to adjust to changing scenario. Rajasthan was one of the few states in India to implement a comprehensive power sector reform programme (Narang, 1999). Prior to reform, the responsibility for power sector management and development in Rajasthan was vested in the following organizations:

1. Department of Energy, Government of Rajasthan
2. Rajasthan State Electricity Board (RSEB).
3. Rajasthan State Power Corporation Ltd. (RSPCL)

However, RSEB was the main body responsible for power sector development in the state. RSEB was owned by the Government of Rajasthan and vested with the responsibility for regulation and supply of power to the entire state of Rajasthan. It obtained the required power for distribution either from its own generating stations, or from neighbouring states.

The process of power sector reforms started way back in 1999, when the Government of Rajasthan approved the Power Sector Reforms Bill, 1999. On July 19, 2000, the Government of Rajasthan was sanctioned a World Bank loan of US $180 million for the Rajasthan power sector restructuring project (Arora, 2001). An independent regulatory commission known as Rajasthan Electricity Regulatory Commission (RERC) was established to regulate the functioning of the power companies and protect the interests of customers in respect of quality, reliability and a fair price for electricity. The functions of erstwhile RSEB, were unbundled in to separate autonomous companies based on functional specialisation, namely

1. Rajasthan Rajya Vidyut Utpadan Nigam (RVUN)
2. Rajasthan Rajya Vidyut Prasaran Nigam (RVPN)
3. The distribution functions of RSEB are vested into three Distribution Companies (Discoms)

A comparison of the structure of Rajasthan power sector before and after reform is given in Table 3.1. Role of state government is limited only for policy decisions. The newly formed regulatory commission is responsible to take decisions in fixing tariff issues, promoting the efficiency etc. The Rajasthan Vidyut Utpadan Nigam, a state owned generation company (Genco) is responsible for generating power from all the existing generating stations of RSEB. The Rajasthan Vidyut Prasaran Nigam, a state owned transmission company (Transco) purchases power in bulk from Genco and other generating stations, both central and private power producers within and outside

Rajasthan, and the neighbouring states based on legally binding power purchase agreements. The Transco is also responsible for overall system planning and co-ordination. The State is geographically divided into three distribution companies (Discoms), namely Jaipur Vidyut Vitaran Nigam, Jodhpur Vidyut Vitaran Nigam and Ajmer Vidyut Vitaran Nigam. These companies approach the regulatory commission individually for fixing their retail tariffs. Discoms purchase electricity on the basis of bulk sales agreements from Transco at a flat rate of 2.17 Rs./kWh, which is further sold to the end-users in the state at different tariffs.

The planning process of the electricity sector in Rajasthan is currently being performed at various agencies within the State like Genco (Generation Company), Transco (Transmission Company), Discoms (Distribution companies), Department of Power, RERC (Rajasthan Electricity Regulatory Commission), etc. Further, they are closely influenced by the policy measures implemented from time to time by various agencies of government of India like Central Electricity Authority (CEA), Ministry of Power (MOP) as well as power producers like National Thermal Power Corporation (NTPC), etc. According to the current understanding, the Discoms and Transco are responsible for secure supply today and in future. Currently there is no central agency to develop an integrated resource plan at state level. Under the current framework, utilities are finding it very difficult to integrate the supply-side and demand-side options simultaneously through an integrated resource planning (IRP) approach.

Table 3.1 Institutional framework of Rajasthan power sector

Activity	*Pre reform (before July 2000)*	*Post reform (after July 2000)*
Policy making	Government of Rajasthan	Government of Rajasthan
Regulation	RSEB/ Government of Rajasthan	Rajasthan Electricity Regulatory Commission
Generation	RSEB owned power plants Rajasthan Energy Development Agency Other purchases	Rajasthan Vidyut Utpadan Nigam Rajasthan Energy Development Agency Other purchases
Transmission	RSEB	Rajasthan Vidyut Prasaran Nigam
Distribution	RSEB	Jaipur Vidyut Vitaran Nigam Ajmer Vidyut Vitaran Nigam Jodhpur Vidyut Vitaran Nigam
System planning and coordination	RSEB	Rajasthan Vidyut Prasaran Nigam
Tariff structure	Agriculture and domestic consumers subsidized by industry and commercial consumers	Agriculture and domestic consumers subsidized by industry and commercial consumers.

3.2.3 Energy Balance

Table 3.2 presents data on total electricity supplied, generated purchased share, T&D losses, and the electricity consumption in different categories in Rajasthan power sector from 1996-97 to 2001-02. The net electricity generation in the state has grown from 18,976 GWh per year in 1996-97 to almost 25,570 GWh in 2001-02. Nearly 75 % of the total electricity supplied to the Rajasthan Power sector was generated in the state's own power stations during 1999-2000. The remaining 25 % was purchased, largely from thermal and nuclear power stations run by the central government and few independent power producers (IPPs). The proportion of outside electricity purchase has been steadily increasing over the past few years.

A consumer category-wise analysis for Rajasthan power sector described in Table 3.2 shows that in the year 2001-02, agriculture consumers formed the biggest segment, consuming 39.7 % of the total energy. Industrial sector was the next biggest segment with a consumption of 28.4 %. The other major categories were domestic (17.8 %) and commercial (5.5 %). In this period (1996-97 to 2001-02), while domestic consumption rose over by 8.5 % per year and agriculture rose steadily by 8.9 %, while industrial consumption rose only by about 1.09 % per year and that too mostly in 2001-02. Commercial consumption did grow significantly but it still forms only a small share. Thus, low tariff consumer categories have grown, while the higher tariff categories have not.

The consumption of energy in the Rajasthan power sector was 18,292 MU during 2001-02, which was one of the highest among state power sectors in India. If one adds 7,278 MU of technical and commercial losses, the gross energy consumption rises to 25,570 MU. This gross energy requirement has increased at a rate of about 5.3% p.a. during the period 1996-07 to 2001-02, which is higher than the all India average growth rate of 5.1% in the same period.

Table 3.2 Rajasthan power sector: power and energy balance

Item	*Units*	*1996-97*	*1997-98*	*1998-99*	*1999-00*	*2000-01*	*2001-02*
Total electricity supplied	GWh	18976.3	20931.42	23183.3	24197	25098	25570
Generated : purchased share	%	77.6	71	74.3	75.3	NA	NA
Transmission and distribution losses	GWh	4911	5551	6837	7282	7412	7278
loss in percentage of total supply	%	25.9	26.5	29.4	30	29.3	27.7
Electricity sold to different consumer categories							
Domestic	GWh	2171	2435.97	2653.6	2852.4	3110	3270
Commercial	GWh	750.9	868.75	844.2	855.3	942	987
Agriculture	GWh	4737.4	4980.35	6032.2	6559.4	6967	7274
Industry	GWh	4932.3	5535.03	4888.7	4573.8	4980	5202
Railways	GWh	182.2	206.51	179.7	220.8	247	266
Outside the state	GWh	313.5	474.34	436.9	544	130	0
Others	GWh	978	879.47	1311	1309.3	1310	1293
Total	GWh	14065.3	15380.42	16346.3	16915	17686	18292

Source: Planning Commission, 2002b

Figure 3.1 and 3.2 indicate the peak and energy deficit during different years in Rajasthan. The peak and energy deficit were as high as 23% and 15%, respectively in year 1997-1998. The current peak and energy deficit are of the order of 6.6 % and 0.6 %, respectively. This does not account for the true peak and energy demand that would grow if uninterrupted power is supplied to domestic and agricultural sector. One of the major reasons for the high growth of electricity demand is the village electrification programme taken by the government of Rajasthan. This is evident with the fact that village electrification in the state by year 2002 has been achieved to the tune of 94.85 %.

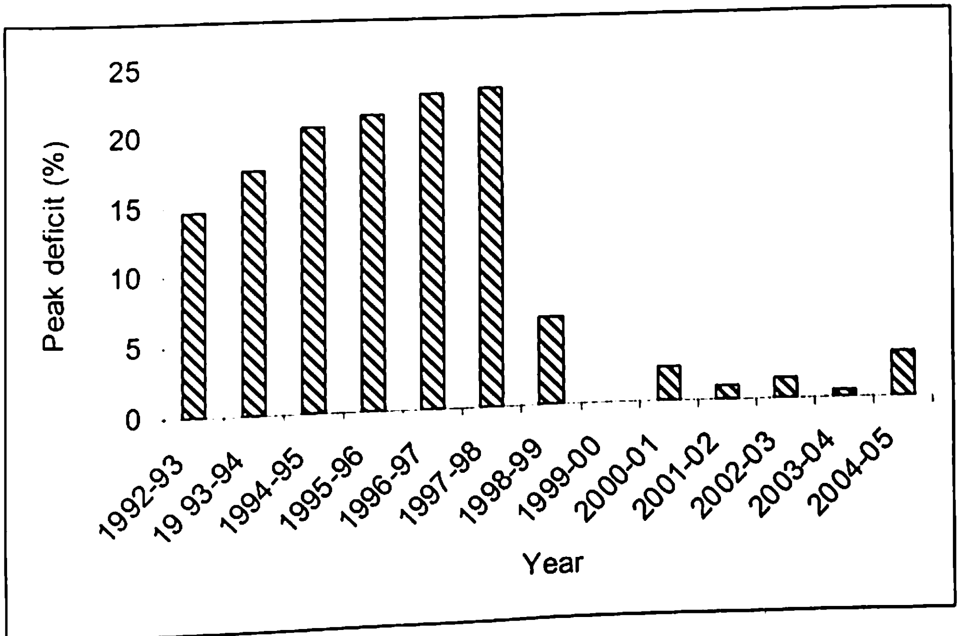

Figure 3.1 Peak deficit in Rajasthan
Source: MOP, 2004

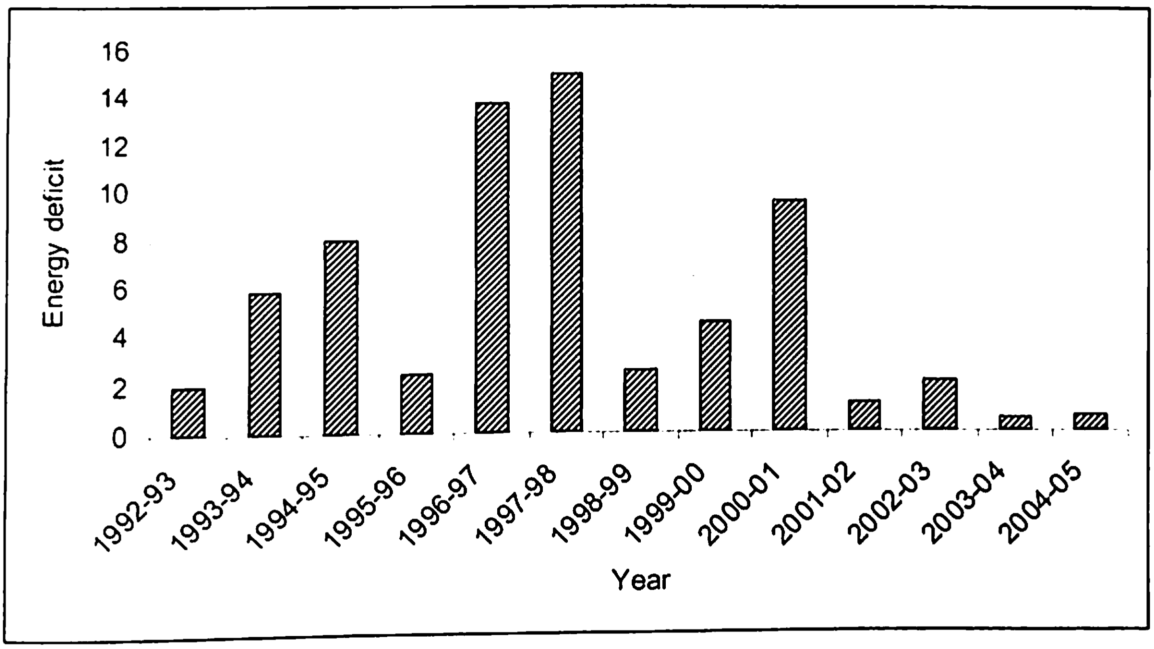

Figure 3.2 Energy deficits in Rajasthan
Source: MOP, 2004

3.2.4 Installed capacity

The total available capacity as on 31/7/2004 in the state was 5038.12 MW, of which 3511.82 MW was from state owned power plants, 1472 MW was from central sector and 54.38 MW from private sector (MOP, 2004). Coal has been the principal fuel for electricity generation in the state, which is imported from other states. In recent years, there has been an increase in gas/naphtha-fired power, utilizing Combined Cycle Gas Turbines (CCGTs).

The growth in peak load and energy requirements during the last decade was about 7.3 % and 7.6 % p.a., respectively. According to the forecasts made by Central Electricity Authority (CEA) in the sixteenth electric power survey, the energy requirements and peak demand are expected to reach up to 56,133 GWh and 9,423 MW, respectively by the year 2012 (CEA, 2000). As regards new planned capacity additions, the only committed extension project is Suratgarh Stage II (500 MW), which will use imported low-grade coal (GOR, 2003a). The private sector, on the other hand, is expected to exploit the potential of new lignite and liquid fuel-based projects. IPP ventures considered in the 10th Plan for 2002-03 to 2006-07 are expected to add 1,700 MW (GEF, 2003). So far, however, large-scale investments by IPPs have not been committed. The most prominent project proposals under negotiation are the Dholpur combined cycle plant of 702 MW capacity and the Barsingsar lignite plant of 500 MW capacity (GOR, 2003b).

3.3 PERFORMANCE OF RAJASTHAN POWER SECTOR

3.3.1 Technical Performance

3.3.1.1 Plant Load Factor

Table 3.3 provides a comparison of the plant load factor (PLF) of various SEBs in India during the period 1992-93 to 2001-02. From a study of this data it can be seen that the performance of Rajasthan power sector in terms of plant load factor was considerably better vis-a-vis other SEBs. There is an increasing trend in average PLF of coal thermal power plants. PLF of 84.8 % in 2001-02 was higher than the all-India average figure of 67 %, however, lower than 86.3 % of APSEB, another well-performing SEB in the country.

3.3.1.2 Auxiliary Consumption

Table 3.4 provides a comparison of the auxiliary consumption of various SEBs in India during the period 1992-93 to 2001-02. The performance of the power sector needs to be improved in terms of auxiliary consumption. It can be seen that the auxiliary consumption in year 2001-02 was about 9.5 %, which was much higher compared to auxiliary consumption of central sector power companies, for example NTPC and

APSEB are having auxiliary consumption of the order of about 7 %. It may be noted that the states which have most of their generation capacities based on hydro electric power plants also show considerably lower auxiliary consumption due to the technical parameters.

3.3.1.3 T&D Losses

Table 3.5 provides a comparison of the T&D losses of various SEBs in India during the period 1992-93 to 2001-02. In 2001-02 T&D losses in Rajasthan were as high as 30% in year 1999-2000. If reported figures are to be believed, T&D losses which have remained at about 17 % in the states such as Punjab, Taminladu and Himachal Pradesh over the last few years are the lowest among all SEBs. If we compare these losses with the utilities of developed countries which are having T&D losses of the order of about 10 %, shows the huge savings potential in Indian utilities (Rao, Kalirajan, and Shand, 1998). Even these reported figures of T&D losses seem to be under estimated, as the utility is keen to show better efficiency ratios. The T&D losses are adjusted against the agriculture consumption by overstating the consumption in this category, which is almost 50 % unmetered and difficult to detect. A clear recognition of the large T & D losses can be found from the tariff order of the RERC in 2001, which lists the T & D losses as 39 % (RERC, 2003). It is difficult to distinguish from the available data, but it is acknowledged that non technical losses arising out of pilferages and improper billing contribute for the significant T&D losses.

Table 3.3 Plant load factor (%) of different thermal power stations

SEBs	*1992-93*	*1993-94*	*1994-95*	*1995-96*	*1996-97*	*1997-98*	*1998-99*	*1999-2000*	*2000-01*	*2001-02*
Northern Region	62.00	64.00	59.10	62.00	64.70	66.70	67.20	70.90	73.10	75.10
Haryana	49.90	40.50	44.70	42.90	47.70	49.40	48.80	53.00	49.70	60.50
Punjab	58.30	63.50	56.70	55.00	65.70	69.10	69.40	74.70	77.90	79.20
Rajasthan	77.00	81.00	75.60	73.70	75.60	80.50	78.10	82.30	85.00	84.80
U.P.	50.50	50.30	43.90	47.30	49.10	48.80	48.90	49.80	57.00	59.70
Delhi(DVB)	54.00	49.00	53.90	51.70	41.70	47.20	38.20	49.90	49.50	45.20
Western Region	59.70	63.40	63.80	68.10	70.20	70.30	70.50	72.30	73.40	74.20
Gujarat	61.60	60.40	60.50	65.30	64.80	65.60	63.60	63.40	66.90	66.30
Maharashtra	59.70	64.10	61.20	64.90	68.70	68.30	68.40	71.70	72.60	74.50
Madhya Pradesh	52.50	56.10	58.20	58.70	62.30	66.00	67.20	69.40	66.60	63.00
Chhatisgarh									65.70	71.30
Southern Region	62.60	68.30	69.10	74.70	75.80	77.10	75.40	79.60	82.00	82.30
Andhra Pradesh	65.00	68.70	70.20	77.40	78.30	82.00	76.80	83.20	85.40	86.30
Tamil Nadu	65.20	69.00	68.10	76.10	72.30	68.10	65.90	72.30	74.80	78.00
Karnataka	49.40	66.90	64.90	67.70	70.20	75.20	81.60	82.30	81.30	81.10
Eastern Region	39.80	44.80	43.70	42.70	42.20	43.00	44.30	46.10	47.90	48.70
Bihar	25.20	24.40	20.00	17.40	15.30	16.10	22.50	19.70	15.40	14.50

Table 3.3 Plant load factor (%) of different thermal power stations (Contd…)

SEBs	*1992-93*	*1993-94*	*1994-95*	*1995-96*	*1996-97*	*1997-98*	*1998-99*	*1999-2000*	*2000-01*	*2001-02*
Tenughat V						51.70	40.10	31.70	36.20	31.50
Jharknand •									20.80	21.00
Orissa *	34.50	35.50	29.00	67.00	69.40	65.30	76.20	85.60	81.70	70.70
West Bengal	31.10	40.50	41.20	34.60	39.20	40.00	36.80	39.80	36.00	38.30
WBPDC	58.10	68.20	60.40	57.60	56.50	52.80	60.70	56.20	55.90	51.70
DPL	28.70	26.30	26.60	26.50	29.50	25.30	17.60	24.80	17.50	30.40
N.E.Region	24.30	19.90	26.80	28.60	27.10	21.30	18.70	18.20	18.50	16.80
Assam	24.30	19.90	26.70	28.60	27.10	21.30	18.70	18.20	18.50	16.80
All SEBs	54.10	56.60	55.00	58.00	60.30	60.90	60.80	63.70	65.60	67.00
NTPC.(STPS)	68.80	76.90	76.20	76.70	76.40	74.40	75.60	79.70	79.50	80.10
NLC	56.40	55.50	60.40	67.60	70.30	72.50	73.60	73.20	80.90	79.50
DVC.	32.30	42.30	38.20	37.80	35.60	38.40	38.00	35.90	36.00	33.60
AEC	62.50	67.00	69.10	69.30	71.40	71.30	74.40	81.70	82.70	82.30
Trombay	54.30	48.80	60.60	72.80	68.80	63.50	61.20	60.80	70.40	72.00
CESC	67.50	71.30	75.60	78.90	74.90	76.90	72.40	64.00	68.30	69.00
BSES				55.30	73.20	82.40	74.80	86.00	81.60	86.50

Source: Planning commission, 2002b

Table 3.4 Auxiliary consumption (%) of different SEBs

	1993-94	*1994-95*	*1995-96*	*1996-97*	*1997-98*	*1998-99*	*1999-2000*	*2000-01*	*2001-02*
	Actual	Actual	Actual	Actual	Actual	Actual	(Provi.)	(RE)	(AP)
1. Andhra Pradesh	5.35	5.66	6.71	6.14	6.87	7.01	7.65	7.57	7.16
2. Assam	8.54	8.09	8.88	8.74	9.32	7.63	7.36	6.50	6.83
3. Bihar	12.78	12.80	13.53	10.27	12.64	13.57	13.84	13.88	13.82
4. Delhi(DVB)	NA	8.84	9.09	8.94	8.68	8.85	8.54	8.27	8.08
5. Gujarat	10.04	9.66	9.25	8.26	9.52	9.58	9.32	9.66	9.21
6. Haryana	5.46	5.26	5.57	5.98	6.51	2.80	0.76	0.67	0.66
HPGC							11.04	11.52	9.39
7. Himachal Pradesh	0.27	0.24	0.20	0.30	0.26	0.25	0.25	0.46	0.51
8. Jammu & Kashmir	1.00	1.00	1.00	0.18	1.00	1.00	1.00	1.00	1.00
9. Karnataka SEB	1.47	1.60	2.02	2.59	2.47	1.95	1.85	0.00	0.00
10. Kerala	0.57	0.38	0.39	0.51	0.46	0.68	0.65	0.83	0.85
11. Madhya Pradesh	9.30	9.09	8.75	8.64	8.73	8.38	8.66	8.39	8.30
12. Maharashtra	7.89	7.53	7.64	5.73	7.46	7.41	7.48	7.37	7.35
13. Meghalaya	0.34	0.35	0.36	0.35	0.42	0.30	0.40	0.40	0.40
14. Orissa SEB	3.29	9.60	12.84						
15. Punjab	4.92	4.49	4.46	4.36	5.01	4.69	5.54	5.47	5.20
16. Rajasthan (Transco.)	7.51	7.10	7.48	7.16	7.52	7.35	8.42	6.67	4.35
Rajasthan (Genco.)								9.50	9.47
17. Tamil Nadu	6.79	6.41	6.71	7.15	6.80	7.15	7.29	6.62	6.78
18. UP (Power corp.)	8.15	7.58	7.59	7.67	7.97	7.97	0.00	0.00	0.00
19. West Bengal SEB	10.73	10.90	12.03	10.91	11.66	12.14	11.37	11.46	11.10
Average of SEBs :	6.96	7.44	7.11	6.59	7.15	7.04	7.20	7.19	7.06

Source: Planning commission, 2002b

Table 3.5 Transmission & Distribution Losses (%) in different SEBs

	SEBs	*1995-96*	*1996-97*	*1997-98*	*1998-99*	*1999-2000*	*2000-01*	*2001-02*
		Actual	Actual	Actual	Actual	Provis.	(R.E.)	(Plan Est)
1	Andhra Pradesh (APTRANSCO)	18.9	33.1	32.5	31.9	35.2	32.9	32.6
2	Assam	26.2	26.4	30.1	40.2	39.2	38.6	30.7
3	Bihar	25.9	25.3	25.4	28.3	27.9	25.0	24.7
4	Delhi	48.0	49.6	42.3	48.7	50.7	47.0	45.0
5	Gujarat	18.3	21.4	21.7	20.1	22.1	20.0	19.2
6	Haryana	31.4	32.8	33.4	33.9	33.8	35.0	33.0
7	Himachal Pradesh	17.5	18.4	19.2	20.1	19.7	18.3	17.4
8	Jammu & Kashmir	48.6	50.0	47.5	47.1	47.0	56.4	46.8
9	Karnataka (KPTCL)	18.5	18.9	18.6	30.2	38.0	36.5	36.0
10	Kerala	20.1	21.4	17.9	17.6	17.4	17.2	17.2
11	Madhya Pradesh	19.5	20.6	19.7	19.5	31.8	31.0	30.0
12	Maharashtra	15.4	17.7	17.1	15.5	30.5	30.0	28.0
13	Meghalaya	17.8	19.5	17.9	20.1	20.6	20.3	20.3
14	Orissa (GRIDCO)	46.9	50.4	49.2	41.9	45.2	49.9	5.3
15	Punjab	18.2	18.9	17.8	16.7	17.2	17.5	17.5
16	Rajasthan (Transco.)	28.5	25.9	26.5	29.4	30.0	29.0	27.7
17	Tamil Nadu	17.0	16.4	16.8	16.9	16.7	16.5	16.3
18	UP (Power corp.)	22.8	27.0	25.5	25.5	42.2	39.8	38.7
19	West Bengal SEB	20.7	20.1	20.0	25.5	29.7	30.0	30.0
	Average :	22.2	24.5	24.0	24.8	30.8	29.9	27.8

Source: Planning commission, 2002b

3.3.3 Financial Performance

The financial performance of the state power sector had deteriorated steadily since 1996-97. RSEB had not been able to earn the statutory rate of return of 3% on net fixed assets without subsidy from the Government of Rajasthan because of its low level of tariffs. In spite of the sales revenue not being able to meet the operating costs, there was not considerable tariff increase during 1993-94 to 2001-02. Therefore, RSEB had to depend on the support of government to sustain its operations. But, the Government of Rajasthan was unable to meet the increasing financing needs of the RSEB because of its continuing poor performance.

3.3.3.1 Cost Structure

Figure 3.3 shows the cost structure of RVUN. The major components of electricity supply costs are: fuel cost, power purchase cost, O & M cost, establishment and administration cost, depreciation cost, interest and other miscellaneous expenses. The average cost composition shows that fuel cost constitute about 64 % of the total cost and interest also contributing huge, adds almost 19 %. This high level of interest reflects the capital structure of the utility.

Comparing the cost structure with other power generation companies (Table 3.6), it may be observed that fuel cost per unit of electricity generation in Rajasthan is 151.70 paise/kWh. This cost is only marginally lower than HPGC where it is 176.30 paise, but substantially higher than the fuel cost in other states. The per unit fuel costs of WBPDC, UPTPGen Corp., APGENCO, KPC and OPGC are 99.95 paise, 87.63 paise, 84.34 paise, 64.49 paise, and 47.60 paise, respectively. Thus, there is a wide variation in the per unit fuel cost across the states. Generally the per unit fuel costs are lower in the states with higher proportion of hydro power generation. The unusually high fuel cost per unit in Rajasthan can be attributed to the large component of transportation cost of coal from the other states.

Another major component in the cost structure of electricity is the interest component. This is the interest paid by the power companies on the borrowing capital for installing the power plants. It may be observed that the interest component per unit of electricity generation in Rajasthan is 44.33 paise/kWh. This cost is only marginally lower than HPGC where it is 58.21 paise, but substantially higher than the fuel cost in other states. For example, in case of UPTPGen Corp. the interest component is only 10.68 paise. The large interest component shows that the utility has high borrowed capital and at higher interest rates.

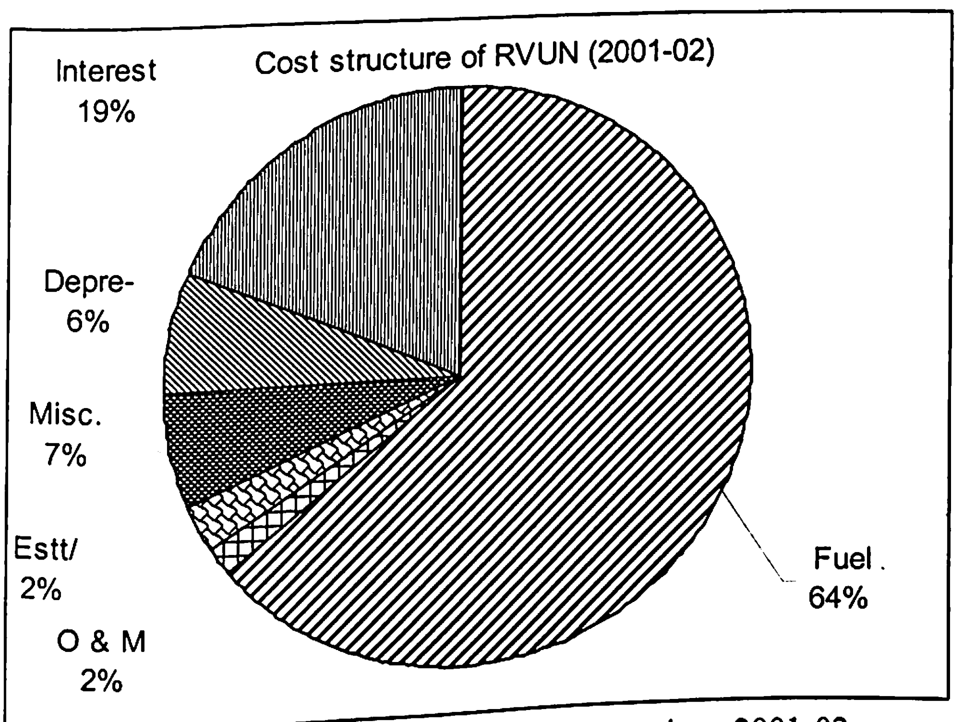

Figure 3.3 Cost structure of generation companies - 2001-02
Source: Planning commission, 2002b

Table 3.6 Cost structure of different generation companies - 2001-02

Utility	*Fuel*	*Power Purchase*	*O & M*	*Estt/ Admn.*	*Misc. exp.*	*Depreciation*	*Interest*	*Total*
				(Paise/Kwh of sale)				
APGENCO	84.34	0.33	7.62	8.15	0.00	17.78	41.81	160.04
HPGC	176.3	0.00	8.47	20.50	0.00	13.25	25.59	244.17
KPC	64.49	0.00	3.57	14.54	2.23	13.44	25.11	123.38
OHPC (Orissa)	0.00	0.00	4.27	9.50	0.00	13.52	28.82	56.12
OPGC (Orissa)	47.60	1.12	9.04	8.34	1.51	30.67	0.00	98.27
Rajasthan (Genco.)	151.70	0.00	4.15	5.50	15.3	15.35	44.33	236.47
UP TPGen. Corp.	87.63	0.00	14.6	14.67	0.00	21.38	10.68	148.99
WBPDC	99.95	0.00	7.79	5.84	0.00	31.82	58.21	203.62

Source: Planning commission, 2002b

3.3.3.2 Electricity tariff

Uneconomic pricing of electricity is also one of the major factors for heavy losses in the Rajasthan power sector. Current electricity tariffs in Rajasthan do not reflect the actual cost of supply to the different consumer groups: industrial and commercial consumers, particularly high voltage consumers, are charged substantially higher than the cost of supply whereas the agricultural sector and, to a lesser extent, the residential sector, are heavily subsidised. Table 3.7 shows the average retail tariff in different sectors. It can be seen that the agricultural sector pays very little, while commercial/industrial users pay significantly more, well more than average costs. Further agriculture sector contributes for a significant portion of consumption (41%). and the share for industry has been declining over time (partially due to their move to captive power). Agricultural and domestic users are subsidised, while other users are charged higher prices (cross-subsidy). But, on average, utilities lose over one rupee per kWh they deliver, with a "cost of supply" of Rs 3.68 /kWh, and average tariff of Rs 2.21 /kWh.

Comparing the average tariff (Table 3.8) to the average cost of supply, it may be seen that the losses of the utility have been increasing over time. This is despite the substantial increase in tariffs recently, over 9.5% p.a. over the 9 years shown. Unfortunately, the average cost of supply has increased even more rapidly, at about 11.8%, and there are indications that this trend will continue because of higher costs of new generation units as well as increased costs for factoring in utility profitability. The cost recovery through revenues has declined from 91% to 76% over the past 10 years (Figure 3.4). The pricing of electricity in irrigation provides no incentives to agricultural consumers to use energy efficient pump sets. The continuation of pricing policies has not only adversely affected the financial position of the utility but has also weakened the borrowing capital from domestic and international funding agencies.

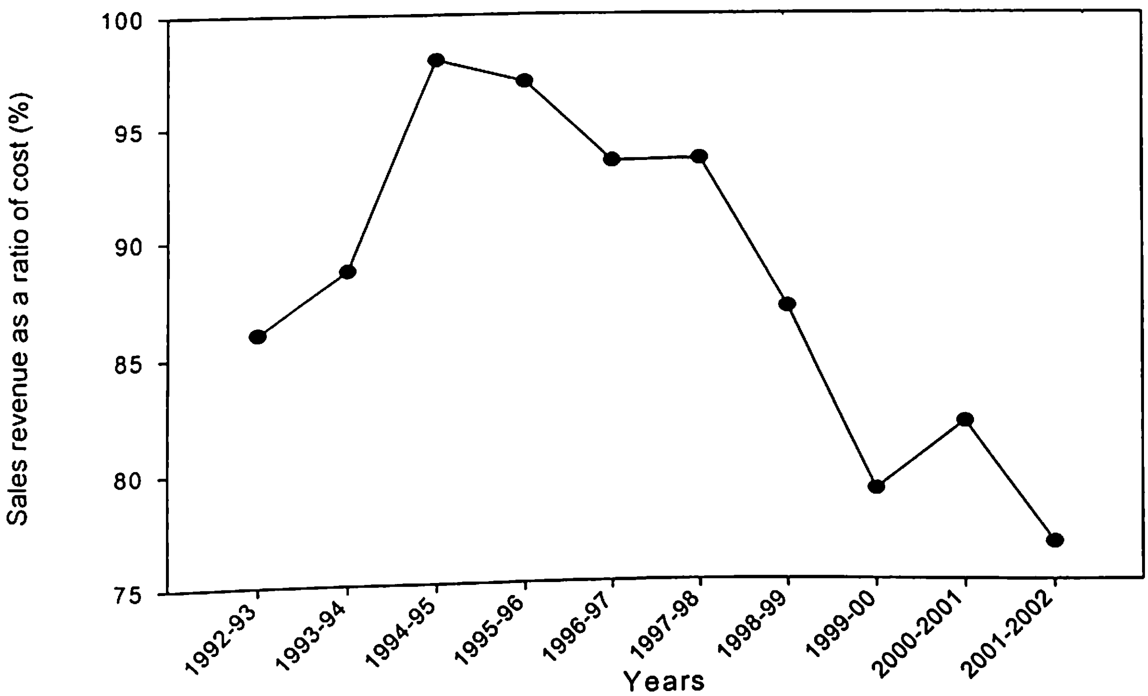

Figure 3.4 Sales revenue as a ratio of cost

Source: Planning commission, 2002b

Table 3.7 Average tariff in different sectors (Paise/kWh)

Sector	*1992-93*	*1994-95*	*1995-96*	*1996-97*	*1997-98*	*1998-99*	*1999-00*	*2000-01*	*2001-02*
Domestic	78.05	82	98.2	122.79	125.71	139.89	158.95	190.87	190.93
Commercial	156.16	170	205.8	264.41	296.17	319.00	400.00	429.76	432.00
Agriculture	30.99	30.8	30.1	31.22	34.58	25.58	33.56	46.26	46.33
Industrial	157.83	178	204.1	271.56	323.60	313.75	379.37	392.88	395.13
Railway traction	152.38	177.4	217.4	314.40	320.13	362.18	308.00	405.88	404.97
Outside state	100.61	128.2	145.3	169.78	208.99	234.78	194.64	0.00	0.00
Overall average	102.15	115.3	133.3	165.53	187.89	178.86	200.35	224.99	221.32

Source: Planning commission, 2002b.

Table 3.8 Cost of supply versus tariff

	Average cost of supply	*Average tariff*	*Shortfall (Losses)*	*Recovery through tariff*
Financial year	paise/kWh	paise/kWh	paise/kWh	%
1992-93	138.2	102.1	36.1	0.74
1993-94	163.8	115.3	48.5	0.70
1994-95	196.5	133.3	63.2	0.68
1995-96	234.5	142.3	70.8	0.67
1996-97	258.6	165.5	79.0	0.68
1997-98	270.8	187.9	82.9	0.69
1998-99	284.3	178.9	105.4	0.70
1999-00	336.1	200.4	135.8	0.68
2000-01	341.3	225.0	116.3	0.66
2001-02	368.2	221.3	146.9	0.60

Source: Planning commission, 2002b

3.3.3.3 Subsidies

Table 3.9 indicates the subsidy receivable from the government and the actual amount received by Rajasthan power utility for the period 1996-97 to 2001-02. The commercial losses have become so high that the current rate of return (excluding subsidy) of the utility has gone down from – 19.2% in 1992-93 to -73.8% in 2001-02.

The level of subsidy as a percentage of revenue has increased from 31% in 1993-94 to almost 66% in year 2001-02 (Figure 3.5). In 2001-02, the total subsidy given to these consumers was of the order of Rs 29,206 million, which is almost 66% of total revenue received (Table 3.9). The quantum of subsidies has become so large that the state government is not in a position to pay the subsidies.

Even if we assume that the entire subsidy is received by the utility, in that case also utility is not in a position of achieving the desired rate of return 3% stipulated by the central government. A part of this subsidy was recovered through cross-subsidisation of railways, industrial and commercial sectors. From time to time, the state government compensates in the form of revenue subsidy, but it does not cover the amount fully. For example, in 1999-2000, as against the net subsidy of Rs 25,661 million provided by the Rajasthan power sector, they got compensation of Rs 17,661 million. Moreover, very often, this is only on paper just to show the stipulated ROR of -3.41 % and that money may not be available for use. No firm could be commercially viable providing this large amount of subsidy. If the state government wants to subsidies some sectors, the subsidy amount should be fully compensated from the state budget.

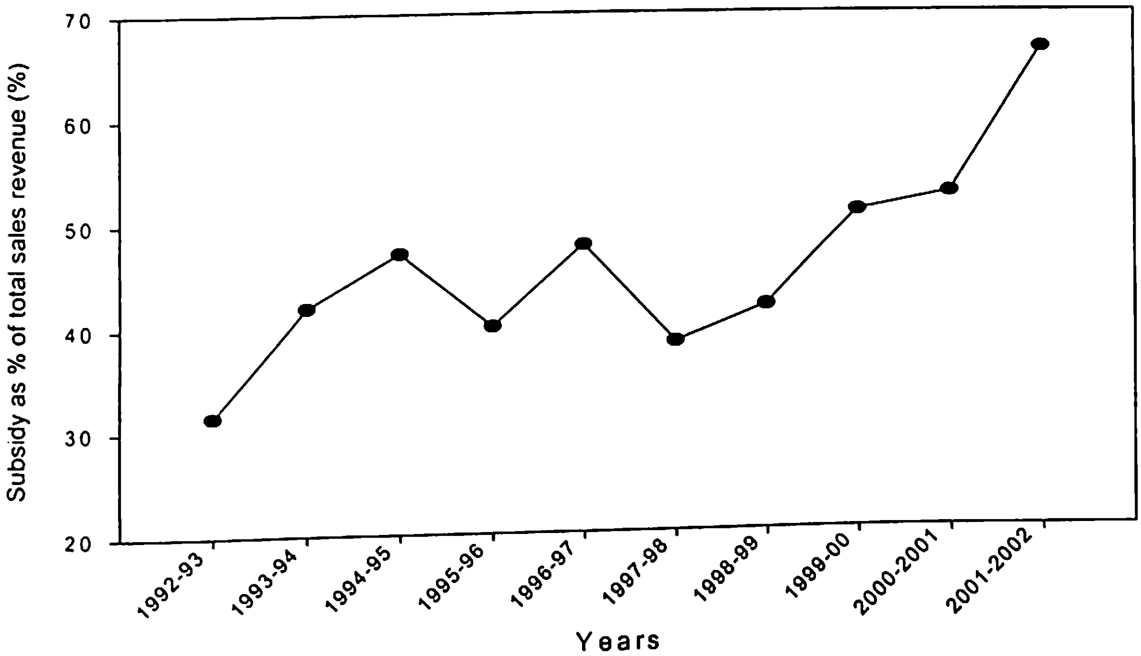

Figure 3.5 Subsidy as percentage of total sales revenue

Table 3.9 Subsidy and receivables in Rajasthan power sector

	1996-97 Actual	*1997-98* Actual	*1998-99* Actual	*1999-2000* Provi.	*2000-01* (RE)	*2001-02* (AP)
			(Rs. million)			
Subsidy to agriculture sector	9,630	11,160	15,610	19,840	20,560	23,410
Subsidy to domestic sector	2,426	3,237	3,833	5,052	4,680	5,796
Subsidy Inter-State Sales	203	23.5	216	769	444	0
Total subsidy	12,259	14,632	19,659	25,661	25,684	29,206
Subventions recd. From State Govt.	5,608	7,049	11,965	17,661	0.0	0.0
Uncovered Subsidy	3,470	2,889	1,846	1,534	20,875	26,863
Commercial losses (excluding subsidy)	-4,380	-610	-1331	-1,899	615	-2412
Commercial losses (including subsidy)	632	65.35	-134.27	-132.86	614.59	-2412
Rate of Return (excluding subsidy)	-19.2	-22.88	-45.35	-48.71	14.96	-73.8
Rate of Return (including subsidy)	2.44	2.34	-4.58	-3.41	14.96	-73.8
Additional revenue for achieving 3% RoR	0.0	7234	14180	20150	-4910	25102

AP= Annual Plan RE = Revised Estimate
Source: Planning commission, 2002b

3.4. OPTIONS TO IMPROVE PERFORMANCE

The performance of electricity utilities in Rajasthan can be improved through cost reduction and additional revenue earnings. Cost can be reduced in many ways. We have considered the possibilities such as: reducing auxiliary consumption, reducing T&D losses, using renewable energy technologies for electricity generation, improving end-use efficiency through DSM programmes and adopting competition in retail supply.

3.4.1 Demand Side Management

Until recently very little attention paid to the energy efficiency activities in Rajasthan power sector. However, improvement in transmission network has been in the top of the agenda in the recent years. A number of DSM programmes are being initiated by DSM cell of Jaipur Discom on pilot scale (JVVN, 2003). These include, power factor improvement in plants, energy efficient pumps for agriculture consumers, CFL installation in domestic consumers, etc. The results of these programmes show a good feasibility and savings potential. If proper finances are arranged, they can be implemented on large scale. These programmes are being implemented on pilot basis with the aid of the international funding agencies such as USAID/ World Bank The main objective of these pilot programs is to assess the primary benefits in terms of energy and peak load reduction. In order to build a concrete DSM plan, there is a need of end-use data, which is currently not available with the utility. The DSM cell is also carrying out load research programmes with the help of non governmental organisations to frame appropriate DSM programmes to its customers. In Rajasthan, DSM is perceived not only as the management of electricity after the electric meter but also as some additional measure at reducing transmission and distribution losses. This has a reason because the transmission and distribution losses are very high currently due to poor management of customer, lack of measuring devices, low electricity prices and other technical reasons.

3.4.2 Renewable Energy Technologies

Although most of the power generation in Rajasthan is coal based, which is costing very high due to high transportation cost involved in long distance coal transportation, but recently the identification of wind power sites and high solar radiations has provided an alternative solution in terms of wind and solar photovoltaic power generation. Recently, Ministry of Non conventional Energy Sources (MNES) has identified 8 wind sites in Rajasthan with average wind power density of more than 150 Watts/sqm at 30 m above ground level, which is considered to be bench mark criteria for establishment of wind farm. So far Rajasthan have about 14 MW installed capacity of wind farms. A 140 MW Integrated Solar Combined Cycle (ISCC) Power Project is planned to be set up at Mathania near Jodhpur in Rajasthan by Rajasthan State Power Corporation Ltd. as a centrally assisted project at a total estimated cost of Rs.87.2 million. The project will comprise a 35 MW solar thermal power plant and 105 MW combined cycle power plant. World Bank and KfW (Kreditanstalt für Wiederaufbau) would provide US $ 49 million grant assistance and DM 250 million loan assistance respectively (MNES, 2003). This will be the first of its kind and the largest such project in the world. Although these technologies have achieved a fair degree of maturity but they are yet to receive user support and R&D efforts.

3.4.3 Reduction in T&D Losses

In year 2001-02, the net requirements of electricity in Rajasthan was about 25,570 MU, of which about 25 % was through outside purchases at higher cost. If we assume the T&D losses to be kept at a minimum of 15 %, then the energy available for sale would be 21,735 MU, thus necessitating an import of only 10 % of the total requirements. This will give a net saving of 3,835 MU, in terms of power purchase cost of Rs 8,485 million at an average power cost of 2.15 Rs/ kWh, which means, a saving of Rs 0.33 per unit of electricity sold. The burden of power purchase can also be reduced through improvements in the operating efficiency of the utility.Recently the RERC has directed the Discoms companies to bring down their existing T&D losses to 20% level in coming five years and reduce it by 5.4% in the financial year 2002-03 (CUTS, 2003). Since it requires interface with the end-users, companies finding it difficult as there is no formal mechanism to involve the consumers in the process. These losses can be reduced to optimum levels by better design of lines, relocation of distribution transformers, installation of capacitors, and use of higher efficiency transformers. As upgrading the existing T&D system will require huge investment, which is beyond the capacity of the state government, an upgrading scheme with private sector participation may prove effective.

3.4.5 Reduction in Auxiliary Consumption

The current auxiliary consumption in the thermal power plants of the Rajasthan is of the order of over 10 %. This is one of the major areas that offer considerable savings potential. Though it is attributed partly due to poor quality of coal, equivalent figures in the other countries demonstrate scope for improvements. Improvement in the power factor of auxiliaries, proper sizing of auxiliaries, and measures such as sliding pressure operation of units, instrumentation for auto air-load control to run the unit with optimum excess air, reliable flame monitors etc. are the possible measures to reduce the high auxiliary consumption in the individual power plants (Parikh, 1996).

3.4.6 Competition in Retail Supply

Moving from monopoly market to competitive market particularly in distribution sector will help in operating the Discoms to operate at a high level of technical efficiency and minimize the costs. Recently enacted Electricity Act (2003) provides open access to transmission as well as distribution of electricity. Further it allows the distribution licensee and generation companies to engage in power trading. Here the regulator has to be cautious while framing the open access policy, as it deals directly with developing a competitive market. This arrangement would allow independent power producers, captive generators, and others to sell electricity to high-tension high-tariff customers.

3.5 SUMMARY

The analysis of the Rajasthan power sector shows that low cost of electricity, high cost and inability of the Discoms to charge economical prices for electricity sold to consumers are the principal reasons for the heavy losses occurred in the power sector. The continuation of pricing policies has not only affected financial position but has also increased the cost of borrowing capital and has weakened the bargaining positions in dealing with independent power producers. Although there is no single magic solution to overnight solve these problems, but the solution has to be identified through attempting all the available alternatives such as, demand side management, better management of the power sector, reducing T&D losses, attempting on renewable energy etc.

Chapter 4

ASSESSMENT OF DSM POTENTIAL FOR RAJASTHAN POWER SECTOR

4.1 INTRODUCTION

The power sector in Rajasthan is expanding at a rapid pace over the past decade as discussed in the previous chapter. Serious concerns have been raised in generating resources to meet the growing energy requirements. In this chapter an attempt has been made to assess the impact of certain DSM programmes in different consumer categories. First, a reference (base case) scenario is developed assuming a continuation of current trends. DSM interventions have been evaluated by forecasting different scenarios. The scenarios are developed based on the basis of government of India's published plans and policies for Rajasthan power sector. Introduction of DSM options is based on the feasible penetration rates in each consumer categories. Renewable energy technologies such as wind, integrated solar combined cycle plants, etc., are also considered as a candidate power parts. Other options such as reducing transmission and distribution losses are also considered while framing scenarios. These scenarios have been developed by asking 'what if?' questions, e.g. what will be the impact if the energy efficient appliances replace the existing appliances? The impact of different demand side and supply side options is assessed in terms of energy, peak demand, and CO_2 emissions.

The questions which have been addressed include the following.

- How much new capacity additions are required for meeting the electricity demand of Rajasthan over the next decade?
- What will be the implications of electricity generation on the environmental emissions?
- What is the extent of resources required to fully meet the projected electricity demand?
- What impact could DSM, renewable energy technologies and reduction in T&D losses offer for meeting the electricity demand and reducing environmental emissions?

4.2 METHODOLOGY AND ASSUMPTIONS

4.2.1 End-Use Forecasting Model for Rajasthan

Electricity demand forecasting is a starting step of utility power planning process. Hence, reliable demand forecasts are critical for successful planning. End-use forecasting approach is adopted in the present analysis. The end-use approach attempts to capture the impact of energy usage patterns of various devices and systems. The end-use models for electricity demand focus on its various uses in the domestic; commercial; industrial; and agriculture sectors of the economy. For example, in the domestic sector electricity is used for cooking, air conditioning, refrigeration, lighting, and in agriculture for irrigation. The end-use method is based on the premise that energy is required for the service that it delivers and not as a final good.

In this study, an end use forecasting model known as Long Range Energy Alternative Planning (LEAP) (SEIB, 2000) model has been used to examine the development of Rajasthan power sector under different planning scenarios. LEAP has been developed by the Stockholm Environment Institute-Boston Centre at the Tellus Institute, with support from the United Nations Environment Programme. Figure 4.1 presents the schematic structure of the end-use demand forecasting model in the LEAP framework. Forecasting under the LEAP framework is done by disaggregating the total electricity demand into a hierarchical format based on four levels: sector; sub-sector; end-use; and device. The proportion of end-use devices is further disaggregated into existing appliances and high efficiency appliances, which are either in use or are likely to be introduced in the future.

LEAP is used for the evaluation of national/regional energy planning policies (Lazarus, Heaps and Raskin, 2000). The system is designed to assist energy planners and decision-makers to identify and quantify the future pattern of energy consumption, the problems associated with this pattern of energy use, and also the likely impact of the different policies. This system also tracks down the long-term energy demand and supply situation in a given country.

A number of researchers have applied LEAP for forecasting the environmental impact due to growth in transport sector (Bose and Nesamani, 2001, Dhakal, 2003). LEAP has also been used for sustainable energy planning by various researchers in Thailand, Vietnam and India (Tanatvanit et al., 2003; Kumar et al., 2003, Bose and Nesamani, 2001).

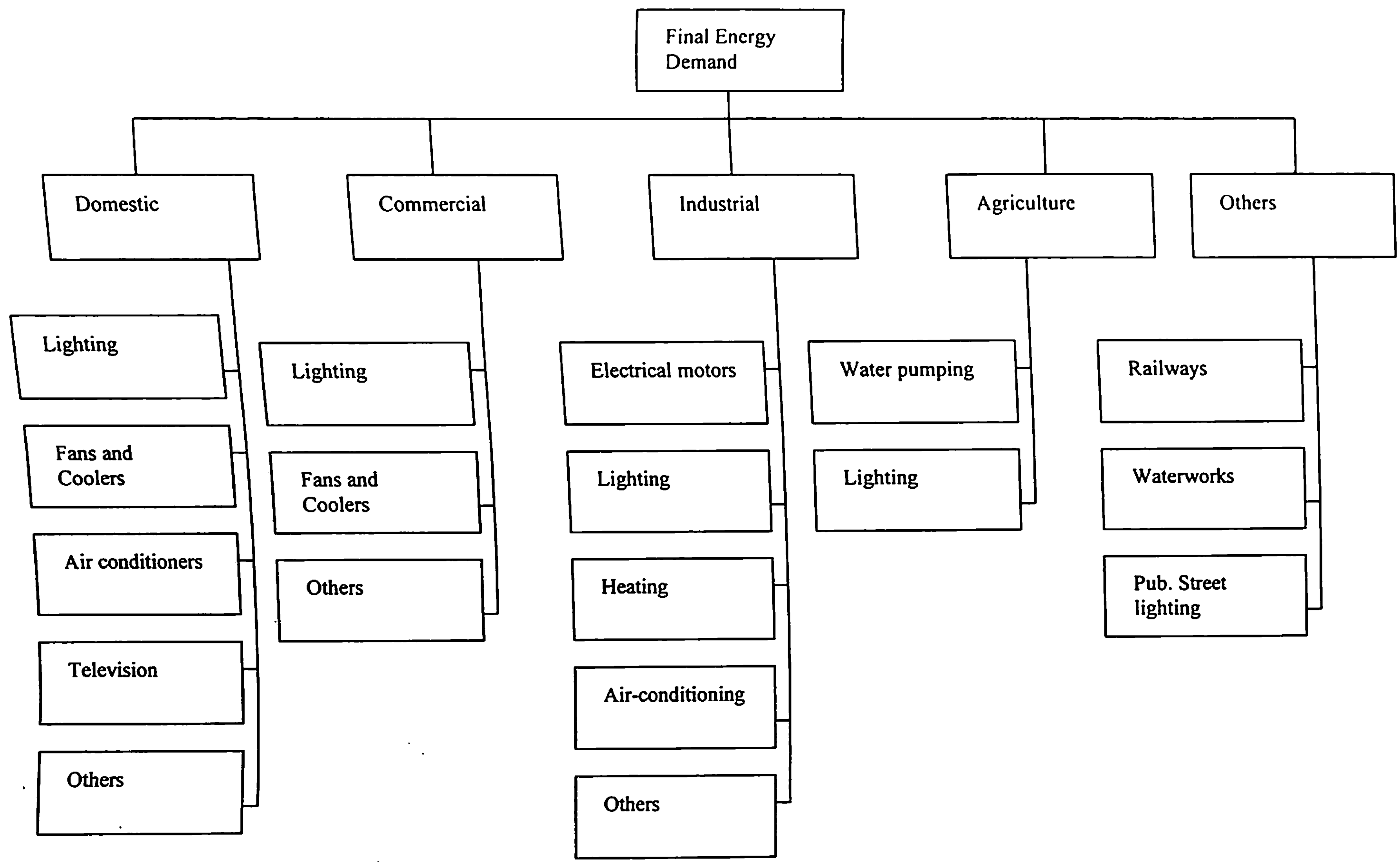

Figure 4.1 Schematic structure of end-use electricity demand model in the LEAP framework

The main driving variables for the future projections of sectoral energy demand are: (i) expected growth rate of consumers and (ii) change in the energy intensity (average annual energy consumption per consumer).

The future projections of sectoral energy demand (E_s) can be expressed by

$$E_s = \sum_{i=0}^{n} N_i * E_{c,i}$$

Where, N_i is the total number of consumers in year 'i' and $E_{c,i}$ is the average energy intensity per consumer in year 'i'.

The number of consumers in year 'i' are estimated based on long-term time-series analysis. Table 4.1 shows past growth trend of number of the consumers in different consumer categories. It is assumed that the same growth trend in number of consumers in different sectors will also prevail in future years. The average growth in no. of consumers between years 1994-2001 was 7.7 % p.a. Industrial HT consumers registered a highest growth (11.8 %) due to rapid industrialisation in the state. But over last three years, there has not been considerable increase in the number of consumers in this category. The domestic and agriculture consumer, which forms the highest share in number of consumers, also increased with a rapid pace during this period. The agriculture sector registered a growth rate of 5.6 % p.a., while domestic sector registered a growth rate of 6 % p.a. Number of consumers in other sectors also increased at a rapid pace.

Table 4.1 Number of consumers and their growth rate in different sectors

Years	*Domestic*	*Commercial*	*Industrial LT/MT*	*Industrial HT*	*Agriculture*
1994	2,679,573	4,83,648	1,12,296	962	4,27,065
1995	2,983,322	5,22,567	1,17,226	1,218	4,75,614
1996	3,179,778	5,46,563	1,21,394	1,465	5,02,238
1997	3,363,800	5,65,488	1,21,801	1,657	5,30,109
1998	3,527,187	5,84,495	1,24,544	1,867	5,55,522
1999	3,101,384	6,10,722	1,28,385	2,023	5,77,395
2000	3,902,520	6,34,695	1,30,353	2,047	5,99,767
2001	4,047,515	6,58,381	1,34,460	2,112	6,26,312
Avg. growth rate (%)	6.0	4.4	2.6	11.8	5.6

Source: CEA, 2002

The energy intensity (annual energy consumption) of each device is formulated as a function of number of devices, capacity of device and average usage hours. The following equation is used to estimate the average energy intensity of each end-use device:

$$E_{i,s} = I_s * H_s$$

where 'I_s' is the capacity of device 's' and 'H_s' represents the annual operating hours for device 's' for end-use 'i' and $E_{i,s}$ is the average energy intensity of devices for end-use 'i'. Summation of energy intensities of different end-uses will give the energy intensity of the consumer (E_c).

Table 4.2 shows past trend of energy intensity in domestic, commercial, LT&MT Industrial, HT industrial, and agriculture sectors. The energy intensity of the consumers in commercial sector, LT industry and HT industry has grown at a rate of -1.3 % p.a. and -10.5 % p.a. over the period of 1994-2001. This represents a gradual decrease in the energy intensity of these consumers. This is due to many factors such as improvement in end-use efficiency, increase in smaller size of industry, fuel switching, shifting to captive generation, etc. For our analysis it is assumed that the energy intensity in these sectors will remain stagnant over the plan period. In case of domestic sector the energy intensity increased at a growth rate of 3.3 %. This is mainly due to increased urbanization and more dependency of these consumers on electrical appliances. For our future projections it is assumed that a growth rate of 2 % p.a. will take place in this sector. Energy intensity in agriculture sector has also registered a growth rate of 3.9 % p.a. The reason for such a high growth rate in this sector is the depleting water table in the state. The future projections for this sector are made by considering an average growth rate of 2.5 % p.a. over the plan period. The other sectors also registered considerable growth in their respective energy intensities. This trend is expected to continue in the plan period.

The total energy intensity of a consumer is disaggregated in to different end-uses. Share of different end-uses in total energy intensity is estimated based on earlier studies (Table 4.3). In case of residential, agriculture and commercial consumers the end-use energy consumption are estimated based on survey results carried out by DSM cell of Jaipur Vidyut Vitaran Nigam (JVVN, 2001). For LT&MT consumers, the share of different end-uses in energy consumption is estimated based on a joint report of TERI and CERI (1995). For Industrial HT consumers the share of different end-uses in energy consumption is estimated based on a HT industries survey conducted by Parikh et al. (1996b) in Maharastra. The energy intensity at device level, which is the annual energy consumption by a device, is estimated by breaking the end-use energy consumption of a consumer in to different end-use devices. Energy intensities are specified for existing, new or retrofitted devices. Additionally, energy intensity changes over time as per the improvements in the technologies.

The present efficiency of end-use appliances and the pattern of energy utilisation for different appliances are assumed to remain unchanged in the future. However, it is too difficult to classify types of devices with a specific end-use because of the variety of devices and also the limitation of data in the industrial sector. So, it is assumed that each type of end-uses in each industry is as existing now.

The estimates of energy consumption in public lighting and waterworks categories are based on connected load (kW) and the average consumption per kilowatt of connected load (kWh/kW). The energy consumption in railway traction is estimated by forecasting the previous trends in energy consumption.

Table 4.2 Average annual energy intensity (thousand kWh) of different consumers

Years	*Domestic*	*Commercial*	*Industrial LT/MT*	*Industrial HT*	*Agriculture*
1994	0.56	1.10	9.40	3569.60	8.58
1995	0.58	1.15	10.2	3015.28	7.82
1996	0.62	1.25	10.66	2599.24	8.69
1997	0.65	1.33	10.33	2599.24	8.94
1998	0.69	1.49	11.01	2048.62	8.97
1999	0.72	1.38	9.22	1860.00	10.45
2000	0.73	1.35	9.16	1690.74	10.94
2001	0.71	1.31	8.59	1636.53	11.30
Avg. growth rate (%)	3.30	9.60	-1.30	-10.50	3.90

Source:CEA, 2002

Table 4.3 Share of end-uses in different consumer categories

Consumers categories	*End-uses*	*Reference*
Domestic (Urban)	Lighting (58 %), Ventilation (22 %), Refrigeration (11 %), TV (6 %), Others (3 %)	Load Research data from DSM cell Jaipur Discom (JVVN, 2001)
Domestic (Rural)	Lighting (72 %), Ventilation (16 %), Others (12 %)	Load Research data from DSM cell Jaipur Discom (JVVN, 2001)
Commercial	Lighting (49 %), Ventilation (45 %), Others (6 %)	Load Research data from DSM cell Jaipur Discom (JVVN, 2001)
Agriculture	Agriculture pump (95 %), Others (5 %)	Load Research data from DSM cell Jaipur Discom (*JVVN,2001*)
LT&MT Industries	Electric Motors (73 %), Lighting (8 %), Others (19 %)	TERI report: (TERI and CERI, 1995)
HT Industries	Electric Motors (46 %), Lighting (6 %), Electric Heating (13 %), Air Compressors (9 %), Melting (15 %), Air-conditioning (3 %), Others (8 %)	HT industries survey conducted by IGIDR in Maharastra (Parikh et al., 1996b)

4.2.2 Input Data for LEAP

As the end-use forecasting approach requires a detailed end-use database, which is not readily available due to absence of load research activities in Indian utilities, the simplistic and broad assumptions are adopted in the analysis. For the present study, the historical data are collected from several reports of the government and non-government agencies such as the Central Electricity Authority (CEA), Ministry of Power (MOP), Planning Commission, Centre for Monitoring Indian Economy (CMIE), The Energy and Resources Institute (TERI), etc. The main data used in the study are listed below:

1. On the demand side, the data used are: the energy intensity at end-use level, energy consumed at device level, penetration of end-use devices in different

consumer sector, share of end-uses/devices in total energy consumption of a consumer, etc.

2. On the supply side the data used are: the T&D losses; load factor; capacity factor; capacity mix; capital and running costs of candidate power plants; etc.
3. A mix of hydropower plants and thermal power plants remains are considered to meet the future electricity demand. The thermal plants include two types of coal-fired plants, gas based combined cycle plants (i.e., CCGT), nuclear plant, integrated gasification combined cycle (IGCC) and pressurized fluidized bed combustion (PFBC) plants. Wind power plants which have already been planned are also considered.
4. Existing plants are assumed to be available during the plan period.The plant characteristic data are entered which includes plant capacity, the energy produced for base year, the efficiency of the plant and the maximum capacity factor of the plants.
5. In the case of Rajasthan, expansion planning for power plants has been carried out by government till the year 2007. Further for year up to 2012, the exogenous input of candidate plants are given to meet the forecasted electricity demand.
6. The cost figures of candidate power plants are entered as the weighted average cost. The capital costs and other details of candidate power plants used in the study are given in Table 4.4.
7. The environmental emissions are estimated in the form of CO_2 SO_2 and NO_x emission, by specifying emission factor for each type of candidate power plant (Table 4.4). The other requirement is the input of the environmental cost. This

has not been considered in this study as very less work has been done in the area of environmental cost for developing countries and such data are unavailable.

Table 4.4 Characteristics of candidate power plants

Candidate plants	*Unit capacity*	*Capital cost*	*Fuel cost*	*Heat rate*	*Emission factors* CO_2	NO_x	SO_2
	MW	$\times 10^3$ Rs./MW	Rs./kcal	kcal/kWh	g/kWh	g/kWh	g/kWh
CCGT	250	35.2	0.8	2,000	550	0.4	1.64
Coal	500	35.8	0.4	2,500	1026	0.6	2.5
Hydro	500	85	NA	2,000	NA	NA	NA
IGCC	250	70.8	0.5	2,017	551	0.24	1.64
ISCC	400	61	0.1	2,000	385	0.17	1.15
Lignite	250	49.9	0.2	2,062	1078	14	1.64
PFBC	450	54.5	0.5	2,013	907	0.25	1.64
Wind	2	33.6	NA	2,000	NA	NA	NA

Source: Shreshtha and Shreshtha, 2003

4.2.3 Scenario Analysis

A central concept in LEAP is scenario analysis. This enables a critical examination of different supply side and demand side options and their economic and environmental impacts. Four alternative scenarios have been created in this study apart from the reference scenario. These scenarios have been compared with reference scenario in terms of overall electricity demand, capacity requirement, environmental emissions, and capital requirements. These scenarios are described in following sub-sections.

4.2.3.1 Reference Scenario

The reference scenario represents a business as usual development strategy of the power sector. In this scenario, only supply side options are considered in meeting the projected electricity demand during the planning horizon of 2002–2012. This is typically the case of traditional supply side electricity planning.

4.2.3.2 Demand Side Management (DSM) Scenario

In this scenario, the same set of supply side options and load growth projections as in the reference scenario have been considered. In addition, a number of DSM options are considered to be implemented over the plan period. The description about energy efficiency potential and level of penetration of these options has been described in section 4.2.6.

4.2.3.3 Reduced Transmission & Distribution (T&D) Losses Scenario

The high level of T&D losses, averaging about 25 % of total generation is an issue of major concern of Rajasthan power sector (CEA, 2002). Indeed, reducing T&D losses to more acceptable level is estimated to be one of the most economic options for improving both system performance and reliability. Recently, in tariff order issued by RERC, the utilities are directed to reduce the T&D losses to an acceptable level of 20 % (RERC, 2003). In this scenario, the same set of supply side options and load growth projections as in the reference scenario are considered. In addition, the T&D losses are assumed to be reduced from the existing level of 25 % in case of reference scenario to 20 % by the end of 2012.

4.2.3.4 Renewable Energy Technologies (RET) Scenario

As government of India plans for meeting 10 % of future electricity demand through renewable energy resources, in this scenario it is assumed that the future capacity mix in Rajasthan have 10 % share through renewable energy sources. RSPCL has already floated a programme of installing 100 MW wind capacity by 2004 (GOR, 2003c). Further, in Mathania an Integrated Solar Combined Cycle (ISCC) plant has been planned by the government. Solar and wind have been identified as potential technologies for power generation in Rajasthan.

4.2.3.5 Integrated Resource Planning (IRP) Scenario

The preceding scenarios have considered the introduction of various scenarios measures such as, DSM, T&D load reduction and renewable energy generation options on an independent basis. Assuming that initiatives could be undertaken on all these options simultaneously, it is appropriate to assess a scenario that combines all the above planning options. The IRP combines all the alternative scenarios together.

4.4 Formulation of DSM Programmes

Several factors affect economic attractiveness of a DSM programme. One is whether the technical intervention such as the installation of a higher efficiency end-use device is made when the existing conventional equipment is due to be replaced. If so, it is termed as "replacement." If not, i.e., if the technical intervention is made regardless of the condition or remaining life of the existing equipment, it is referred to as a "retrofit." The DSM programmes considered in this study involve replacement as well as retrofit measures. Overall, nine DSM programmes are considered in this study.

4.2.4.1 Market Penetration

Market penetration of a DSM option depends on the level of consumer awareness, extent of cost sharing required by the consumer and the discount rate of the consumer (Reddy et al., 1997). Market penetration of DSM options in this study is assumed based on the potential number of consumers, existing market sales rate of the end-use devices as well awareness about the energy efficient technology. The total targets of DSM programmes consider new as well as existing consumers. For measures with shorter life equipment replacement costs are discounted and incorporated in to calculations.

4.2.4.2 Savings Potential

For estimating savings, the energy consumption of a DSM option is compared with the base standard option. The annual energy savings are multiplied by number of adoptions to obtain energy savings from each option. To arrive at the generation requirements, T&D losses of about 22 % have been incorporated in the demand projections. Peak power savings are estimated by applying an annual load factor on the energy savings at the generating end. Since there has been load shedding during peak hours the normalised load factor (0.72) is assumed by considering the due allowances for the power cuts.

4.2.4.3 Programme Costs

Programme costs include the capital, installation and operation and maintenance costs. For each DSM option it is proposed that about fifty percent of the initial incremental capital cost is shared by utility. The programmes are assumed to be implemented in between 2002 and 2012.

4.2.5 Characteristics and Assumptions of DSM Programmes

Table 4.5 summarises the characteristics and assumptions of individual DSM programmes considered in this study. Only a limited set of DSM programmes are analysed; thus, the results presented should not be viewed as the total or maximum potential for DSM savings in Rajasthan. Following sections discuss the detailed assumptions made for formulating the DSM programmes.

Table 4.5 Characteristics and assumptions of DSM programmes used in analysis

DSM option	*Programme description and penetration targets*	*Savings (%) per DSM measure*	*Measured incremental cost*	*Life (Years)*
Compact Fluorescent lamps (CFL)	Replacement of at least one light point of incandescent lamp by CFL for domestic consumers by year 2012.	60 %	175 Rs./device	5
Energy Efficient Refrigerator (EER)	Assuming all the new consumers buy energy efficient refrigerators as a part of DSM programme.	30 %	2,000 Rs./device	10
Energy Efficient Ballast (EEB)	Replacement of at least one conventional ballast tube light by electronic ballast tube light for urban domestic consumers by the year 2012.	15 %	250 Rs./device	5
Energy Efficient Fan (EEF)	Replacement of at least one old inefficient fan by energy efficient fan for urban domestic consumers by the year 2012.	10 %	300 Rs./device	10

DSM option	*Programme description and penetration targets*	*Savings (%) per DSM measure*	*Measured incremental cost*	*Life (Years)*
Energy Efficient Air conditioners (EEAC)	Replacing old inefficient air-conditioners by efficient air-conditioners for commercial sector consumers. It is assumed that 10 % of total consumers own at least one energy efficient air-conditioners by the year 2012.	10 %	3000 Rs./device	10
Energy Efficient Motors (EEM)	Replacing old inefficient electric motors by efficient motors for industrial consumers. Assumed 30 % of connected motor load is replaced by energy efficient motors by the year 2012.	10 %	2000 Rs./kW	15
Energy Efficient Industrial Lighting (EEL)	Replacing old inefficient industrial lights by efficient lights for industrial consumers. It is assumed that 30 % of connected industrial lighting load is replaced by energy efficient lights by the year 2012.	15 %	1500 Rs./kW	5
Power Factor correction (PFC)	Improving the power factor from existing 0.92 to 0.96, 30% of total LT &MT consumers opt for the programme by the year 2012.	5 %	1000 Rs./kVAR	5
Energy Efficient Pump sets (EEP)	Assuming that all the new connections after 2002 adopt energy efficient pumps.	30 %	4000 Rs./pump	10
Retrofication of existing Pump sets (RET)	Retrofication of existing pumping system by reducing the losses in suction and discharge lines. Assumed that about 40% of the existing pump-sets are retrofitted over the plan period	20 %	2500 Rs./pump	5

4.2.5.1 Compact Fluorescent Lamps (CFLs)

Present lighting use in domestic sector is largely from incandescent lamps and to some extent from tube lights. In domestic sector, there exists a very strong case for replacing low efficiency conventional incandescent lamps by high efficiency compact fluorescent lamps. A CFL consumes 4–5 times less energy for the same lumen output and last up to 13 times more than the standard incandescent lamp (Kumar et al., 2003). Recently, a demonstration project was initiated for CFL installation by JVVN (JVVN, 2003), 100 numbers of 40/60 Watt incandescent lamps were replaced by 15 Watt CFLs. Savings of the order of 8-10% were observed in the electric bill of consumers.

As a part of DSM activities, it is proposed to replace incandescent lamps by CFLs in domestic consumers. It is assumed that CFLs will replace only the most frequently used incandescent lamps. It is also assumed that, on an average, one light point per consumers will be replaced by CFLs. Average savings of 60 % per CFL are assumed for replacing the conventional incandescent lamps.

Table 4.6 shows the annual targets for this DSM programme. It is seen that there is a net saving on demand side of 228.6 MW and the number of total adoptions in the programme is 4,359 thousand CFLs. The cost of saved demand for the utility is Rs. 5,100/kW. The net energy savings by the terminal year of the plan is about 5,887 GWh and the average cost of saved energy is 0.20 Rs./ kWh.

Table 4.6 Annual programme targets for replacing incandescent lamps by CFL

Years	*Demand savings* (MW)	*Energy savings* (GWh)	*Total adoptions* Nos (Thousands)	*Programme cost* (Rs. million)
2003	9.4	55.9	329	24.9
2004	20.8	124.4	355	48.6
2005	34.5	207.6	383	71.1
2006	51.1	308.0	414	92.6
2007	70.9	428.6	447	113.1
2008	93.6	567.4	424	131.3
2009	120.1	730.3	453	148.1
2010	151.0	920.9	484	163.8
2011	186.9	1143.1	518	178.2
2012	228.6	1401.5	554	191.6
Total	228.6	5,887.7	4,359	1,163.3

4.2.5.2 Energy Efficient Refrigerators

There is considerable energy saving potential in domestic refrigerators. For the 165-litre, manual defrost, CFC-based refrigerator, the TERI standard prescribes a maximum energy-consumption value of 0.65 kWh/day (TERI, 1998). This is 50 % less than the efficiency value prescribed in the latest standard proposed by the BIS (Bureau of Indian Standards), which is 1.25 kWh per day. For a typical Indian refrigerator of 165-litres the proven technologies of efficiency improvement can reduce consumption from 1.25 kWh per day to 0.65 kWh per day. This is almost 50 % savings as compared to standard conventional refrigerator. But for our analysis, it is assumed that all the new refrigerators sold after savings of the order of 30 % are assumed by replacing conventional refrigerators by energy efficient refrigerators.

This DSM programme is suggested for urban domestic consumers. Presently there are about 1,780 thousand urban domestic consumers (CEA, 2002). Considering present growth trend, this number is expected to increase to about 3,040 thousand. It shows that about 1,260 thousand new consumers will be added. Based on the load research survey of Jaipur Discom, 42 % of urban domestic consumers own refrigerators (JVVN, 2001). It means about 529 thousand new refrigerators will be added in the market. Assuming all the new refrigerators added in the market are energy efficient refrigerators. This represents the 41 % market share of energy efficient refrigerators by the year 2012.

Table 4.7 shows the annual savings realised through energy efficient refrigerator programme. It is seen that 12.2 MW of demand saving is possible with this DSM option. The cost of saved demand for the utility is Rs. 25,508/kW. The net energy savings by the terminal year of the plan is about 314.1 GWh and the average cost of saved energy is Rs. 0.93/kWh.

Table 4.7 Annual DSM programme targets for energy efficient refrigerators

Year	*Demand savings*	*Energy savings*	*Total adoptions*	*Programme cost*
	(MW)	*(GWh)*	*Nos (Thousands)*	*(Rs. million)*
2003	0.6	3.7	41.1	7.7
2004	1.3	8.0	43.4	14.6
2005	2.2	13.0	45.8	20.6
2006	3.1	18.6	48.2	25.9
2007	4.1	25.0	51.0	30.5
2008	5.3	32.3	53.7	34.4
2009	6.7	40.5	56.7	37.8
2010	8.2	49.9	59.8	40.7
2011	9.9	60.4	63.1	43.2
2012	11.8	72.2	66.6	45.2
Total	11.8	323.6	529.4	301.1

4.2.5.3 Energy Efficient Electronic Ballasts

Magnetic ballast based fluorescent tube lights are very commonly used in residential and commercial sector, each consumes about 14 Watts. It may be worthwhile to replace them by energy efficient electronic ballasts, which can raise efficiency of the fixture by 12 % to 30 % and reduces the electric consumption of the fluorescent tube light by about 15 % (TERI, 2002).

Table 4.8 shows the annual targets for the electronic ballast programme. It is proposed to replace one fixture per consumers by electronic ballast in domestic (urban) sector by the year 2012. This shows a total market penetration of 3,192 thousand new electronic ballasts. It is seen that 12.7 MW of peak demand savings can be realised through this programme. The cost of saved peak demand for the utility is Rs.

17,881/kW. The net energy savings by the terminal year of the plan is about 349.3 GWh and the average cost of saved energy is Rs. 0.54/ kWh.

Table 4.8 Annual DSM programme targets for electronic ballasts

Year	*Demand savings*	*Energy savings*	*Total adoptions*	*Programme cost*
	(MW)	*(GWh)*	*Nos (Thousands)*	*(Rs. million)*
2003	0.7	4.0	197.2	4.9
2004	1.4	8.7	218.8	9.2
2005	2.3	14.0	242.4	13.0
2006	3.3	20.0	267.7	16.3
2007	4.5	27.0	295.3	19.2
2008	5.7	34.8	324.8	21.7
2009	7.2	43.7	357.0	23.9
2010	8.8	53.8	391.5	25.7
2011	10.6	65.1	428.8	27.2
2012	12.7	77.8	469.0	28.5
Total	12.7	349.3	3192.5	189.6

4.2.5.4 Energy Efficient Fans

Fans and coolers account for about 22 % of total domestic energy consumption (JVVN, 2001). It is proposed to replace old, inefficient fans by efficient ones for urban domestic consumers. A saving of 10 % in energy consumption has been assumed through such replacements.

Table 4.9 shows the annual targets for the energy efficient fans programme. It is seen that 17.4 MW of peak demand saving is possible with this DSM option. It is assumed that by the year 2012, at least each urban domestic consumer will own one energy efficient fan. A total of 1,868 thousand energy efficient fans will be required during the plan period. This will require a total investment of Rs. 313.4 million. It is seen that 17.4 MW of demand saving is possible with this DSM option. The energy savings by the terminal year of the plan is about 458 GWh and the average cost of saved energy is Rs. 0.68 /kWh. The cost of saved demand for the utility is Rs. 17,988 /kW.

Table 4.9 Annual DSM programme targets for energy efficient fans

Year	*Demand savings (MW)*	*Energy savings (GWh)*	*Total adoptions Nos (Thousands)*	*Programme cost (Rs. million)*
2003	0.8	4.7	135.5	7.3
2004	1.7	10.3	144.9	14.0
2005	2.8	16.9	155.2	20.1
2006	4.1	24.7	165.9	25.7
2007	5.6	33.9	177.5	30.8
2008	7.4	44.6	189.9	35.5
2009	9.4	57.0	202.9	39.7
2010	11.7	71.3	217.0	43.5
2011	14.4	87.8	231.9	46.9
2012	17.4	106.7	247.9	49.9
Total	17.4	457.9	1,868.6	313.4

4.2.5.5 Energy Efficient Air Conditioner

It is proposed to replace old inefficient air-conditioners by energy efficient air-conditioners as a part of DSM programme in commercial sector. The total number of consumers in this sector is about 635 thousand (CEA, 2002). Considering current growth trend in these consumers, the total number of commercial consumers is expected to increase up to 1,002 thousand consumers by the year 2012. Considering that about 10

% of these consumers will replace their existing air conditioners by energy efficient air conditioner through a DSM programme. This will represent a total market share of about 100 thousand energy efficient air conditioners. A saving of 10 % in energy consumption has been assumed through such replacements.

Table 4.10 shows the annual targets for this DSM programme. It is seen that there is a net demand saving of 11.8 MW and energy savings are of the order of 173.3 GWh. The cost of saved demand for the utility is Rs. 9,406 /kW. The average cost of saved energy is Rs. 0.64/ kWh.

Table 4.10 Annual programme targets for energy efficient air conditioner

Year	*Demand savings (MW)*	*Energy savings (GWh)*	*Total adoptions Nos (Thousands)*	*Programme cost (Rs. million)*
2003	0.6	1.0	5.8	2.7
2004	1.3	2.5	6.5	5.2
2005	2.2	4.6	7.4	7.4
2006	3.1	7.4	8.3	9.4
2007	4.1	11.0	9.2	11.2
2008	5.3	15.5	10.1	12.7
2009	6.7	21.1	11.4	14.1
2010	8.2	27.9	12.5	15.2
2011	9.9	36.2	13.7	16.2
2012	11.8	46.1	15.1	17.1
Total	11.8	173.3	100.0	111.0

4.2.5.6 Energy Efficient Motors

Electric motors are used in industries to drive pumps, fans, compressors, machine tools and a wide variety of other process equipment. Energy efficient motors

% of these consumers will replace their existing air conditioners by energy efficient air conditioner through a DSM programme. This will represent a total market share of about 100 thousand energy efficient air conditioners. A saving of 10 % in energy consumption has been assumed through such replacements.

Table 4.10 shows the annual targets for this DSM programme. It is seen that there is a net demand saving of 11.8 MW and energy savings are of the order of 173.3 GWh. The cost of saved demand for the utility is Rs. 9,406 /kW. The average cost of saved energy is Rs. 0.64/ kWh.

Table 4.10 Annual programme targets for energy efficient air conditioner

Year	*Demand savings (MW)*	*Energy savings (GWh)*	*Total adoptions Nos (Thousands)*	*Programme cost (Rs. million)*
2003	0.6	1.0	5.8	2.7
2004	1.3	2.5	6.5	5.2
2005	2.2	4.6	7.4	7.4
2006	3.1	7.4	8.3	9.4
2007	4.1	11.0	9.2	11.2
2008	5.3	15.5	10.1	12.7
2009	6.7	21.1	11.4	14.1
2010	8.2	27.9	12.5	15.2
2011	9.9	36.2	13.7	16.2
2012	11.8	46.1	15.1	17.1
Total	11.8	173.3	100.0	111.0

4.2.5.6 Energy Efficient Motors

Electric motors are used in industries to drive pumps, fans, compressors, machine tools and a wide variety of other process equipment. Energy efficient motors whose efficiency is 3 to 5 % higher than that of conventional motors (owing to better design and materials), are available. These motors cost about 30 % more than their equivalent standard motors (TERI, 2002).

Table 4.11 shows the annual targets for DSM programme for energy efficient motors. There are 130 thousand LT& MT consumers and with a total connected load of 1,714 MW. Further, about 2,000 HT consumers contribute for a connected load of 1,855 MW (CEA, 2002). It is assumed that 30 % of the consumers adopt energy efficient motors in both the industrial consumer's categories. This represents a total industrial connected load of about 3,569 MW. Considering the present growth trend, this load is expected to increase up to 5,891 MW by the year 2012. According to the study conducted by Parikh et al. (1996b), 48 % of the total industrial load is from electric motors and pumps. Assuming the same proportion in Rajasthan will give the connected electric motor load of about 2,827 MW. Considering 30 % of this total connected load eligible for replacement due to retirements and new adoption during next ten years (i.e. by the year 2012) by energy efficient motors. This will lead to about 783 MW load to be replaced by energy efficient motors, by the year 2012. It is seen that 31.2 MW of peak demand and 902.1 GWh of energy can be saved by the end of year 2012. This is equivalent to a cost of saved demand of Rs. 9,384/kW. The cost of saved energy is Rs. 0.32/kWh.

Table 4.11 Annual DSM programme targets for energy efficient motors

Year	*Demand savings* (MW)	*Energy savings* (GWh)	*Total adoptions* MW of connected motor load	*Programme cost* (Rs. million)
2003	1.9	11.5	58.2	4.0
2004	4.1	24.4	60.2	8.5
2005	6.5	39.0	65.2	13.3
2006	9.1	55.1	68.4	18.6
2007	12.1	73.0	71.6	24.3
2008	15.3	92.7	73.5	30.5
2009	18.8	114.3	76.6	37.1
2010	22.6	137.8	79.8	44.3
2011	26.7	163.3	81.7	52.0
2012	31.2	191.0	84.8	60.2
Total	31.2	902.1	783.5	292.8

4.2.5.7 Energy Efficient Industrial Lighting

Industrial lighting accounts for about 4 % of total industrial connected load (Parikh et al., 1996b). Energy efficient lighting systems whose efficiency is 10 to 15 % higher than that of conventional lighting systems (owing to better design of reflectors, improved technologies etc.) are quite feasible DSM option in this sector. The average adoptions in lighting system have been obtained by assuming that 30 % of connected lighting load (kW) is replaced by energy efficient lights by the year 2012. Table 4.12 shows the annual targets for DSM programme for energy efficient lighting systems. It is seen that 9.6 MW of peak demand and 264 GWh energy can be saved by the year 2012. The total cost of saved demand to utility is Rs. 26,875/kW. The cost of saved energy is Rs. 0.97 /kWh.

Table 4.12 Annual DSM programme targets for energy efficient industrial lighting

Year	*Demand savings* (MW)	*Energy savings* (GWh)	*Total adoptions* kW of the connected lighting load	*Programme cost* (Rs. million)
2003	0.5	2.9	8,257	2.9
2004	1.1	6.4	8,589	6.3
2005	1.7	10.4	8,812	10.2
2006	2.5	15.0	9,144	14.8
2007	3.4	20.3	9,476	20.0
2008	4.3	26.3	9,699	25.9
2009	5.5	33.2	10,027	32.5
2010	6.7	40.8	10,359	40.0
2011	8.1	49.3	10,582	48.3
2012	9.6	58.9	10,914	57.5
Total	9.6	264.0	1,04,032	258.4

4.2.5.8 Power Factor Correction

Industrial loads are usually inductive in nature and have a lagging power factor. Improvement of the power factor by adding capacitor banks can result in a reduction in peak power demand. It is proposed to introduce a DSM programme for improvement of power factor from the existing 0.92 to 0.96. Further it is assumed that about 30 % of total LT &MT consumers opt for the programme by the year 2012. Table 4.13 shows the annual targets for DSM programme for power factor correction. It is seen that 23.4 MW of peak demand can be saved by the year 2012. The total cost of saved demand to utility is Rs. 18,504/kW.

Table 4.13 Annual DSM programme targets for power factor correction

Year	*Demand savings*	*Energy savings*	*Total adoptions*	*Programme cost*
	(MW)	*(GWh)*	*Number of consumers (Thousands)*	*(Rs. million)*
2003	1.3	0	4.2	6.3
2004	2.8	0	4.4	13.0
2005	4.5	0	4.5	20.3
2006	6.4	0	4.7	28.2
2007	8.6	0	4.9	36.5
2008	11.0	0	5.0	433.5
2009	13.6	0	5.2	55.1
2010	16.6	0	5.4	65.2
2011	19.8	0	5.6	76.0
2012	23.4	0	5.7	87.4
Total	23.4	0	49.6	433.4

4.2.5.9 Energy Efficient Pumps

Agriculture sector is having about 700 thousand consumers (CEA, 2002). Considering the current growth pattern of agriculture consumers, this number is expected to reach up to 926 thousand by the year 2012. Assuming that all the new pumps bought after the year 2002 are energy efficient pumps, because of a DSM programme. This will lead to 226 thousand energy efficient pumps by the end of plan period.

Table 4.14 shows the annual targets for DSM programme for energy efficient pumps. It is seen that 66 MW of peak demand and 1,891 GWh of energy can be saved by the year 2012. This is equivalent to a cost saving of Rs. 6,378/kW. The cost of saved energy is Rs. 0.22/kWh.

Table 4.14 Annual DSM programme targets for energy efficient pumps

Year	*Demand savings (MW)*	*Energy savings (GWh)*	*Total adoptions Nos (Thousands)*	*Programme cost (Rs. million)*
2003	3.9	23.3	16.7	10.8
2004	8.3	49.9	18	20.4
2005	13.3	80.0	19.3	28.9
2006	18.9	113.9	20.7	36.4
2007	25.1	151.7	21.9	42.8
2008	31.9	193.5	23.3	48.4
2009	39.4	239.6	24.5	53.1
2010	47.6	290.0	25.9	57.1
2011	56.4	345.1	27.2	60.3
2012	66.0	404.9	28.5	62.8
Total	66.0	1891.9	226	421.0

4.2.5.10 Retrofication of Agriculture Pumps

Agriculture sector is having about 700 thousand consumers (CEA, 2002). It is assumed that, 40 % of existing pumps are retrofitted by the year 2012. This will lead to 280 thousand pumps retrofitted by the end of the plan period. A saving of 10 % in energy consumption has been assumed through such replacements. The cost of retrofication is assumed to be Rs. 2500 per pump.

Table 4.15 shows the annual targets for DSM programme for retrofication of agriculture pumps. It is seen that 52.6 MW of peak demand and 1,506 GWh of energy can be saved by the year 2012. This is equivalent to a cost saving of Rs. 9,366/kW. The cost of saved energy is Rs. 0.33/kWh.

Table 4.15 Annual DSM programme targets for retrofication of pumps

Year	*Demand savings (MW)*	*Energy savings (GWh)*	*Total adoptions (Nos) (Thousands)*	*Programme cost (Rs. million)*
2003	3.1	18.5	19.9	12.6
2004	6.6	39.7	21.6	23.9
2005	10.6	63.7	23.0	33.8
2006	15.1	90.7	24.7	42.6
2007	20.0	120.8	26.2	50.1
2008	25.4	154.1	27.8	56.7
2009	31.4	190.8	29.4	62.2
2010	37.9	231.0	30.9	66.8
2011	45.0	274.8	32.5	70.5
2012	52.6	322.5	34.0	73.5
Total	52.6	1506.6	270.0	492.7

4.2.6 Summary of DSM Programmes

Table 4.16 shows the summary of DSM programmes arranged according to the cost of saved peak demand for the utility. Following conclusions are drawn from the analysis of these DSM programmes.

1. CFL programme is highly attractive to the utility. The highest energy and peak demand savings are expected to be realised by the CFL programme in domestic sector, followed by energy efficient pump programme in agriculture sector.

2. The CFL programme is also attractive from the economics point of view, as the cost of saved energy and cost of saved capacity is minimum for this programme i.e. 0.20 Rs./ kWh and Rs. 5,100 /kW respectively.
3. Domestic and agriculture sectors show the highest savings in terms of energy and peak demand. Thus the DSM programmes in these sectors are highly recommended in order to reduce the increasing energy demand in these sectors.
4. The average cost of saved energy for all the DSM programmes is Rs. 0.60/ kWh. It shows that all the DSM programmes cost less when compared with the average unit cost of electricity supply i.e. Rs. 2.36/kWh (see table 3.5).
5. The average cost of saved capacity is Rs. 16,959/kW, which is much less than the average cost of creating additional capacity which is approximately Rs. 40,000/kW.

The estimates of savings potentials are highly sensitive to market penetration rates of different DSM options. For instance in domestic sector an increase in the market penetration rate for CFL lighting option from 1 to 1.5 CFL per consumer, can result in increase in cumulative energy savings from 5,887 GWh to 8,831 GWh. by the year 2012. Similarly the peak demand savings would increase from 228.6 MW to 342 MW.

Table 4.16 Summary of DSM programmes

DSM option	*Sectors*	*Peak demand savings (MW)*	*Cumulative energy savings by 2012 (GWh)*	*Programme cost (Rs. million)*	*Cost of saved energy (Rs./kWh)*	*Cost of saved capacity (Total resource) (Rs./kW)*
Compact fluorescent lamps	Domestic	228.6	5,887	1,163	0.20	5,100
Energy efficient pumps	Agriculture	66.0	1,891	421	0.22	6,378
Energy efficient air –conditioners	Commercial	11.8	173	111	0.64	9,046
Energy efficient motors	Industrial	31.2	902	292	0.32	9,384
Retrofication of pumps	Agriculture	52.6	1,506	492	0.33	16,157
Energy efficient electronic ballasts	Domestic	12.7	349	189	0.54	17,881
Energy efficient fans	Domestic	17.4	457	313	0.68	17,988
Power factor correction	Industrial	23.4	NA	433	NA	18,504
Energy efficient refrigerators	Domestic	11.8	323	301	0.93	25,508
Energy efficient industrial lighting	Industrial	9.6	264	258	0.97	26,876

4.3 ANALYSIS OF RESULTS

4.3.1 Results of Reference Scenario

4.3.1.1 Sectoral Energy Demand

Sectoral demand projections during the plan period (2002-2012) indicate higher growth in domestic and agriculture sector, while industrial and commercial sector register lower growth rates in the same period (Table 4.17). The overall electricity demand for all the sectors in the state is estimated to rise at the rate of 7.6 % p.a. during 2002- 2007 and 6.8 % p.a. during 2007-2012. The projected energy requirement in the domestic sector increases from 4,314 GWh in 2002 to 11,837 GWh in 2012. This shows an average growth rate of 10.8 % p.a. during 2002-2007 and 10.2 % p.a. during 2007-2012. The proportion of electricity demand in this sector gradually increases from 22.7 % in 2002 to 29.6 % in 2012.

The projected energy requirement in the commercial sector increases from 1,175 GWh in 2002 to 2,631 GWh in 2012. This shows an average growth rate of 8.5 % p.a. during 2002-2007 and 8.1 % p.a. during 2007-2012. The proportion of electricity demand in this sector gradually increases from 6.1 % in 2002 to 6.5 % in 2012.

The projected energy requirement in the LT & MT industrial sector increases from 1,730 GWh in 2002 to 2,254 GWh in 2012. This shows an average growth rate of 3.2 % p.a. during 2002-2007 and 3.1 % p.a. during 2007-2012. The proportion of electricity demand in this sector gradually decreases from 9.1 % in 2002 to 5.6 % in 2012.

The projected energy requirement in the HT industrial sector increases from 4,795 GWh in 2002 to 11,081 GWh in 2012. This shows an average growth rate of 8.5 %

p.a. during 2002-2007 and 7.3 % p.a. during 2007-2012. The proportion of electricity demand in this sector decreases gradually from 25.2 % in 2002 to 27.6 % in 2012.

The projected energy requirement in the agriculture sector increases from 6,287 GWh in 2002 to 11,063 GWh in 2012. This shows an average growth rate of 6.5 % p.a. during 2002- 2007 and 5.6 % p.a. during 2007-2012. The proportion of electricity demand in this sector gradually decreases from 33.1 % in 2002 to 27.6 % in 2012.

4.3.1.2 Overall Energy and Peak Demand

Based on the energy demand forecast, the transformation programme of LEAP has been used to simulate the energy supply to assess the adequacy of primary resources to meet the forecasted energy demand. *Transmission & Distribution Module* has been used to accommodate the losses occurring in the transmission, or distribution of electricity. The peak demand has been estimated by assuming a suitable overall load factor of the system. In the reference scenario, results from the LEAP model reveal that the total energy demand is estimated to be about 24,711 GWh and 50,301 GWh in 2002 and 2012, respectively, as presented in Table 4.18. The energy requirement in 2012 is more than two times the energy demand in 2002. The peak demand is expected to increase from 4,195 MW in 2002 to 8,324 MW in the year 2012 in reference scenario.

Table 4.17 Electricity demand in different consumer categories during 2002-2012

Sector	*Base year consumption in 2002*	*Projected energy demand in 2007*	*Annual growth rate*	*Projected energy demand in 2012*	*Annual growth rate*
Units	GWh	GWh	%	GWh	%
Domestic	4,314	7,269	10.8	11,837	10.2
Commercial	1,175	1,774	8.5	2,631	8.1
Industrial LT& MT	1,730	1,934	3.2	2,254	3.1
Industrial HT	4,795	7,646	8.5	11,081	7.3
Public lighting	118	136	3.9	163	3.7
Railways	258	364	7.1	513	7.1
Agriculture	6,287	8,288	6.5	11,063	5.6
Water works	311	390	5.4	500	4.9
T&D losses	6,000	8,500	6.2	11,000	4.8
Total (all Rajasthan)	24,986	36,301	7.6	51,042	6.8

Figure 4.2 and Figure 4.3, shows the official energy and peak demand forecasts respectively, made in sixteenth electric power survey of India by CEA (CEA, 2002). The forecasts made by CEA indicate an energy demand of 56,133 GWh and a peak demand of 9,423 MW by the year 2012. The energy and peak demand forecasts in reference scenario differs from the official energy demand forecasts of CEA, as it incorporates the intended development focus, introduced through interventions in the form of planned growth of connections and adjustment in energy intensity. But still the results of the forecasts are comparable with the official forecasts.

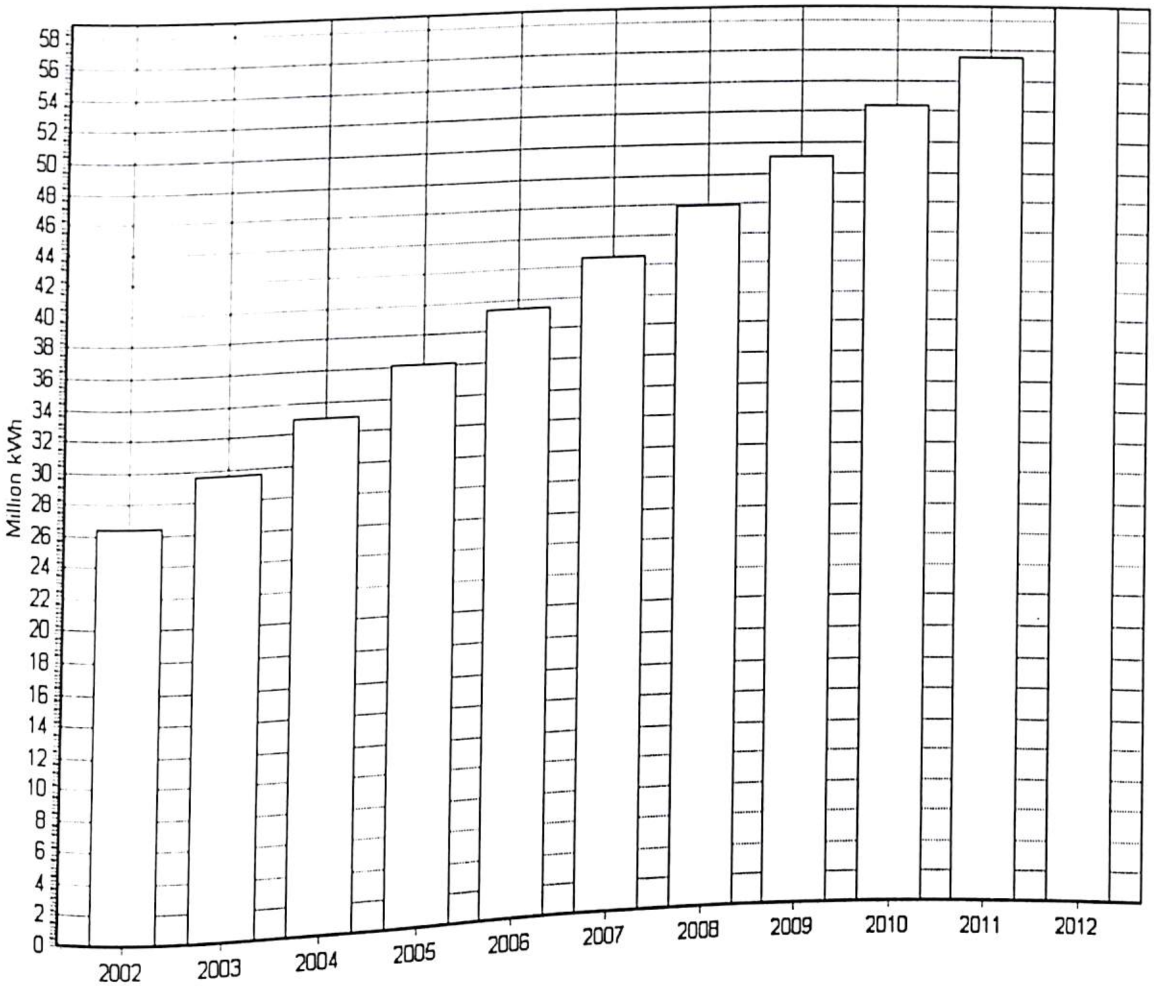

Figure 4.2 Energy demand forecast by CEA

Source: (CEA, 2002)

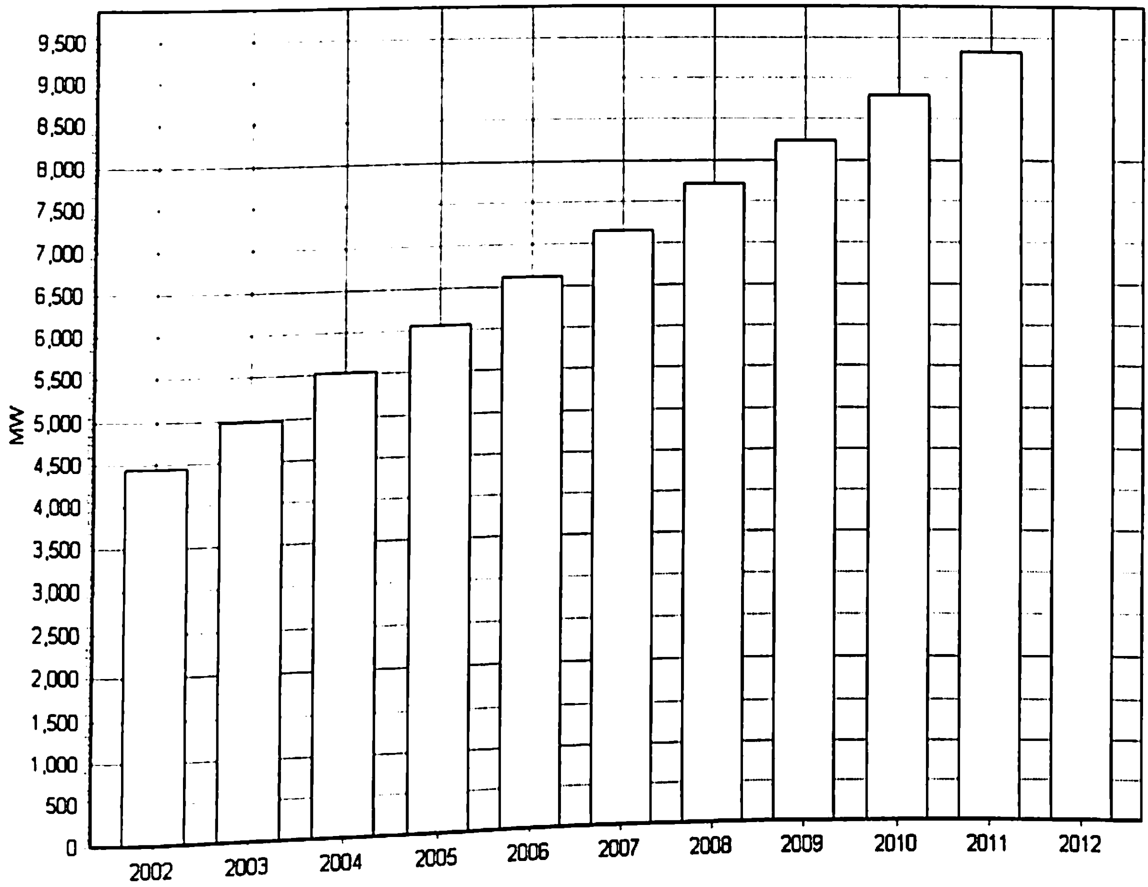

Figure 4.3 Peak demand forecast by CEA

Source: (CEA, 2002)

4.3.1.3 Capacity and Resource Requirements

Two dispatch rules for each power plant has been specified according to the merit orders to meet a default load curve. In this method, each power plant is dispatched in turn by merit order and run until it meets the total electricity requirements. Shares among fuel usage and substitutable devices for an end-use have been determined exogenously and not by the model. Candidate power plants to meet future electricity supply have been synthesised largely according to the expected technological growth.

Here, it is assumed that the expansion of generation capacity will meet the forecasted demand completely and so no shortages will occur during the plan period, new capacity should be added to the system in order to meet the growing demand. As seen in Table 4.18, the installed capacity is expected to increase to 11,303 MW by the end of year 2012, from the base year capacity level of 4,887 MW. This shows almost two-fold increase in the installed capacity. The primary energy resource requirements increase from 8,185 thousand tonnes of coal equivalent in the base year 2002 to 15,467 thousand tonnes of coal equivalent in the end year 2012. It represents an increase of 1.88 times in the primary resource requirements from the base year value. The impact on environmental emissions is increased from 16,030 thousand tonnes of CO_2 equivalent to 32,640 thousand tonnes of CO_2 equivalent by the year 2012.

Based on this forecast, and the average installation and maintenance cost per kW of the new generating capacities, the cumulative total capital expenditure needed to meet the above capacity requirements is about Rs. 251.9 billion (at constant price). Thus a phased investment expansion programme for power sector should be prepared to meet the demand in most economic and reliable way. As the state government would not be able to meet this level of capital expenditures, private sector may be encouraged to finance and invest in power generation projects like the independent power producers scheme.

Table 4.18 Results of the reference scenario

Year	*Units*	*2002*	*2004*	*2006*	*2008*	*2010*	*2012*	*Ratio 2012/2002*
Energy requirements	GWh	24,711	28,641	33,326	38,449	44,070	50,301	2.03
Peak demand	MW	4,195	4,836	5,598	6,426	7,329	8,324	1.98
Capacity requirements	MW	4,887	7,314	8,249	9,201	10,351	11,303	2.19
Capital requirements (Cumulative system cost)	Rs. billion/time Period	11	53	101	151.0	201	250	-
Energy consumption	million tonnes of coal equiv.	7	8	9	10	12	13	1.85
Environmental emissions	million tonnes of CO_2 equiv.	45	52	57	68	80	93	2.1

4.3.1.4 Capacity Mix

Figure 4.4, shows the installed capacity profile under the reference scenario. The new capacity installations are accomplished mainly through coal and gas based power plants. The installed capacity of conventional coal based power generation increases from 2,450 MW in base year 2002 to 4,559 MW by the end of year 2012 representing 41 % of the total installed capacity. The share of other plants in the year 2012 include 12.6 % (1,423 MW) hydroelectric plants, 6.8 % (774MW) CCGT, 3.5 % (400MW) IGCC, 4.4 % (250 MW) lignite, 8 % (800 MW) PFBC, 5.9 % (672 MW) nuclear, 2.2 % (250 MW) wind, 1.2 % (140 MW) ISCC and 14.9 % (1,685 MW) temporary allocation.

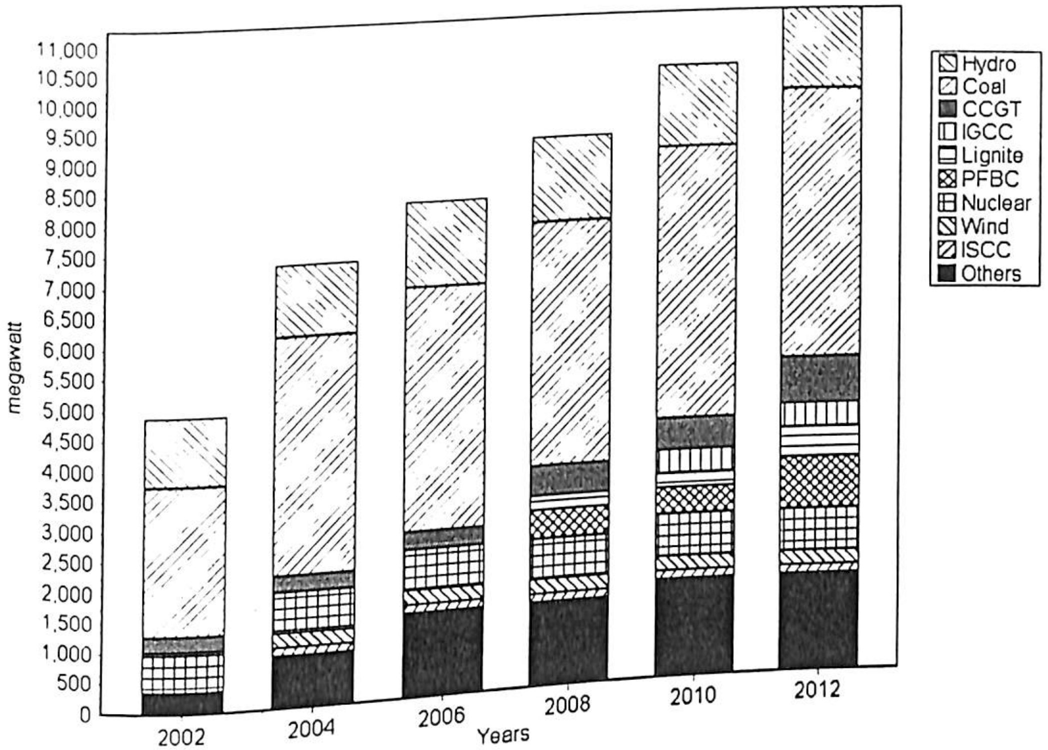

Figure 4.4 Installed capacity profile under the reference scenario

The overall energy demand and supply in reference scenario shows that the increased electricity demand would result in the increased use of fossil fuel and significant portion of fuel requirement would be met by coal based power plants. This would result in the increased release of greenhouse gases (GHGs). Reducing the growing energy requirements through energy efficiency not only reduces the capital requirements for new capacity additions but also controls the release of GHGs.

4.3.2 Scenario Comparison

In this section, forecast results of alternative scenarios are compared with reference scenario. This comparison is carried out in terms of overall electricity demand, capacity requirement, environmental emissions, and capital requirements.

4.3.2.1 Energy Demand

Figure 4.5 provides a comparison of energy demand under different scenarios. Energy demand in reference scenario is expected to grow from 24,985 GWh in 2002 to 51,042 GWH in 2012, which represents an annual compound growth of 6.8 % over the forecast period. DSM, T&D and IRP scenarios results in a reduced energy demand of 2,910 GWh, 2,585 GWh, and 5,495 GWh respectively in the year 2012 as compared to reference scenario. Lowest energy demand is registered under the IRP scenario. This shows an average growth rate of about 5.3 % per year. It may be noted that a considerable savings can be achieved through reduction in T&D losses only.

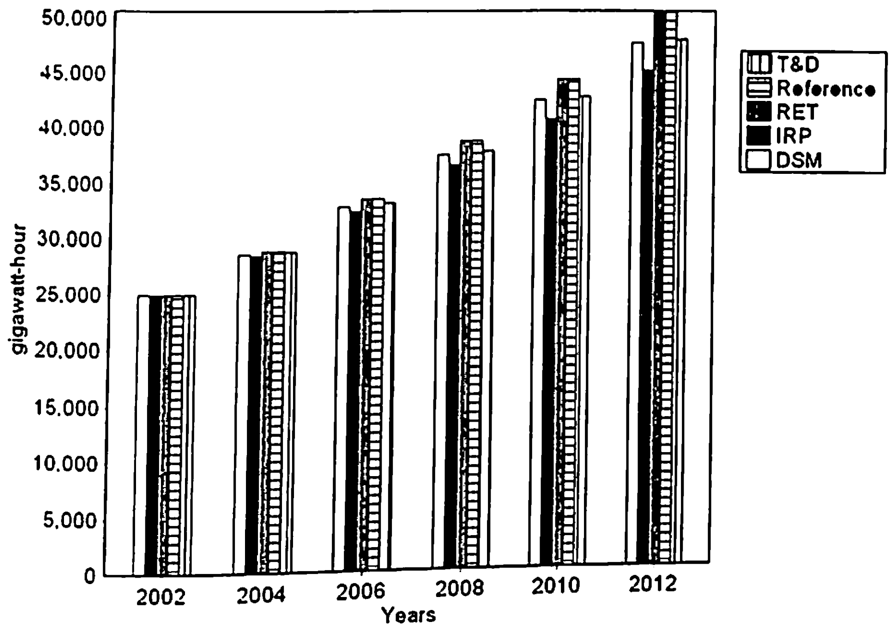

Figure 4.5 Energy demand under different scenarios

4.3.2.2 Peak Demand

The power demand would increase at the same rate as the energy demand unless the demand profile undergoes some changes. The forecast of demand profile pattern is extremely important as this determines the type of generation plant or DSM options to be considered. As the best approximation, the shape of load-curve is assumed to remain unchanged. The reference, RET and T&D scenarios assume a constant load factor of 0.7, while in case of DSM and IRP scenarios a load factor of 0.72 is assumed for peak demand estimation. Figure 4.6 shows the peak demand under different scenarios and Figure 4.7 shows the peak demand savings, when these scenarios are compared with reference scenario. In reference scenario, the peak demand is projected to grow from 4,195 MW in 2002 to 8,324 MW in 2012, representing an annual growth rate of 6.5 %. Peak demand is reduced by 692 MW, 421 MW, and 1,102 MW in DSM, T&D, and IRP scenarios, respectively as compared to the reference scenario by the year 2012 (Figure 4.7).

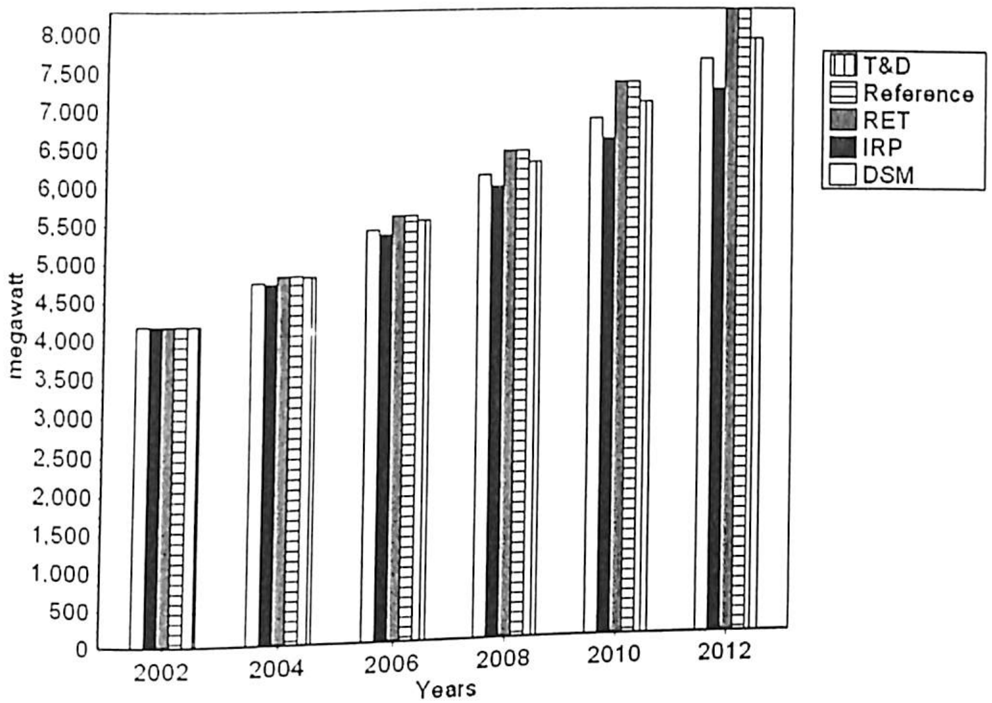

Figure 4.6 Peak demand under different scenarios

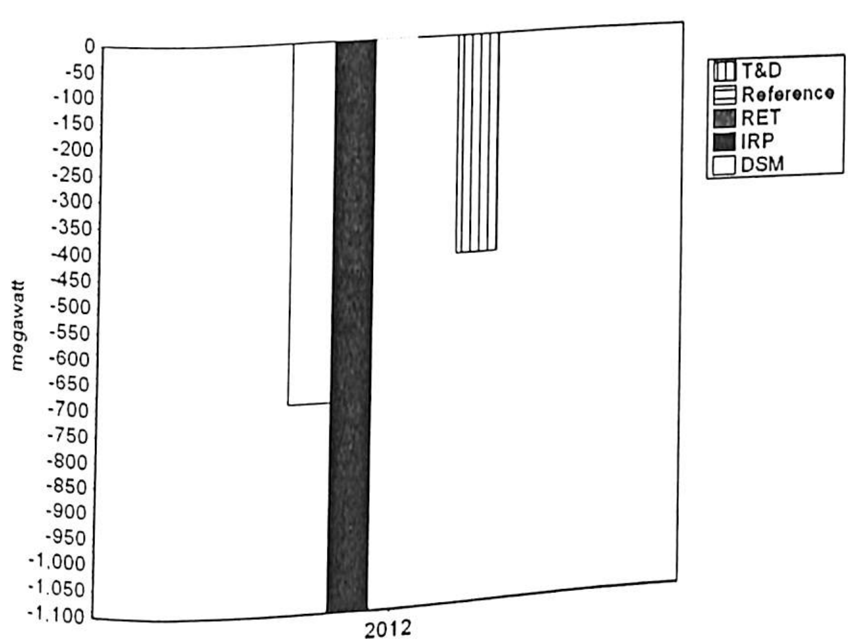

Figure 4.7 Peak demand savings when compared with reference scenario

4.3.2.3 Capacity Requirement

Figure 4.8 shows the capacity requirements, and Figure 4.9 shows the capacity mix in different scenarios. Figure 4.10 shows the capacity savings when compared with reference scenario. The total capacity requirement under the reference scenario is estimated to be about 11,303 MW. The capacity mix mainly comprises the coal-based capacities and gas-based power generating units. In case of RET scenario the total capacity requirements are of the order of 11,865 MW, which represents a higher value as compared to reference scenario. This is due to the fact that the renewable energy based power plants are assumed to operate at a lower capacity factor, leading to higher capacity requirements. In case of DSM and IRP scenarios, the installed capacity requirements are 10,601 MW and 10,715 MW, respectively. It shows a capacity saving of 702 MW and 588 MW in DSM and IRP scenario respectively, as compared to the reference scenario. The reason for less capacity savings in IRP scenario is mainly due to the more dependency on renewable energy based power plants which are specified to have a lower capacity factor.

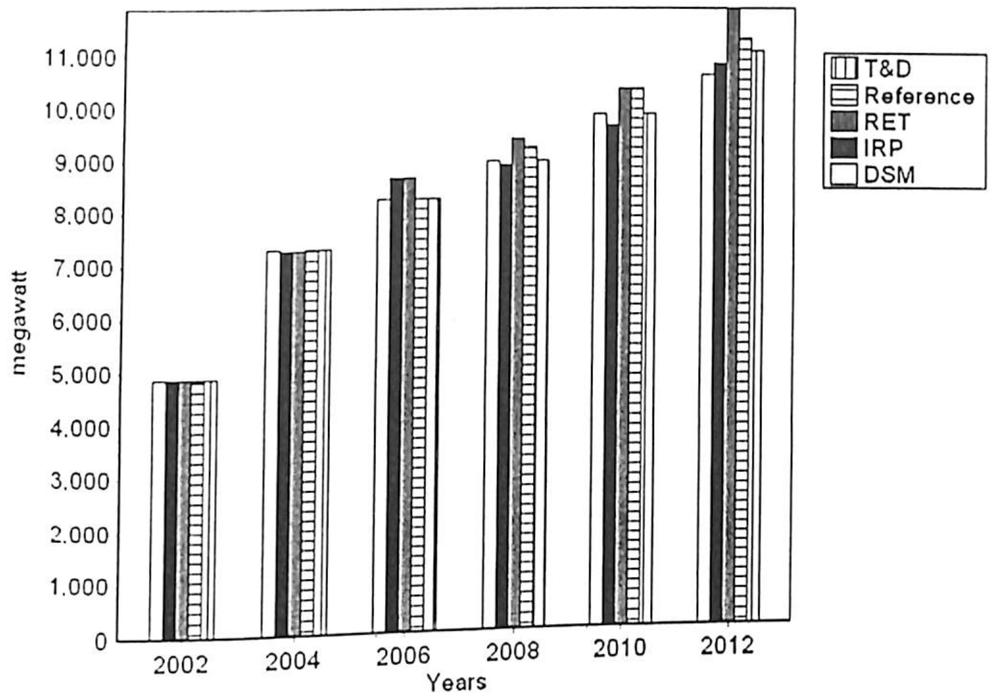

Figure 4.8 Capacity requirements under different scenarios

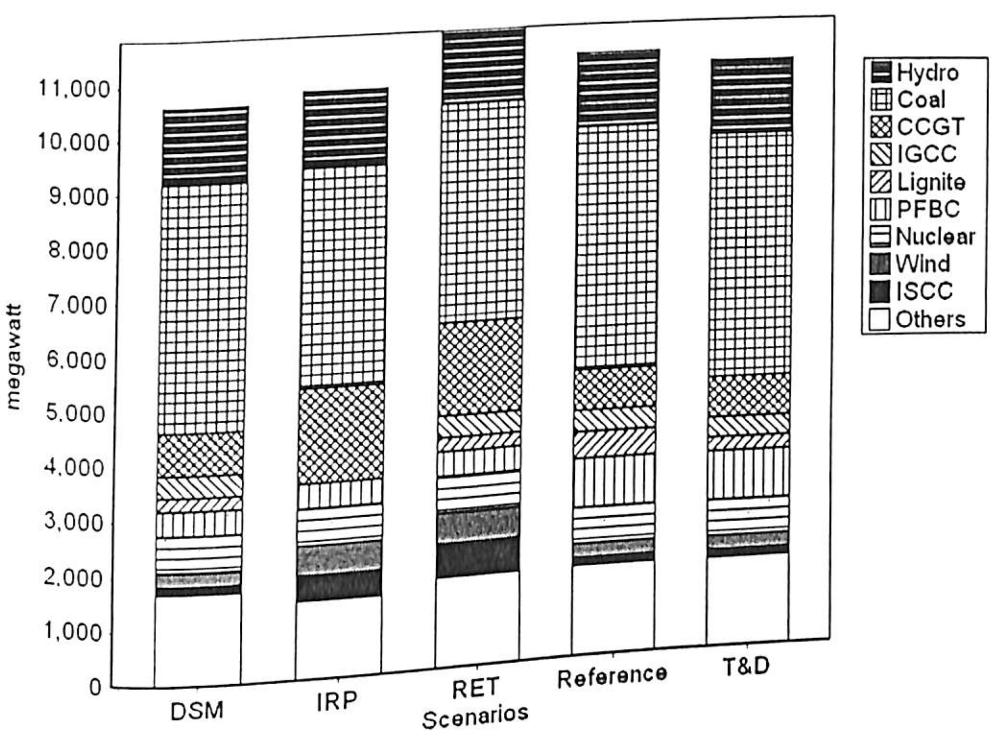

Figure 4.9 Capacity mix by year 2012, under different scenarios

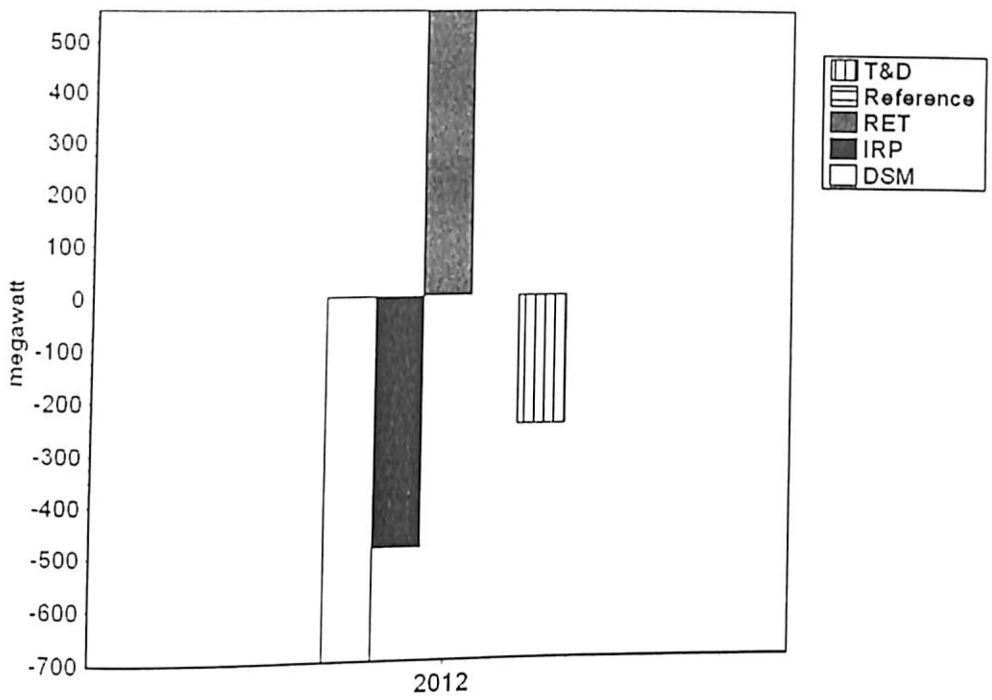

Figure 4.10 Capacity savings when compared with reference scenario

4.3.2.4 Capital Requirements (System costs)

Figures 4.11 shows the cumulative system costs and Figure 4.12 represents the cost savings due to reduced capacity requirements under the alternative scenarios. The cumulative system represents the costs incurred to build and operate the electric power system under different scenarios as well as investments made in DSM programmes in different scenarios. The cumulative system cost in reference scenario is Rs. 249.8 billion, while in case of IRP scenario the cumulative system cost is Rs. 242.5 billion. This represents a significant financial savings of Rs. 7.3 billion. The cumulative system costs in DSM and T&D scenario are Rs. 242.8 billion and Rs. 245.6 billion, respectively. This represents a financial savings of Rs. 7.0 billion in DSM scenario and Rs. 4.2 billion of T&D scenario.

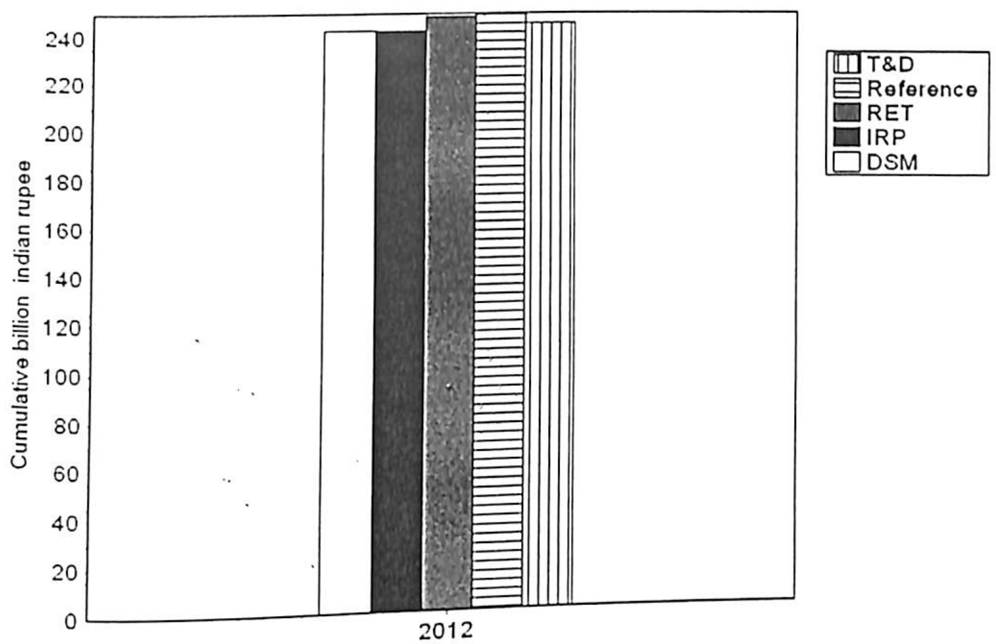

Figure 4.11 Cumulative system costs (present value) in different scenarios

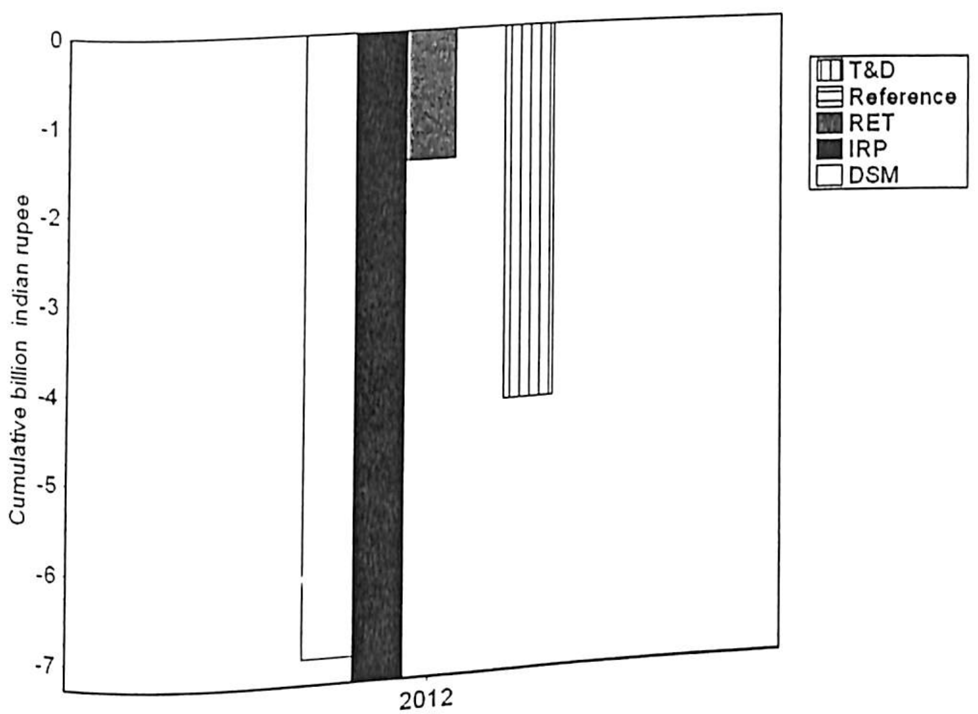

Figure 4.12 Cumulative system costs savings (present value) when compared with reference scenario

4.3.2.5 Energy Resource Requirements

Figures 4.13 and 4.14, provides a comparison of energy resource requirements under different scenarios. DSM, T&D and IRP scenarios result in reduced energy resource requirements as compared to reference scenario. Lowest energy resource requirement is registered under the IRP scenario. The energy resource requirement by the end of year 2012 is 15.3 million tonnes of coal equivalent (MTCE) which is reduced by 2.2 MTCE and 0.8 MTCE in IRP and DSM scenarios, respectively. The energy resource requirements increase almost 1.8 times the base year energy resource requirements under the reference scenario, while the IRP scenario register an increase of 1.6 times the energy resource requirements of base year.

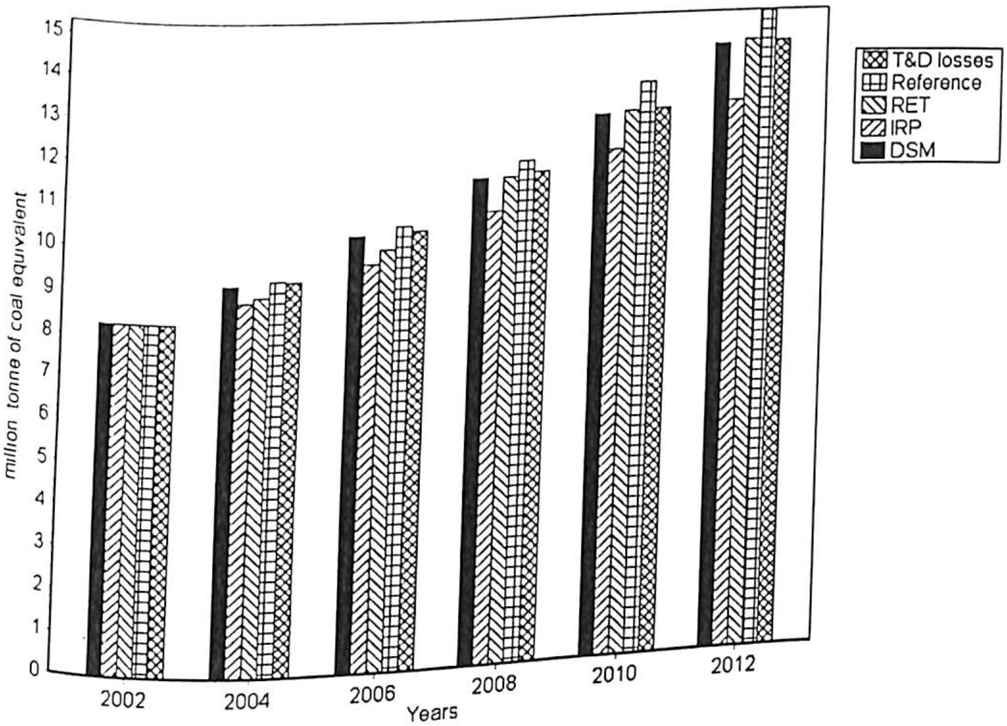

Figure 4.13 Energy resource requirements under different scenarios

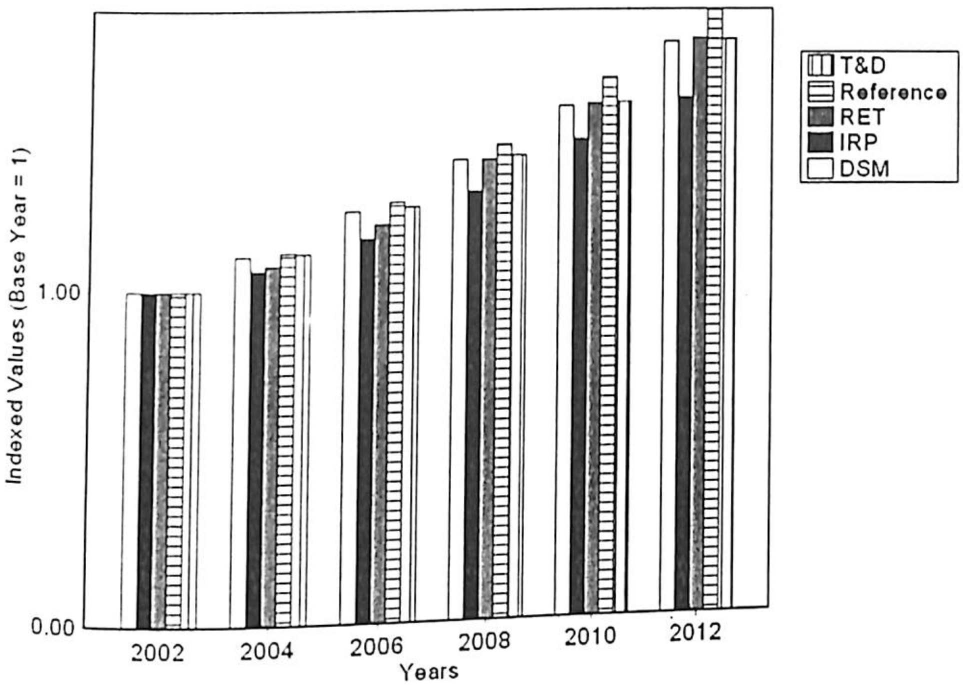

Figure 4.14 Energy resource requirements (indexed base year =1) under different scenarios

4.3.2.6 Environmental Emissions

Figures 4.15 and 4.16 provide a comparison of environmental emissions under different scenarios. DSM, T&D and IRP scenarios results in reduced environmental emissions as compared to the reference scenario. Lowest emissions are registered under the IRP scenario. In case of reference scenario, the environmental emissions are of the order of 86.5 million tonnes of CO_2 equivalent, which are reduced by 18.2 million tonnes of CO_2 equivalent and 7.5 million tonnes of CO_2 equivalent in IRP and DSM scenarios, respectively. The environmental emissions increase almost 1.9 times the base year environmental emissions under the reference scenario, while the IRP scenario registers an increase of 1.6 times the environmental emissions of base year. In fact the RET scenario itself reduces the environmental emissions by 9.4 million tonnes of CO_2 equivalent, when compared with the reference scenario.

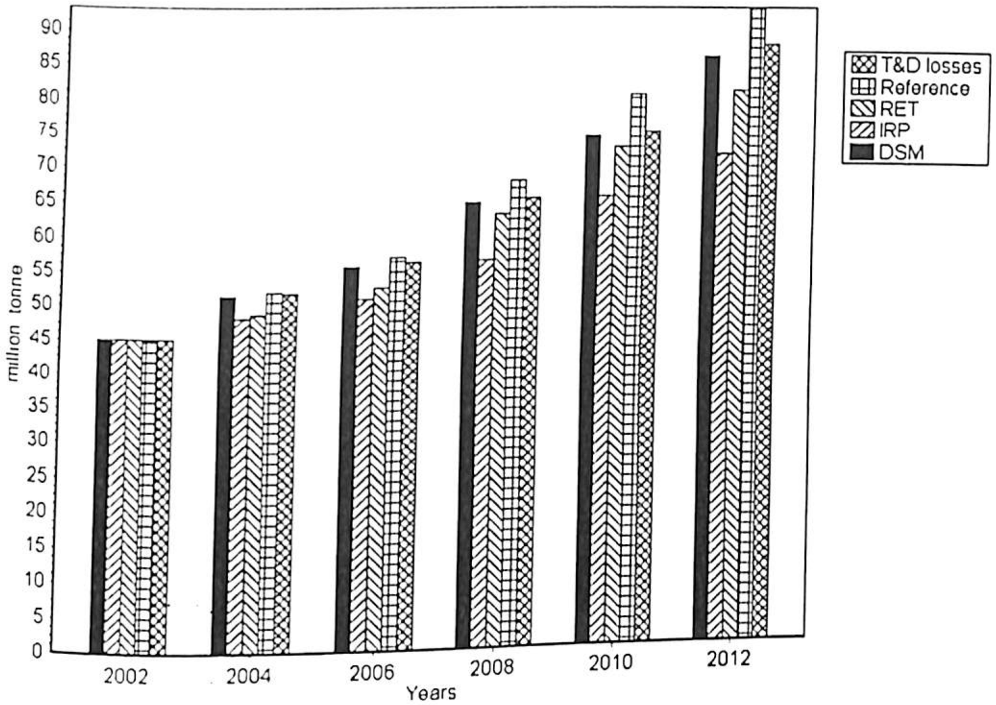

Figure 4.15 Environmental emissions (CO_2 equivalent) under different scenarios

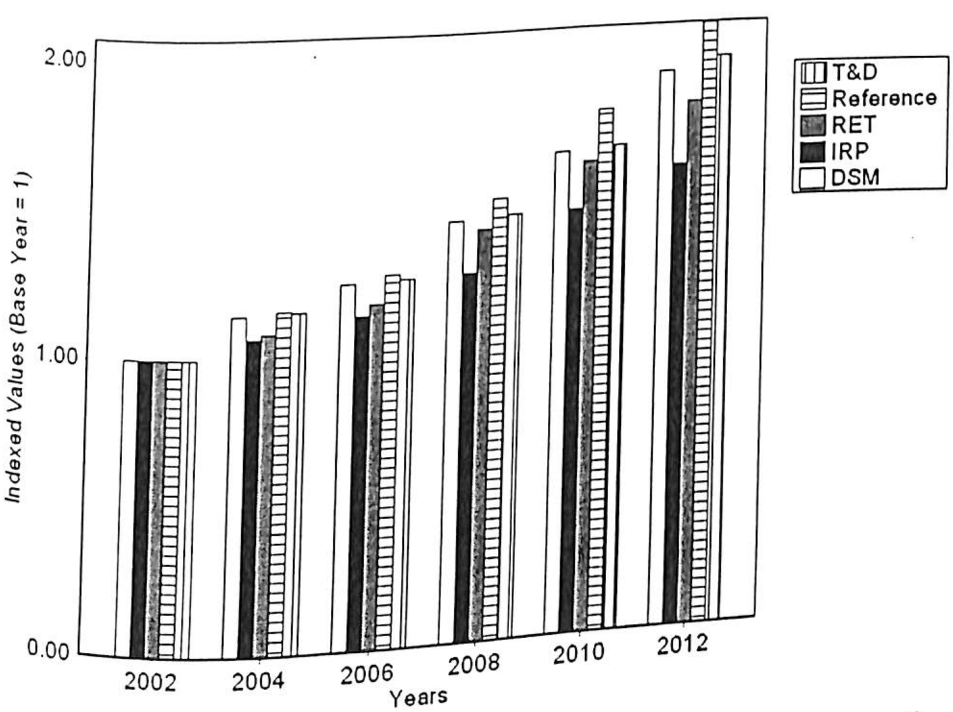

Figure 4.16 Environmental emissions (indexed base year =1) under different scenarios

4.4 COST BENEFIT ANALYSIS

The alternative scenarios are compared from an economic point of view with the reference scenario in terms of the ratio between benefits and costs and avoided cost of GHG emissions. Table 4.19 shows the summary of cost benefit analysis of different scenarios. The total cost represents the net present value of the total expenditures made in various DSM options under different scenarios. The costs are discounted at 12 % interest rate and presented in present value. The benefits are the avoided generation costs, expressed in present value (PV), and derived from the comparison between the alternative scenarios and the reference scenario. Due to the complexity involved in the evaluation of all costs and benefits in power generation, only three important economic factors are considered: capital investment, operation and maintenance, and fuel costs. The benefit cost ratio for the DSM, T&D and IRP scenarios are 2.3, 2.2 and 1.8, respectively. This represents that investing in DSM activities is almost two times beneficial than investing in new capacity additions. In case of RET scenario as described earlier, there is no investment in DSM options. This scenario considers only supply side options, i.e. replacing conventional power plants by renewable energy based power plants. The benefits in this case also include avoided generation costs due to reduced fuel consumption. This also results in reduced GHG emissions. Although the capital cost is higher due to higher unit cost of these power plants, but due to reduced running cost the net benefits (avoided generation cost) work out to be Rs. 1.5 billion.

The alternative scenarios also result in reduced GHG emissions. For example, the emission savings in IRP scenario when compared with reference scenario are of the order of 16.4 million tonnes of Carbon equivalent.

The reduction in GHG emissions and the cost of reducing them is shown in Table 4.19. The cost of avoided GHG emissions is a ratio of net discounted GHG emission savings to the net DSM expenditures in different sectors. Amongst all the alternative scenarios considered in the present study, IRP scenario results in the lowest cost of avoiding GHG emissions (Rs. 681.8/ tonnes of carbon equivalent), followed by T&D and DSM scenarios having the costs as Rs. 1321.4/ tonnes of carbon equivalent, and Rs. 1,432/ tonnes of carbon equivalent, respectively.

The results of the present analysis have also been compared with other studies to check the consistency of the analysis. It has been observed that the results match fairly well with other studies, for example, Reddy and Parikh (1997) estimated the average cost of conserved carbon as Rs. 960/tonnes of carbon equivalent though DSM in industrial sector in India. In the present study also the cost of conserved carbon was found to be in the range of Rs. 681/tonnes of carbon equivalent to Rs. 1432/tonnes of carbon equivalent.

Tables 4.20 and 4.21 represent the cost-benefit-analysis based on the discount rates of 10 % and 14 %, respectively. The results of cost-benefit-analysis are highly sensitive to the discount rate. For example, the value of saved carbon increases from 681.8 million tonnes of carbon equivalent to 795.5 million tonnes of carbon equivalent, if the discount rate is decreased from 12 % to 10 %. Similarly the avoided costs are highly sensitive to the discount rates. For example, if the discount rate is increased from 12 % to 14 %, the avoided cost of electricity generation decreases from Rs. 16.4 billion to 14.3 billion.

Table 4.19 Cumulative costs and benefits compared to reference scenario at 12 % discount rate

	Scenarios			
	DSM	RET	T&D	IRP
a. Costs (DSM programmes) (Rs. billion)				
1. Domestic	3.8	0.0	0.0	3.8
2. Commercial	0.1	0.0	0.0	0.1
3. Industrial LT& MT	0.5	0.0	0.0	0.5
4. Industrial HT	0.1	0.0	0.0	0.1
5. Agriculture	0.8	0.0	0.0	0.8
6. T&D	0.0	0.0	3.7	3.7
b. Total costs (1+2+3+4+5+6) (Rs. billion)	5.3	0.0	3.7	9.0
c. Benefits (Avoided generation costs) (Rs. billion)	12.4	1.5	8.0	16.4
d. Net benefits (c-b), (Rs. billion)	7.1	1.5	4.3	7.4
e. Benefit/Cost ratio (c/b)	2.3	NA	2.2	1.8
f. GHG savings (million tonnes of carbon equivalent)	8.4	16.1	6.6	28.2
g. Discounted GHG savings (million tonnes of carbon equivalent)	3.7	7.9	2.8	13.2
h. Cost of saved carbon (g/b) (Rs./ tonnes of carbon equivalent)	1,432.4	NA	1,321.4	681.8

Table 4.20 Cumulative costs and benefits compared to reference scenario at 10 % discount rate

	Scenarios			
	DSM	RET	T&D	IRP
a. Costs (DSM programmes) (Rs. billion)				
1. Domestic	1	0	0	1
2. Commercial	0.1	0	0	0.1
3. Industrial LT& MT	0.6	0	0	0.6
4. Industrial HT	0.2	0	0	0.2
5. Agriculture	4.3	0	4.3	4.3
6. T&D	0.0	0	0	4.3
b. Total costs (1+2+3+4+5+6) (Rs. billion)	6.2	0	4.3	10.5
c. Benefits (Avoided generation costs) (Rs. Billion)	14.2	1.7	9.2	18.9
d. Net benefits (c-b), (Rs. billion)	8.0	1.7	4.9	8.4
e. Benefit/Cost ratio (c/b)	2.3	NA	2.1	1.8
f. GHG savings (million tonnes of carbon equivalent)	8.4	16.1	6.6	28.2
g. Discounted GHG savings (million tonnes of carbon equivalent)	3.7	7.9	2.8	13.2
h. Cost of saved carbon (g/b) (Rs./ tonnes of carbon equivalent)	1,675.4	NA	1,535.1	795.5

Table 4.21 Cumulative costs and benefits compared to reference scenario at 14 % discount rate

	Scenarios			
	DSM	RET	T&D	IRP
a. Costs (DSM programmes) (Rs. billion)				
1. Domestic	0.8	0	0	.8
2. Commercial	0.1	0	0	0.1
3. Industrial LT& MT	0.5	0	0	0.5
4. Industrial HT	0.1	0	0	0.1
5. Agriculture	3.4	0	0	3.4
6. T&D	0.0	0	3.3	3.3
b. Total costs (1+2+3+4+5+6) (Rs. billion)	4.9	0	3.3	8.2
c. Benefits (Avoided generation costs) (Rs. billion)	10.9	1.3	7.0	14.3
d. Net benefits (c-b), (Rs. billion)	6.0	1.3	3.7	6.1
e. Benefit/Cost ratio (c/b)	2.2	0.0	2.1	1.7
f. GHG savings (million tonnes of carbon equivalent)	8.4	16.1	6.6	28.2
g. Discounted GHG savings (million tonnes of carbon equivalent)	3.7	7.9	2.8	13.2
h. Cost of saved carbon (g/b) (Rs./ tonnes of carbon equivalent)	1324.3	NA	1178.5	621.2

4.5 SUMMARY OF THE RESULTS

- In all the alternative scenarios, the total cost (overall power system expansion and DSM investment) is significantly lower than the reference scenario, which does not incorporate DSM in the planning. In spite of higher capacity requirements in RET scenario, the overall system planning cost for the plan period is lower, because the running costs of the renewable energy based power plants (Wind and ISCC) is significantly lower than the conventional candidate power plants.
- DSM investments are very small as compared with total system planning costs. Thus a small amount investment in DSM can save a lot of expenditure on resource planning.
- The cost of saved energy in all the DSM options considered is significantly lower than the long range average cost of electricity. This shows that the investment in DSM is much more effective than investment made in new generating capacities.
- Among all the alternative scenarios considered, IRP scenario seems to be highly cost effective and environment friendly.
- Investment in DSM programmes in domestic and agriculture sectors can lead to substantial energy savings as they affect a large number of consumers. The cost of saved energy is much lower for CFL programme in domestic sector and energy efficient pump programme in agriculture sector.
- The benefit-cost ratios are highest in case of DSM scenario. Further the benefit-cost ratios are discount rate sensitive.

Chapter 5

MAJOR BARRIERS FOR DSM IMPLEMENTATION IN RAJASTHAN POWER SECTOR

5.1 INTRODUCTION

There is no doubt that the savings projected through various DSM programmes in chapter 4 are within achievable limits. But actual implementation of these programmes has variety of technical, policy, institutional, financial and information related barriers (Verbruggen, 2003; Clinch, 2003; Kulczycka,2003). Successfully marketing and implementation of DSM in Indian utilities will require the development of new skills, new institutional structures, new laws and regulations, new businesses, and whole new industries. The size of this task alone is a large barrier to DSM. One of the objectives of this thesis was to study and identify various barriers in actual implementation of DSM programmes. This chapter identifies the major barriers through a series of in-depth interviews with the top utility officials of Rajasthan. Suitable policy measures are suggested for removing these barriers.

5.2 METHODOLOGY

Since the objective of the study was to obtain a contextual understanding of the barriers for DSM implementation, in person survey was considered as an appropriate method. For the purpose of this study, 20 top officials of various organizations were selected as samples for data collection. Since the study is targeting key policy makers, therefore the judgmental sampling method was adopted while selecting sample. Experts selected for interview were top management officials of RERC, Transco, Discoms, Department of energy, Government of Rajasthan and some independent consultants in the state. A list of the experts interviewed is enclosed in appendix-A

The semi-structured interview style was chosen because it allows the respondent to speak in his or her own words on the topic of interest and allows the interviewer to adapt the interview to capitalize on the special knowledge, experience or insights of respondents. Because these individuals were located in different organizations, prior appointments through telephone or fax were taken to conduct the interviews. The interviews were conducted during June 2003. The interviews lasted for an average of one hour. The questions in interviews covered broadly the DSM implementation issues, which are as follows.

- What are the pros and cons for implementing DSM programmes through existing utility framework?
- Are tariff reforms necessary for implementing DSM?
- Who should carryout IRP under the current framework of the utility?
- What are the disincentives for utility to implement DSM?
- What are the barriers for end users in adopting DSM measures?
- What mechanisms the regulators should adopt to increase attractiveness of DSM in utilities?

- Does the utility staff have enough expertise for monitoring and evaluation of DSM programmes?

5.3 BARRIERS FOR DSM

Table 5.1 summarises the key barriers for implementation of DSM programmes, especially in the context of Rajasthan power sector. These barriers include the barriers related to the utility for promoting DSM programmes as well as the barriers related to the end users in adopting the DSM measures. A brief discussion on the salient aspects of the responses given by the experts with respect to specific barriers is attempted in next section.

Table 5.1 Key Barriers for DSM implementation

Key Barrier	*Elements of Barrier*
Lack of planning	Lack of centralized planning; no central agency to develop an integrated resource plan at state level.
Institutional barriers	Lack of institutional mechanism; limited ESCOs market development; lack of legal and regulatory provisions for utilities to work with ESCOs.
Lack of expertise	Lack of aggressive marketing expertise for of energy efficiency technologies; lack both expertise in planning with utility and regulatory commission.
Non scientific tariff	Under-priced electricity tariffs; heavy subsidy to domestic and agricultural sectors.
Lack of incentives to utilities	No incentives to utilities to increase energy efficiency; traditional regulation does not support DSM investments; fix rate of electricity purchase price for Discoms
Lack of essential information	Lack of end-use information; absence of load research activities; limited availability of information on existing end-use technologies.

Key Barrier	*Elements of Barrier*
Lack of finances with utility	Lack of access to capital; high cost of borrowing capital; limited financial capital of potential customers; bias in financing for large enterprises compared to smaller ones (as reflected in interest rates).
Severe shortage of capital	Industries are facing severe capital shortages; many firms operate only periodically due to lack of capital to purchase raw materials; investments are made only in critical items.
High price of energy-efficient equipment	Consumers are extremely sensitive to first price; consumers buy whatever equipment has the lowest price irrespective of efficiency.
Mistrust between consumers and utility	Many consumers do not pay their electric bills; large debts; consumers do not believe that a utility will have a sincere interest in helping them reduce their electricity bill.
Perception of risk	Technical and business risk; short-term view of investment (e.g., short paybacks required); risk that existing production processes may be affected.

5.3.1 Lack of Planning

The planning process of the electricity sector in Rajasthan is currently being performed at various agencies within the State like Genco, Transco, Discoms, Department of Power, etc. Further, they are closely influenced by the policy measures implemented from time to time by various agencies of government of India like Central Electricity Authority (CEA), Ministry of Power as well as power producers like National Thermal Power Corporation (NTPC), etc. According to the current understanding, the Discoms and Transco are responsible for secure supply today and in future. But one important question is to what extent they should be hold responsible for it, and what should be the cost of secured quality power supply to the consumers?

The experts unanimously agreed that the major barrier in DSM implementation is due to the deficiency in the planning system. Currently there is no central agency to develop an integrated resource plan at state level. Under the current framework, utilities are finding it very difficult to integrate the supply-side and demand-side options simultaneously through an integrated resource planning (IRP) approach. In current structure where the functions of the electricity industry have been unbundled into separate businesses, IRP can be undertaken in the natural monopoly elements of the industry, i.e. the Transco and Discoms. These utilities, while sourcing new supply options should evaluate the supply-side project's merit relative to demand-side options.

5.3.2 Institutional Barriers

Discoms are seen as a natural choice to implement DSM, as they have advantage of consumer contact, established consumer relations, a billing system and a delivery capability within the state. But, currently these Discoms do not have any institutional mechanism who can take up the task for implementing the DSM programmes. Some Discoms have recently formed a DSM cell with limited resources and expertise to take up the DSM promotional activities. But still they are unable to handle the large scale DSM programmes. Experts emphasized on the need of developing private sector capabilities through ESCO market development. ESCO business requires performance contracting, a concept with which utility and consumers are yet not familiar. In case of utility involvement in promotion of DSM programmes with ESCOs, new institutional arrangements, practices and legal provisions will be required; for bills. Utilities may not be willing to participate in such arrangements. It was also recognized that private sector development would not occur naturally, and a market that is conducive to DSM should be created first by the Discoms.

5.3.3 Lack of Expertise

Restructuring in Rajasthan power sector has resulted in new organizations that are acting, in part, in new capacities. The newly formed Discoms bear responsibility for improving the end-use efficiency of their consumers. DSM cells have been created in these Discoms for this purpose. These DSM Cells lack both expertise as well as the manpower required to kick start a DSM activity. Marketing of energy efficiency appliances as a part of DSM activity is a new concept for these DSM cells. Since the philosophy of DSM, namely working with the consumer, was alien to traditional SEB culture, an urgent need exists for the DSM cells to be educated in the areas of customer contacts, end-use technologies and expanding their perspectives to system scale rather than their narrow job descriptions. A rapid progress can be made on both fronts, if additional staff with experience in customer-oriented industries could be hired. The training should be focused and persistent with opportunities for field exercises.

Regulatory commission's staff also needs DSM oriented training and expertise. This was evident when one of the member of the regulatory commission expressed his opinion that with almost a flat load curve of Rajasthan power system, there was no scope for DSM, while it is the fact that flat load curve had been achieved by limiting the power supply to agriculturists and load shedding that cannot be considered as regular DSM measures. Further even with flat load curve energy conservation through DSM is still feasible.

day or day of the year. The fixity of the price erases any incentive for Discoms to be alert for building strategic load shape under the principles of DSM.

When we argued that, when the Discoms are not able to recover their costs fully, as average cost of supply is higher than average tariff. DSM can provide a means for mitigating that loss. The utility officials told that, in case of subsidized consumers (Agriculture and Domestic) promoting DSM may save their subsidized amount, but the saved electricity will go again to the subsidized consumers only rather than diverting it to non subsidized consumers and generating higher revenues. This leads to a net loss to utility in terms of expenses made against the DSM promotion activities.

Experts noted that short-term profit considerations motivates utility managers to increase sales, conservation poses a threat of revenue erosion, which in turn threatens earnings. For example there is a fairly good savings potential exists in industrial sector through different DSM measures. Funding for these projects can easily be made available through financial institutions in terms of tri party agreements or equipments leasing, etc. There are little incentives to utility to reduce consumption by industrial consumers who are their best paying consumers.

5.3.6 Lack of Essential Information

Implementing a DSM programme presents significant challenges for managing a large volume of end-use information of the consumers. Two type of end-use information is essential for structuring a cost effective DSM programme. The first is the information on existing end-use technologies in use by customers and the second is the time patterns of energy use called load shapes. The usual process for updating these data is customer surveys and load research on statistical samples. Both databases need to be built, but frankly, the cost and time commitments would be significant.

Because of the very low level of computerization within the utilities, handling and compilation of the end-use data for DSM programmes formulation will be very difficult. It is recommended that part of the budget for implementing the pilot DSM project be devoted to the purchase of computers and software for better document and records management.

5.3.7 Lack of Finances for Utilities

Poor financial conditions of the Discoms do not allow them to make investments in large scale DSM programmes. In most cases, financial institutions prefer to lend based on balance sheet financing. It means that either the utilities should have strong balance sheet, or its client where it intends to put a DSM measure. As a result, utilities find it difficult to raise finances. Further, due to a lack of credit history, utilities are treated as a high credit risk. This leads to high collateral requirements, which utilities are unable to provide. The biggest DSM potential exists in agriculture sector, the agriculture consumers have poor financial condition and cannot provide even the seed money to take up the energy efficiency projects. If financing of these programmes is arranged through ESCOs in terms of tri party arrangement. Being small size of the individual project, the financial institutions find very high transaction cost of the project and do not like to finance them.

While asking the feasibility to get financing of a DSM project through ESCOs, the experts told that, in most cases, financial institutions prefer to lend based on balance sheet of ESCO. It means that either ESCO should have strong balance sheet, or its client.

As a result, ESCOs find it difficult to raise finances. Since ESCO industry is still in initial stages in India, this has been a major barrier to the growth of ESCO industry itself. Due to a lack of credit history, ESCOs are treated as a high credit risk. This leads to high collateral requirements, which ESCOs are unable to provide.

5.3.8 Severe Shortage of Capital

The experts in the survey from industry side indicated that most of Rajasthan's industries are marble and cement based industries, which are facing severe capital shortages, so severe that many operate only periodically due to lack of capital to purchase raw materials. In addition, the investment needs in aged, out-of-date industrial equipments are enormous, as are the pressures just to stay viable. The industrial consultants interviewed told that for many industries investments are made only in critical items. Experts in the survey identified lack of capital as the primary barrier to installing DSM measures. Many of the experts in the survey told that most of the industries are willing to make improvements in end-use efficiency, but lack of capital is the major barrier which hinders them in opting for energy efficiency improvements. Clearly, upfront financial assistance will have to be a central component in any DSM programme initiated in Rajasthan.

5.3.9 High Price of Energy-Efficient Equipment

A number of experts identified the high prices for energy-efficient equipment as a significant barrier to DSM investments. They explained that equipment buyers are extremely sensitive to first price: they choose the lowest-priced piece of equipment even when they know that the more efficient, but more expensive, piece will be much cheaper to operate and in general will be of higher quality.

This price relationship between efficient and inefficient equipment is due in part to the fact that most energy efficient equipments are not locally made. The experts said that even though they recognized superior efficiency and technology in the branded equipment, they would buy whatever had the lowest price.

One solution to this problem is for the utility to defray part of the cost of DSM measures by providing financial incentives or financing for its customers. The costs to provide financing, however, can be fully recovered through shared savings contracts, with the individual customers benefiting from the financing rather then being recovered from all rate payers, and thus avoiding cross subsidies. To encourage the highest level of participation, at least some portion of the incentives will need to be provided up front rather then after installation is verified or in some way reduce the first cost of the energy efficient equipment. Another solution is for the private sector (ESCOs) to offer financing that is paid back through shared savings in the customers' utility bills.

5.3.10 Mistrust Between Consumers and Utility

In recent years, due to severe economic slowdown, many companies found themselves unable to pay their electric bills, and consequently ran up large debts with the electric utility. In addition, mandatory curtailments have created bad feelings between the utility and some of their customers. This mistrust between consumers and utility that exist might be overcome once the utility show they are interested in providing customer service in addition to selling electricity and once there is a better understanding of the benefits of DSM. Some customers simply do not believe that a company in the business of profiting from the sale of electricity would have a sincere interest in helping them to reduce their electricity bill. Once they understand, most participants will be willing to accept assistance from their utility.

Perhaps the best way around this barrier is for the utility to quickly build a positive working relationship with their key customers. Once customers see that the utility is interested in a business partnership, and they have a chance to learn more about the rationale and benefits of DSM, they may choose to participate.

5.3.11 Perception of Risk

Consumers do not have experience with proven cost effective DSM technologies. As a result they perceive these technologies to be unreliable, particularly if they have not installed the measure. Further they are reluctant to adopt new, innovative technologies due to their performance uncertainties and fear for a possible disruption in routine caused by the implementation of energy efficiency measures (Parikh et al., 1996b; Khanna and Zilberman, 1999). Technical support may be provided to consumers through pilot demonstration projects to gain experience and build confidence in terms of reliability and performance of these technologies.

5.4 POLICY MEASURES TO OVERCOME THE BARRIERS

- It should be made mandatory for Discoms to develop their own DSM plans so that they could trade with a wide range of potential suppliers (e.g. Independent Power Producers, Generation Companies, Central sector suppliers such as National Thermal Power Corporation, National Hydro Power Corporation, etc.) and consumers (through DSM) as well as develop their own resources (savings through transmission and distribution loss reduction) through a least cost planning approach. According to this idea Discoms should present an amount of energy and power to be purchased by Transco, at a reasonably acceptable price. Of course it should be the starting point for negotiations and reassessments of Discoms position, but behind that proposal a full internal analysis using integrated resource planning should be done, with different alternatives for trade with Genco and other suppliers as well. In such a scenario the role of generating companies will be limited and they have to provide electricity at competitive rates.

- Present tariff does not provide appropriate signals to consumer for shifting towards conservation. The subsidized rates also lead for inefficient usage of electricity by these consumers. Until the subsidy is removed it is very difficult to promote DSM in these consumers. There is a necessity of tariff reforms to improve prospects of DSM.
- Without differential tariff between peak and off-peak periods, there is no enthusiasm for Discoms for implementing DSM measures. The unfortunate situation gets worse. While Transco does face the market price variations, they have none of the qualifications for implementing DSM, they are arms-length removed from retail customers, Discoms being their only customers.
- Consumers do not have enough experience with proven cost effective energy-saving measures. As a result the end-users perceive energy efficiency technologies to be unreliable, particularly if they have not installed the measure. Further the end-users are reluctant to adopt new, innovative technologies due to their performance uncertainties and fear for a possible disruption in routine caused by the implementation of energy efficiency measures. There is a need to develop pilot demonstration projects to build confidence of consumers in terms of reliability and performance of energy efficiency technologies.

- In order to finance the EE and DSM activities, a dedicated fund may be raised through a special levy for DSM applied on consumers of electricity per unit of electricity sold. Furthermore, the administration of the funds can be made by utility with regulatory oversight.

Chapter 6

DSM IMPLEMENTATION: STRATEGIES

6.1 INTRODUCTION

DSM implementation involves the use of appropriate institutional framework for market penetration of energy efficient technologies. Didden and Williams (2003) classify these frameworks in to two categories: (i) artificial DSM framework, (ii) natural DSM framework. The artificial DSM framework is created by regulatory commission by making it mandatory for the utilities to achieve certain level of savings through DSM. These DSM targets are specified by the utility as a part of their integrated resource planning (IRP). Under the natural DSM framework the responsibility is given to such an actor (e.g. ESCOs) which has its own commercial interest in implementing DSM. This chapter discusses both possibilities in detail. The financial implications to the utility under the artificial DSM framework are described through a quantitative analysis of hypothetical DSM programmes. The analysis attempts the most common structures of electricity supply industry namely a vertically integrated electricity utility and completely unbundled electricity utility having separate identities in generation, transmission and distribution. As DSM implementation involves marketing of energy efficiency technologies and programmes, there is a need for an appropriate institutional framework that has the capability to encourage customer participation. This chapter also discusses the possible institutional arrangements for DSM implementation. Following are the key issues addressed for implementing DSM.

- What are the roles of different actors in implementing DSM under the current utility framework?
- What are the incentives and disincentives for energy companies in implementing DSM?
- What are the possible institutional arrangements for implementing DSM?

6.2 ARTIFICIAL DSM FRAMEWORK

Under the artificial DSM framework, regulators put obligation for utility to perform certain level of DSM (Eyre, 1998). The regulators require utility to achieve energy efficiency goals (e.g., a minimum amount of CFLs per household) after a certain period of time. It is the utility's responsibility which DSM programmes it will implement to achieve these standards. If they do not achieve the standards the utility could be financially penalized, or even worse, their supply license could be withdrawn. The main disadvantage of this system is the high monitor and evaluation cost. As utility bears the responsibility for minimizing their consumers costs, they can implement DSM under this framework. The scope of the utility's DSM responsibilities depends on how broadly the regulators define the utility's obligation to minimize its consumer's costs. At a minimum, regulators may require utilities to plan and invest in DSM that minimises the cost of electricity to end users.

In next subsections the applicability of DSM/IRP for each of the different entities: Generation Utility, Transmission Utility, Distribution Utility, and The State Government are discussed.

6.2.1 Generation Utility (Genco)

- It will be very difficult for the generating utilities to integrate the long-term supply-side and demand-side plans simultaneously under an IRP framework, especially in a situation when generation is owned by state and central power generating companies.
- Currently, there is no central agency to develop an integrated resource plan at state level.
- The regulators can play an important role in compelling the generators to evaluate the supply-side project's merit relative to demand-side options.

6.2.2 Transmission Utility (Transco)

- Due to the fact that the transmission networks will remain a monopoly, there are opportunities for implementing DSM under the IRP framework through Transco.
- Transco takes a crucial position on the whip for balancing the various options of an IRP-plan.
- Transco may be directed by appropriate regulations for taking this additional task of promoting DSM while sourcing new supply options.
- DSM programmes can be initiated by the Transco through a nation-wide competitive tendering schemes and the cost of DSM can be recovered via the transmission charges or some other regulatory mechanisms.

- System boundaries are an important issue in restructured electricity markets. For example, the Indian electricity market has state level transmission utility to trade for electricity from state and central sector electricity generating companies.

6.2.3 Distribution Utility (Discom)

- The Discom can be an important vehicle for introducing DSM programmes. This will also avoid their distribution system capacity upgrades.
- It is possible for Discoms to provide a standardised DSM programme, but it is unlikely that Discoms could aggressively promote market transformation strategies which include development of energy efficiency standards and codes, etc.

6.2.4 State Government

- The state governments can perform DSM under the IRP framework through state planning commission in co-operation with the electricity companies.
- The government can put more emphasis on the target of increasing economic efficiency through DSM, and with wider environmental and social goals, e.g., CO_2 reduction.
- This may only make full sense of IRP, where the environmental and social objectives have also been taken into consideration. But, in case of Rajasthan the state government does not have any central agency which could aggressively perform this task.

6.3 NATURAL DSM FRAMEWORK

The main idea of a natural DSM framework is to give the responsibility for energy efficiency improvement to an entity that will have no financial losses if electricity consumption is reduced. Such entity can be either the manufacturers of energy efficiency equipments or energy service companies (ESCOs) which can provide energy efficiency services using market-based mechanisms such as performance contracting. This framework has already been tried in Ahemdabad Electricity Company (AEC) in Gujarat (Weisbroad et al., 1998). There are two basic models under which the ESCOs perform the DSM programmes. This includes the shared savings contract and the guaranteed savings contract.

6.3.1 Guaranteed Savings Contract

Under this guaranteed savings contract the ESCO installs an energy efficient measure and takes full responsibility for its proper functioning. The customer enters into separate agreements for energy services and for financing. Typically the ESCO arrange financing, but is not a party to the finance agreement. The ESCO and the customer enter into a turnkey contract or "energy services agreement" whereby the ESCO provides engineering, equipment installation, and other services such as operations, maintenance, and savings verification. Performance guarantee is offered by ESCO for a guaranteed savings. The second agreement, a financing agreement, covers the customer's obligation to pay for the project's initial costs. It is typically fixed and unconditional; it is not contingent on or subject to offset based on actual energy cost savings. The ESCO is paid for by the savings due to the installed equipment.

6.3.2 Shared-Savings Contracts

Under the shared savings contract, savings are verified periodically (e.g., monthly, quarterly, annually) by the ESCO and the payment to ESCO is based on the realised savings from project. The end-user bear the responsibility for minimal hours of operation and minimum energy load levels of their plant. The ESCO remains responsible for project performance, including any on-going equipment servicing, maintenance and monitoring functions. The ESCO receives the payments through utility for verified, delivered kW and kWh energy savings, typically over a 7 to 10 year term.

The problems faced by such contracts are as follows:

- An ESCO must at least recover the costs of its audit, which may not be the case with small customers.
- ESCOs may not always install the newest and most efficient equipment. Indeed, because the ESCOs are responsible for the maintenance and proper operation of the installed equipment they may only install equipment that has reached a certain technological maturity and which they are familiar with.
- Because the ESCO industry is still under the developing phase, governments have to play an active role to stimulate their activities.

6.4 FINANCIAL IMPLICATIONS OF DSM

The strongest economic rationale for a utility to perform DSM is the possibility of increased profits. Therefore, the financial impact of DSM activities on the utility, which pursue them, is to be analysed. This section analyse the short run and long run financial impact of DSM on a vertically integrated as well as a completely unbundled electricity utility.

Consider an electricity utility implementing DSM programmes. The financial impact of DSM programmes on the utility will have following components.

C, the direct DSM **costs**, i.e. the costs of implementing the DSM programme;

B, the **benefit** of avoided costs for energy supply;

L, the **lost revenues** due to reduced kWh sales;

R, additional **revenues**, e.g. payments for energy efficiency services from customers, or payments for DSM programme implementation from a dedicated EE&DSM Funds;

L-B are the **net lost revenues** due to reduced kWh sales as an effect of the DSM for the customers (i.e. the lost margin that would have been generated by selling instead of saving the kWh).

The **lost revenues** L are dependent on the consumer class concerned, and on the electricity prices to this consumer class.

The **avoided costs** B are different for different energy companies and different DSM programmes which are promoted.

The financial impact on electricity utility in terms of profit or loss due to DSM implementation can be expressed with the help of following equations.

B + R > C + L (i.e., the utility makes a profit out of DSM)

B + R < C + L (i.e., the utility faces a loss out of DSM)?

In order to quantify financial impact of DSM on different energy companies, the basic market prices and costs of electricity are estimated as follows (hypothetical values, but based on typical Indian conditions):

- Wholesale peak power price to Discoms Rs. 3.0 / kWh
- Wholesale partial peak price to Discoms Rs. 2.0 /kWh
- Wholesale off peak price to Discoms Rs. 1.25 /kWh
- Transmission charges Rs. 0.25/ kWh
- Variable distribution costs: losses to domestic consumers Rs. 0.5 /kWh
- Variable distribution costs: losses to agriculture consumers Rs. 0.75 /kWh

- Variable distribution costs: losses to commercial and industrial consumers Rs. 0.25 /kWh
- Price of electricity to domestic consumers. Rs. 3.0/ kWh
- Price of electricity to industrial/ commercial consumers. Rs. 4.5/kWh
- Price of electricity to agriculture consumers. Rs. 0.75/kWh
- Avoided capacity charges Rs. 0.75/kWh
- Avoided transmission network upgrades Rs. 0.05 /kWh
- Avoided distribution network upgrades Rs. 0.10 /kWh

The next sub-sections analyse the financial impacts of DSM programmes in different consumer categories performed by the electricity utilities in short-term as well as in long-term point of view.

6.4.1 Short-term View with Peak Demand Shortage

The short-term view is used to analyse the financial impact of a DSM programme on the utility. It can examine whether to implement or not the programme. The short-term perspective on net lost revenues is more relevant, as it considers the economic attractiveness of DSM for the utility. Two different types of electricity industry structures, namely unbundled electricity distribution utility (Discom) purchasing electricity from power pool and a vertically integrated electricity utility generating its own power, having its own transmission network and its own distribution network are considered for the analysis.

6.4.1.1 Example: Discom buying from the power pool

The net lost revenues for Discom can be expressed by following equation:

Net lost revenues = lost revenues – (avoided) short-term marginal costs (cost of electricity from the power pool + transmission fee + variable distribution costs: losses)

The net lost revenues to Discom will depend on the consumer class concerned, and on the electricity prices to this consumer class. Table 6.1, 6.2 and 6.3 shows the financial implications of hypothetical DSM programmes in domestic, industrial/commercial, and agriculture consumers respectively.

Table 6.1 Effect of a hypothetical DSM programme offered by Discom in domestic sector: Short-term view with peak demand shortage

Cost component	*Rs./kWh*
Lost revenues	3.50
Avoided cost of electricity from power pool	3.00
Transmission fee	0.25
Variable distribution costs: losses	0.50
Net lost revenues	**-0.25**

Table 6.2 Effect of a hypothetical DSM programme offered by Discom in industrial/ commercial sector: Short-term view with peak demand shortage

Cost component	*Rs./kWh*
Lost revenues	4.50
Avoided cost of power purchases	3.00
Transmission fee	0.25
Variable distribution costs: losses	0.25
Net lost revenues	**1.00**

Table 6.3 Effect of a hypothetical DSM programme offered by Discom in agriculture sector: Short-term view with peak demand shortage

Cost component	*Rs./kWh*
Lost revenues	0.75
Avoided cost of power purchases	3.00
Transmission fee	0.25
Variable distribution costs: losses	0.75
Net lost revenues	**-3.25**

DSM programmes in domestic sector will lead to a net profit of Rs. 0.25/kWh to the Discom (Table 6.1). If one considers the DSM programme cost as Rs. 1.0/kWh and the Discom share the 50% of the cost of the programme, the net profit would be Rs. -0.25/kWh (loss). But, if the saved electricity is further sold to industrial or domestic sectors, this will further lead to overall profits to the Discom.

Typically, the highest net revenues losses (Rs. 1.0/kWh) are experienced by floating DSM programmes in industrial and commercial sectors (Table 6.2). Assuming Rs. 0.5/kWh as cost of DSM programme incurred to the Discom, the net revenues loss to Discom increases to Rs. 1.5/kWh. If the saved electricity is diverted to domestic or agriculture sector, which are getting subsidised electricity, the losses to the Discom further increase.

Implementing DSM in agriculture consumers will be highly beneficial to the Discom. It leads to a net profits of Rs. 3.25/kWh to the Discom (Table 6.3). Assuming Rs. 0.5/kWh as cost of DSM programme incurred by the Discom, the net profit becomes Rs. 2.75/kWh. If the saved electricity is diverted to industrial or domestic sector, the profits of Discom will further increase.

6.4.1.2 Example: Vertically integrated electricity utility

In case of a vertically integrated utility, the generation, transmission and distribution portfolios are held with a single electricity utility. This is a common structure in states where the restructuring of state electricity boards has not yet been carried out. The net lost revenues for such utility can be expressed by following equation:

Net lost revenues = lost revenues – (avoided) short-term marginal costs (fuel expenditures + variable distribution costs: losses).

Table 6.4, 6.5 and 6.6 shows the financial implications of hypothetical DSM programmes in domestic, industrial/commercial, and agriculture consumers respectively.

Table 6.4 Effect of a hypothetical DSM programme offered by a vertically integrated utility in domestic sector: Short-term view with peak demand shortage

Cost component	***Rs./kWh***
Lost revenues	3.50
Avoided fuel cost	2.00
Variable distribution costs: losses	0.50
Net lost revenues	**1.00**

Table 6.5 Effect of a hypothetical DSM programme offered by a vertically integrated utility in industrial/ commercial sector: Short-term view with peak demand shortage

Cost component	***Rs./kWh***
Lost revenues	4.50
Avoided fuel cost	2.00
Variable distribution costs: losses	0.25
Net lost revenues	**2.25**

Table 6.6 Effect of a hypothetical DSM programme offered by a vertically integrated utility in agriculture sector: Short-term view with peak demand shortage

Cost component	*Rs./kWh*
Lost revenues	0.75
Avoided fuel cost	2.00
Variable distribution costs: losses	0.75
Net lost revenues	**-2.00**

Implementing DSM programmes in domestic consumers will lead to net lost revenues of Rs. 1.0/kWh to the vertically integrated electricity utility (Table 6.4). If considering the DSM programme cost as Rs. 1.0/kWh and the utility shares 50% of the cost of the programme, the net lost revenues further increases to Rs. 1.5/kWh. But, if the saved electricity is diverted to industrial sector, this may lead to a profitable situation for the electricity company.

Implementing DSM programmes in Industrial/ commercial consumers may accrue highest net revenue losses of Rs. 2.25/kWh to the utility (Table 6.5). These are their high paying consumers for the utility and highest revenue is generated through electricity sales to this category of consumers. Assuming Rs. 0.5/kWh as cost of DSM programme incurred to the utility, the net revenue loss further increases to Rs. 2.75/kWh. As currently there is no load shedding to industrial and commercial consumers, it is quite possible that the saved electricity may be diverted to domestic or agriculture consumers, which are getting subsidized electricity, the losses to the electricity company further increases.

Implementing DSM in agriculture consumers will lead to net profits of Rs. 2.0/kWh to the utility (Table 6.6). Assuming Rs. 0.5/kWh as cost of DSM programme incurred to the utility, the net profit reduces to 1.5/kWh. If the saved electricity is diverted to industrial or domestic consumers, this will further lead to overall profits to the utility.

6.4.2 Long-term View with Need for New Capacity

The long-term perspective is the one taken by the society and used, e.g., in the total resource cost test, which is one important cost-benefit test for DSM programmes, used as a tool to decide whether DSM programmes are cost-effective and should be implemented or not from the perspective of society. The cost of avoiding the environment pollution through DSM has not been considered in this analysis.

6.4.2.1 Example: Discom buying from the power pool

Under the long-term perspective, if a Discom implements DSM programmes, the benefits are in the form of avoided marginal electricity costs, avoided transmission fee, avoided distribution losses, and avoided distribution network upgrades. The net lost revenues in this case can be expressed by following equation:

Net lost revenues = lost revenues – (avoided) long-term marginal costs (cost of electric energy from the power pool + transmission fee + variable distribution costs: losses + avoided distribution network upgrades)

Table 6.7, 6.8 and 6.9 show the financial implications of hypothetical DSM programmes in domestic, industrial/commercial, and agriculture consumers respectively.

Table 6.7 Effect of a hypothetical DSM programme offered by Discom in domestic sector: Long-term view with need for new capacity

Cost component	***Rs./kWh***
Lost revenues	3.50
Cost of electricity from power pool	3.00

Cost component	Rs./kWh
Transmission fee	0.25
Variable distribution costs: losses	0.50
Avoided distribution network upgrades	0.10
Net lost revenues	**-0.35**

Table 6.8 Effect of a hypothetical DSM programme offered by Discom in industrial/ commercial sector: Long-term view with need for new capacity

Cost component	*Rs./kWh*
Lost revenues	4.50
Cost of electricity from power pool	3.00
Transmission fee	0.25
Variable distribution costs: losses	0.25
Avoided distribution network upgrades	0.10
Net lost revenues	**0.90**

Table 6.9 Effect of a hypothetical DSM programme offered by Discom in agriculture sector: Long-term view with need for new capacity

Cost component	*Rs./kWh*
Lost revenues	0.75
Cost of electricity from power pool	3.00
Transmission fee	0.25
Variable distribution costs: losses	0.75
Avoided distribution network upgrades	0.10
Net lost revenues	**-3.35**

Implementing DSM programmes in domestic consumers will lead to a net profit of Rs. 0.35/kWh to the Discom (Table 6.7). If one considers the DSM programme cost as

Net lost revenues = lost revenues – (avoided) long-term marginal costs (fuel expenditures + capacity costs + variable T&D costs: losses + avoided transmission network upgrades + avoided distribution network upgrades)

Table 6.10, 6.11 and 6.12 shows the financial implications of hypothetical DSM programmes in domestic, industrial/commercial, and agriculture consumers respectively.

Table 6.10 Effect of a hypothetical DSM programme offered by vertically integrated utility in domestic sector: Long-term view with need for new capacity

Cost component	***Rs./kWh***
Lost revenues	3.50
Fuel expenditures	2.00
Capacity costs	0.75
Variable distribution costs: losses	0.50
Avoided transmission network upgrades	0.05
Avoided distribution network upgrades	0.10
Net lost revenues	**0.15**

Table 6.11 Effect of a hypothetical DSM programme offered by vertically integrated utility in industrial/commercial sector: Long-term view with need for new capacity

Cost component	***Rs./kWh***
Lost revenues	4.50
Fuel expenditures	2.00
Capacity costs	0.75
Variable distribution costs: losses	0.25
Avoided transmission network upgrades	0.05
Avoided distribution network upgrades	0.10
Net lost revenues	**1.35**

Table 6.12 Effect of a hypothetical DSM programme offered by vertically integrated utility in agriculture sector: Long-term view with need for new capacity

Cost component	*Rs./kWh*
Lost revenues	0.75
Fuel expenditures	2.00
Capacity costs	0.75
Variable distribution costs: losses	0.75
Avoided transmission network upgrades	0.05
Avoided distribution network upgrades	0.10
Net lost revenues	**-2.90**

Implementing DSM programmes in domestic consumers will lead to net lost revenue of Rs. 0.15/kWh to the vertically integrated electricity utility (Table 6.10). If considering the DSM programme cost as Rs. 1.0/kWh and the utility share the 50% of the cost of the programme, the net lost revenue further increases to Rs. 0.65/kWh. But, if the saved electricity is further sold to industrial, this may lead to a profitable situation for the utility.

The utility in long-term may accrue highest net revenue losses of Rs. 1.35/kWh by floating DSM programmes in industrial and commercial consumers (Table 6.11). Assuming Rs. 0.5/kWh as cost of DSM programme incurred to the utility, the net revenue loss further increases to Rs. 1.85/kWh for the utility.

Implementing DSM in agriculture consumers will lead to a net profit of Rs. 2.90/kWh to the utility (Table 6.12). Assuming Rs. 0.5/kWh as cost of DSM programme incurred to the utility, the net profit becomes Rs. 1.40/kWh. If the saved electricity is diverted to industrial or domestic consumers, this will further lead to overall profits to the utility.

6.4.3 Implication of Quantitative Analysis

1. Typically the results are better for Discoms than for vertically integrated companies, particularly, if the short-term perspective is relevant. The highest net lost revenue is experienced by vertically integrated utility, particularly in the short-term perspective.
2. Typically, both types of electricity utilities are better off by performing the DSM in agriculture consumers. The profits are further increased if someone else runs (pays) the DSM programme.
3. Typically, both types of electricity utilities face a net loss by performing DSM in industrial and commercial consumers. The losses are further increased if someone else (ESCOs) performs DSM.
4. A positive economic result is possible, in long-term perspective for vertically integrated utilities.
5. It is always better for an electricity utility to do it by itself than to let someone else do it, because then the utility only has the net lost revenues, but not the profit from the service.
6. This result holds, unless a special situation is providing higher avoided costs (e.g., avoided network upgrades), or a policy mechanism is providing, e.g., a co-funding of DSM costs, or the allowance to increase prices (e.g., through a better alignment of allowed revenues with cost drivers, which is valid as in case of regulated electricity utilities in India).

6.5 INSTITUTIONAL FRAMEWORK

DSM programme implementation involves the use of appropriate marketing strategies along with technologies. The market penetration of each DSM programme needs an appropriate institutional framework that has capability to encourage consumer participation. Such an institution can act as a coordinator between the consumer, utility and other key players. This section suggests four conceptual institutional frameworks for DSM implementation, which are as follows:

1. DSM Cell within an Existing Institution
2. Creation of a New DSM Cell
3. DSM Cell within Electricity Utility
4. DSM Projects for Existing ESCOs

6.5.1 DSM Cell within an Existing Institution

Under this framework, it is proposed to create an independent DSM cell within an existing institution of the state, but outside the utility framework (Figure 6.1). The DSM cell will receive outside funding and at later stage will also offer commercial services (such as NPC, Chamber of Commerce and Industrial Association). The DSM cell will be responsible for implementation of the DSM programmes and recruit personal with different expertise. During start-up well defined information programmes can be undertaken and at later stages the DSM cell can have its own targets for DSM implementation.

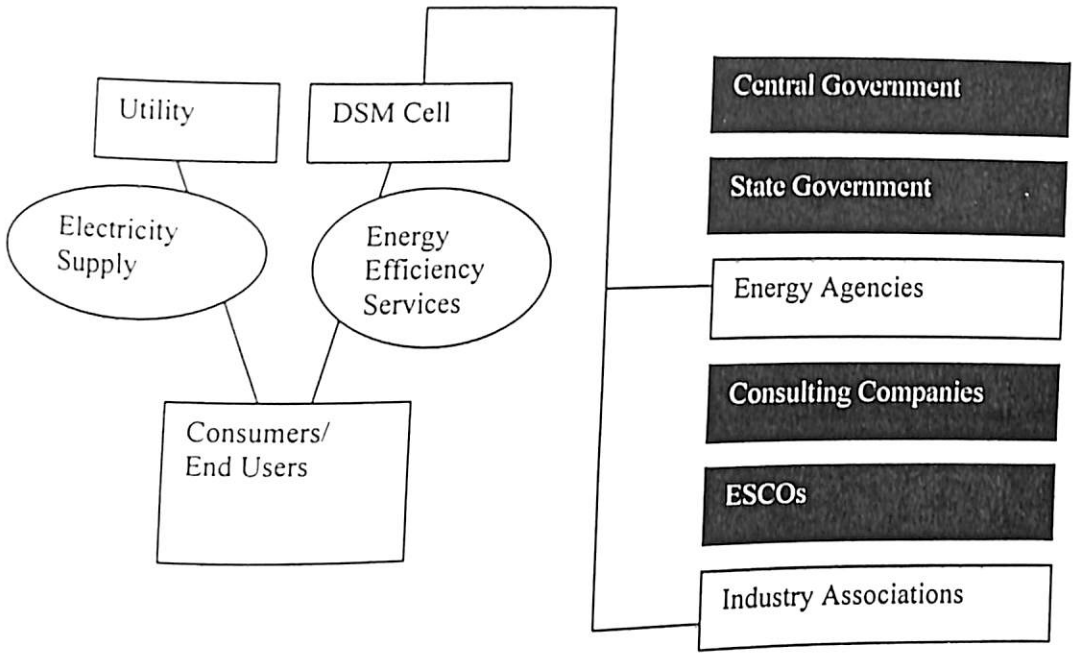

Figure 6.1 DSM Cell within an Existing Institution of the State

Pros.

- Low upfront cost
- Reputation of host institution can be used.
- Comprehensive cost and energy efficiency services can be offered.
- Better representation of the end-users/ consumers interests.

Cons.

- Difficulties in finding host institutions.
- Lack of cooperation with the existing electricity supply companies.
- No specialized DSM attitude and lack of specialized know-how.

6.5.2 Creation of a New DSM Cell

Under this framework, it is proposed to create an independent DSM cell within the state (Figure 6.2). The DSM cell can be represented as a part of a national DSM programme. During the start up period the DSM cell will receive the funding from national or state budgets for general energy awareness activities and cost free energy efficiency services. After the start-up period the cell may provide fee paid consultancy services. At a later stage the cell will also provide ESCO services (such as NPC, Chamber of Commerce and Industrial Association). The DSM cell will be responsible for implementation of the DSM programmes and recruit personal with different expertise.

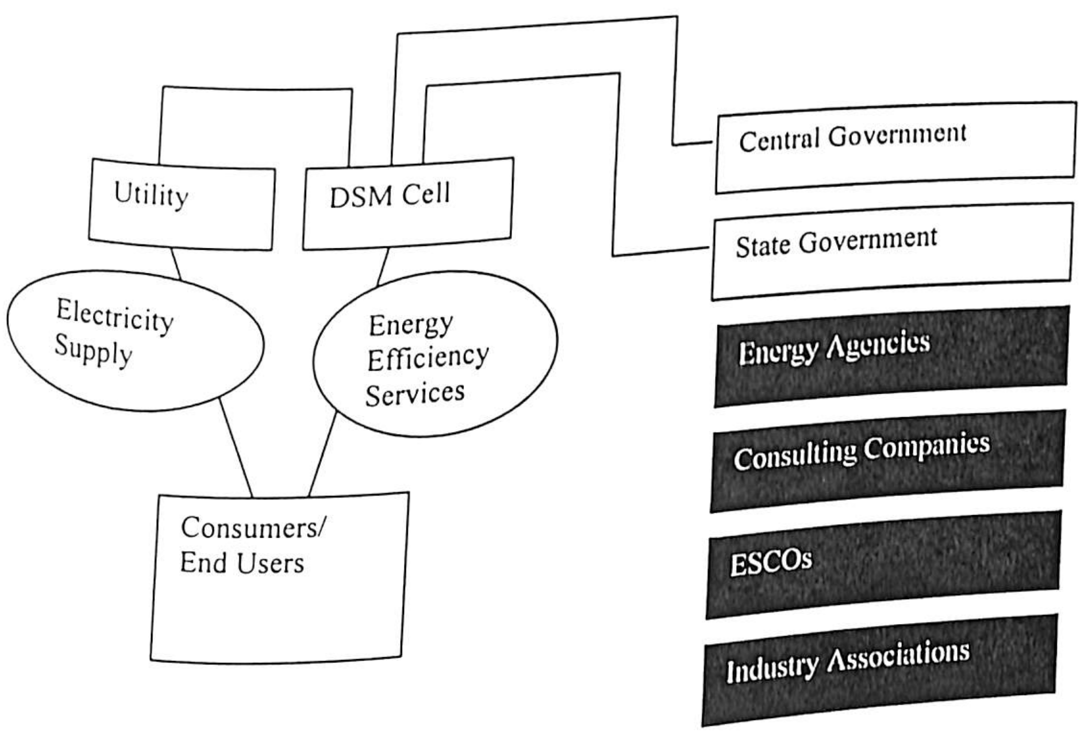

Figure 6.2 Creation of a New DSM Cell

Pros.

- Direct contact with state enterprises
- Creation of a specialised cell with relevant know how
- Easy transfer of experience

Cons.

- Uncertainty regarding commercial services
- Insecure future will not attract qualified personnel
- High cost because of a new operational cell
- Difficulties in hiring or developing experience rapidly.
- Energy companies might not co-operate if losses as a consequence of programmes run by the agency are not avoided through correct price regulation

6.5.3 DSM Cell within Electricity Utility

The DSM cell will be an existing part of electricity utility and most of the energy efficiency services will be financed by the electricity utility (Figure 6.3). The start-up for the DSM cell will be negotiated with the central and state Government. The DSM cell will also develop its own commercial services. The work for DSM cell will be considered as a pilot project for the development of a market for commercial DSM services.

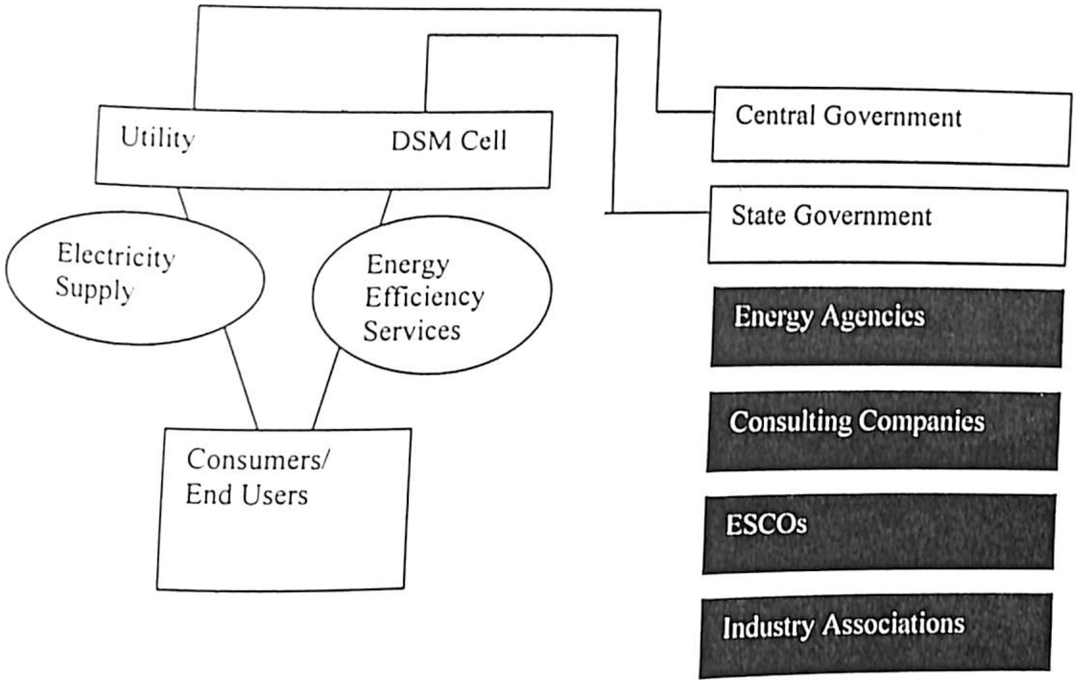

Figure 6.3 DSM Cell within Electricity Utility

Pros.

- It would reduce administrative costs.
- Utilities have direct contact with the customer. It can also collect information on consumer's energy use patterns.
- In some states energy companies already have a considerable experience in delivering DSM to their consumers.
- Tariff aspects can also be included.
- Cut off criteria will be the avoided cost at the utility level.
- DSM measures will be closely coordinated with supply requirements.

Cons.

- Energy companies might see the delivery of energy efficiency to customers as conflicting with their commercial objectives.
- Energy companies have no tradition and experience in energy efficiency.
- Reluctance of consumers to participate in programmes in energy efficiency offered by the utility.

6.5.4 DSM Projects for Existing ESCOs

Under this framework the DSM cell of electricity utility will prepare DSM projects through state funding and call the local ESCOs and consulting companies for its field implementation (Figure 6.4). The DSM cell will also monitor the performance of these field implementations.

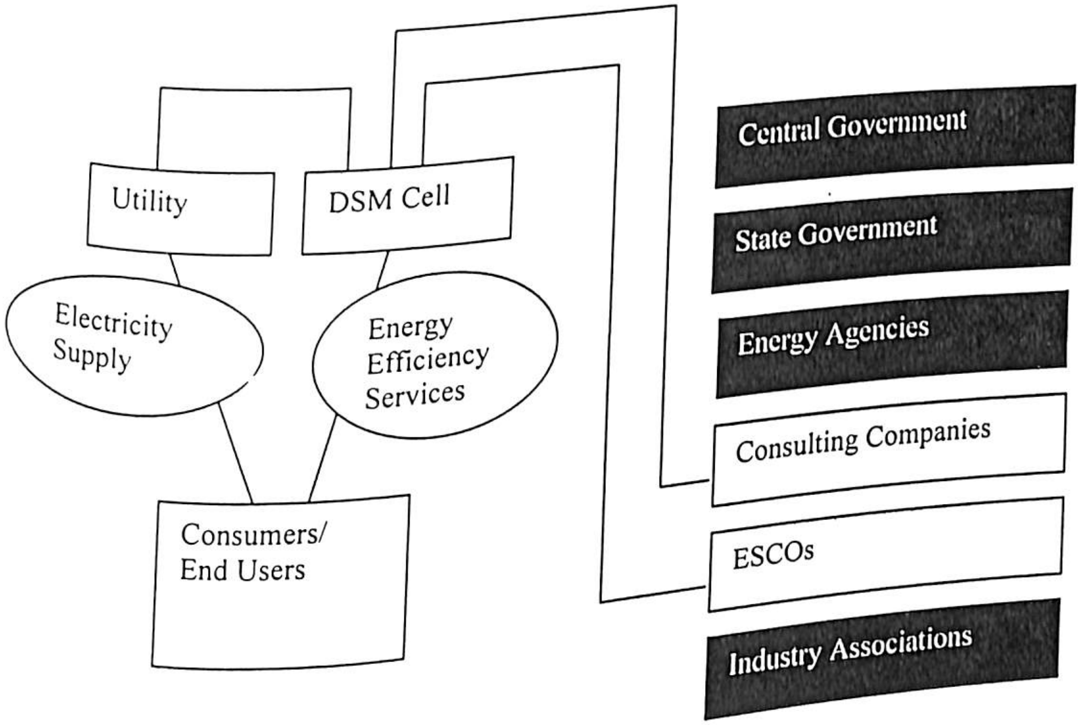

Figure 6.4 DSM Projects for Existing ESCOs

Pros.

- It would reduce programme administrative costs.
- ESCOs will have direct contact with the customer.
- Utility can achieve its desired goals.
- Utility can utilise the marketing experience of ESCOs for better delivery of DSM to their customers.
- Utility can achieve its desired load shape objectives through proper DSM measures

Cons.

- ESCOs may not be interested in delivering DSM to small customers (Domestic and Agriculture) due to small quantum of savings.
- ESCOs may not always install the newest and mostly most efficient equipment.
- Because the ESCO industry is under the developing phase in India, governments have to play an active role to stimulate their activities.

Chapter 7

ASSESSMENT OF DSM IMPLEMENTATION STRATEGIES

7.1 INTRODUCTION

As discussed in previous chapter, there are various barriers for implementing DSM programs in Rajasthan power sector. A range of DSM implementation strategies have come out of our discussions with the utility officials and experts involved in DSM implementation. But, actual DSM implementation involves different actors with conflicting objectives and different implementation strategies with varying implications in effectiveness, cost, feasibility, efficiency and stakeholder acceptance (Metty and Beckwith, 2002; Clarke, 1994). This necessitates a critical analysis of the range of alternative strategies to determine preferred strategy or combination of strategies from specific stakeholder point of view. This chapter evaluates a range of alternative DSM implementation strategies from a multicriteria perspective using the Analytic Hierarchy Process (AHP) method (Saaty, 1990; Hobbs and Maheshwari, 1990).

7.2 DSM IMPLEMENTATION STRATEGIES

A literature review was conducted to identify a range of alternative DSM implementation strategies. The literature review indicated that if all possible criteria and alternative strategies were included in the hierarchy, the number of pair-wise comparisons required would be unmanageable for stakeholder input. The number of evaluation criteria and alternatives strategies needed to be reduced to those that were most important and reflected the problem conception of the stakeholders.

To ensure that the hierarchy criteria and alternatives were meaningful to the stakeholders, in-depth interviews were conducted with representatives of the three stakeholder groups. A semi-structured interview style was chosen because it allows the respondent to speak in his or her own words on the topic of interest and allows the interviewer to adapt the interview to capitalize on the special knowledge, experience or insights of respondents. The purpose of these interviews was to identify any DSM implementation strategies that had failed to emerge from the literature review. Three experts from each stakeholder group were interviewed. Experts selected for interview were officials of Rajasthan Electricity Regulatory Commission (RERC), Transmission Companies (Transco), Distribution companies (Discom), and some independent consultants in the state. Based on extensive literature review and interviews with different stakeholders, eight alternative implementation strategies and six evaluation criteria (Table 7.1) were selected for the final hierarchy design.

7.2.1 Dedicated Funds

Financing energy efficiency equipments/ projects is a major problem in implementing DSM programmes. Utilities, consumers, as well as ESCOs are not having enough funding to invest in such projects. It was suggested to create a dedicated fund by government to finance DSM activities. Such funds can support energy efficiency projects and development of ESCOs in state power sector. Such funds have been created in many countries to promote energy efficiency/DSM programmes. The experience with funds is however mixed with success as well as failure stories. Some of the funds created in developing countries include Energy Saving Fund (ESF) in Czech Republic, Indian Renewable Energy Development Agency (IREDA) Energy Efficiency Fund, Hungary Energy Efficiency Credit Fund (EECF), and Energy Project Special Account (EPSA) in Korea (Painuly et al., 2002).

7.2.2 Public Benefit Charges

As discussed in the chapter 6, the implementation of DSM in certain section of customers poses a threat of revenue loss to the utility. Loss of income through reduced electricity sales may be mitigated if utility have access to funds raised through the public benefits charge to carry out DSM programmes. Recently almost 20 States in the USA have introduced public benefits charges, so that energy companies like SMUD in these States can continue with EE-DSM programmes (Thomas et al., 2000).

7.2.3 Revenue Regulation

Revenue regulation is one more way to overcome the financial disadvantage faced by utilities in promoting DSM. Under revenue regulation, the total allowable revenue of a utility is set each year at a particular rupee figure. Within this revenue cap, the utility is free to set the structure and levels of retail prices in any way it chooses. Any over or under collection of revenue in one year is corrected in determining the allowable revenue for the following year. This strategy has been quite successful in promoting DSM in countries such as the UK, Denmark and Italy (Thomas et al., 2000).

7.2.4 Technical Support

Consumers do not have experience with proven cost effective DSM technologies. As a result they perceive these technologies to be unreliable, particularly if they have not installed the measure. Further they are reluctant to adopt new, innovative technologies due to their performance uncertainties and fear for a possible disruption in routine caused by the implementation of energy efficiency measures (Parikh et al., 1996a; Khanna and Zilberman, 1999). Technical support provided to consumers through pilot demonstration projects can help in building confidence in terms of reliability and performance of these technologies.

7.2.5 Obligation to Perform DSM

Regulators can make it obligatory for utility to promote certain level of DSM. Regulator may negotiate the DSM target with utilities in their tariff approval hearings. Implementation of a proportionate DSM programme can be made a non-bypassable condition for sale of power from central government power plants (NTPC, NHPC) to the state utilities. In Denmark around 700 GWh per year of electricity was saved between 1994 and 1998 through energy companies' DSM activities, e.g., through free energy efficiency audits for industry and commerce, programmes promoting compact fluorescent lamps (CFLs), rebate programmes for Class A refrigerators and freezers (Thomas et al., 2000). The basis for this success were agreements between utilities and government, the legal obligation to perform IRP, the allowance to fund DSM costs via the tariffs, and the "no-profit-no-loss"-principle of Danish electricity price regulation, which allowed the utilities to recover any net lost revenues from the reduction in kWh sales.

7.2.6 Tax Exemption and Incentives

For many customers the electricity bill is a relatively low expense item, and their sensitivity to minor changes (increases or decreases) in the amount they pay for electricity is negligible. On the other hand, tax paid to the government is a more significant expense and seems to attract disproportionately more attention from individuals and businesses (Parikh et. al., 1996a). Any potential to minimise a tax bill usually attracts some interest and it is possible to capitalise on this heightened interest to provide signals promoting investment in energy efficiency. Providing a financial incentive for energy efficiency through the existing tax system can be an effective mechanism for government to financially interact directly with energy end-users as the required administrative framework is already in place.

7.2.7 Promoting through Industry Associations

A consortium approach, particularly in the initial phase can be quite successful in promoting DSM programmes (Reddy and Parikh, 1997). The consortium may consist of representatives from organizations including utilities, IDBI (as financial organization), industry (especially from manufactures of efficient appliances and equipments) and association representatives like Confederation of Indian Industries (CII) and Associate Chambers of Commerce and Industries (ASSOCHAM) appropriate governmental departments and agencies like Bureau of Energy Efficiency (BEE), Energy Management Centre (EMC), and research institutions like TERI, etc.

7.2.8 Promoting through Energy Service Companies (ESCOs)

Many researchers have argued that the ESCOs can play an important role for implementing DSM programmes. They recover the cost from the savings made by consumers on account of these programmes (Vine et al., 1998; Lee et al., 2003). Government can also provide standard business development support to ESCOs in the form of start up grants, subsidies and rebates to encourage the energy performance contracting.

7.3 HIERARCHY DESIGN

The formulation of the decision hierarchy is a critical step in the AHP process. A summary of the AHP method is described in appendix B. AHP involves decomposing the problem into a hierarchy of interrelated decision elements i.e. goal, evaluation criteria and solution alternatives. Figure 7.1 shows a three level hierarchy tree developed for selecting an appropriate DSM strategy. At the top of the hierarchy is the planning goal, which is defined as the "DSM implementation" in present context. The factors that affect the choice of the best strategy are divided in to six generic groups: effectiveness, economic feasibility, compliance flexibility, legal feasibility, potential for market transformation and stakeholder acceptance (Table 7.1). The next layer consists of the solution alternatives under consideration for satisfying the overall decision goal. Eight alternative strategies discussed in section 7.2, were selected as alternatives for the AHP hierarchy. Arranging the goal, criteria and alternatives in this manner allows the decision maker(s) to visualize the complex relationships inherent in the situation and assess the importance of each issue at each level.

Table 7.1 Hierarchy evaluation criteria

Evaluation Criteria	*Definition*
Effectiveness	The ability of the DSM implementation strategy to achieve the goal of DSM implementation
Economic feasibility	The economic impact that the DSM implementation strategy will have on utility business viability
Compliance flexibility	Utility flexibility in adopting the DSM implementation strategy with its existing business activities
Legal feasibility	The need for new or modified laws to implement the strategy
Potential for market transformation	The reduction in market barriers resulting from market intervention, as evidenced by a set of market effects, that lasts after the intervention has been withdrawn, reduced, or changed
Stakeholder acceptance	Acceptability of the DSM implementation strategy to different stakeholders

7.4 SURVEY DESIGN

In order to rank alternative strategies a survey was conducted on the participants of a USAID sponsored one week training program on "Regulatory implementation of IRP/DSM" organized by the Institute of International Education (IIE) at Jaipur and Hydrabad. The program was attended by 20 participants in Jaipur and 20 participants in Hydrabad. There were 18 participants from utilities (mainly Discom), 8 participants from Regulatory commissions and 14 experts from consumer groups. A questionnaire was circulated among the participants to collect their responses on the six evaluation criteria and the eight alternative strategies (see appendix C). In the first section, the participants were asked to give their preferences, assigning 1 to the most preferred strategy and 8 to the least preferred strategy. In second section, the participants were asked to give their weightage on six different evaluation criteria used for evaluation of alternative DSM implementation strategies. The weightages were assigned in terms of VH: Very High, H: High, M: Medium, L: Low, VL: Very Low for the specified criteria. In third section, participants were asked to compare the relative importance of DSM implementation strategies with respect to specified criteria.

7. 5 CRITERIA IMPORTANCE WEIGHING

Survey participants were asked to compare the relative importance of each evaluation criterion when selecting a strategy to meet the goal of DSM implementation. From the individual participant's importance weights, the average relative importance weights of the evaluation criteria for each group were calculated. The results of the pair-wise comparison for Effectiveness (Eff), Economic feasibility (Eco), Compliance

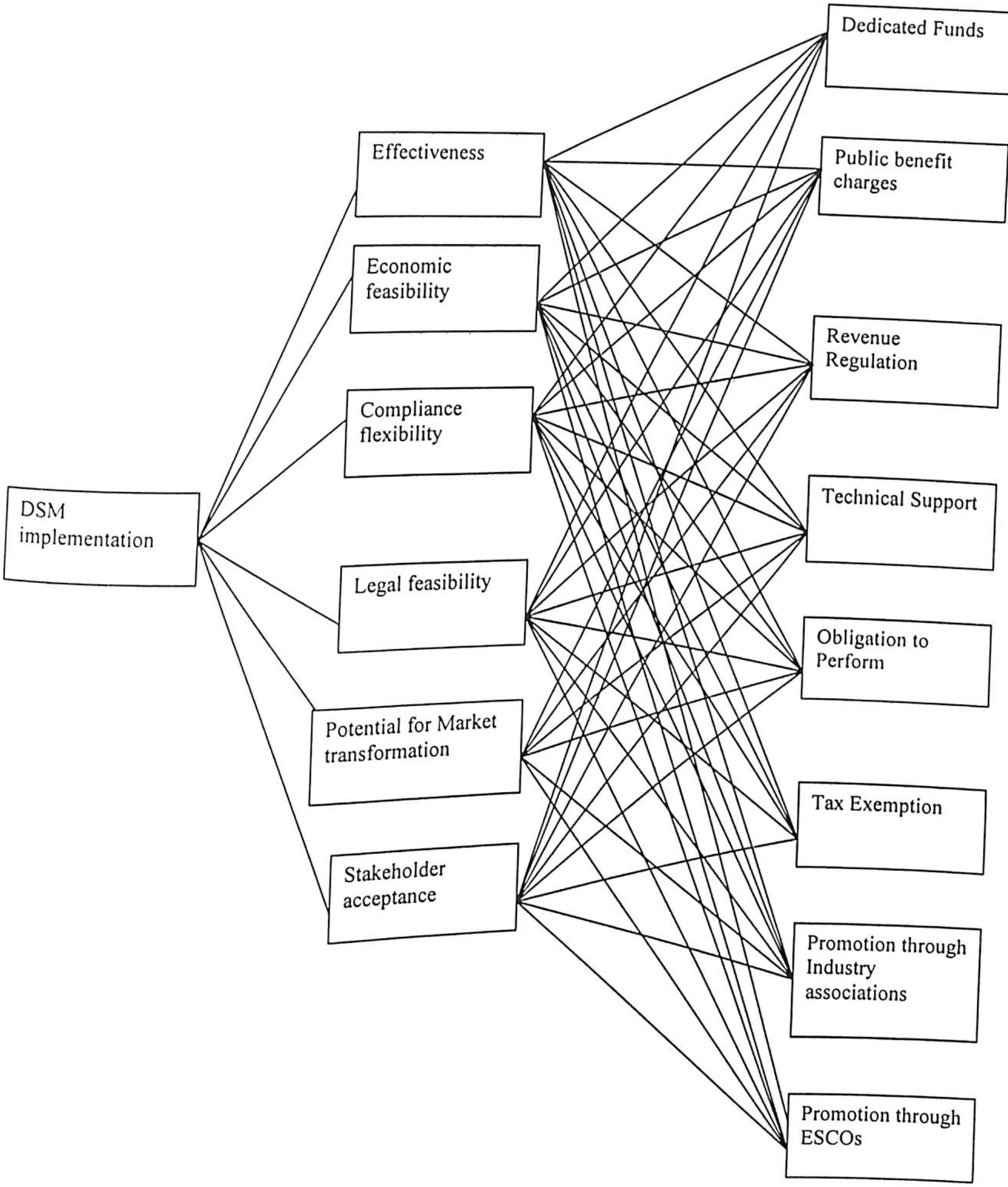

Figure 7.1 Hierarchy tree for selecting appropriate DSM implementation strategy

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7. 5 CRITERIA IMPORTANCE WEIGHING

Survey participants were asked to compare the relative importance of each evaluation criterion when selecting a strategy to meet the goal of DSM implementation. From the individual participant's importance weights, the average relative importance weights of the evaluation criteria for each group were calculated. The results of the pair-wise comparison for Effectiveness (Eff), Economic feasibility (Eco), Compliance flexibility (Comp), Legal feasibility (Leg), Potential for market transformation (Pot) and Stakeholder acceptance (Stake) criteria for utility, regulatory and consumer groups are shown in matrices A, B and C, respectively. The priority vectors generated for the individual stakeholder group from these matrices is presented in Table 7.2.

. The higher the value given to a particular criterion, the greater its perceived importance with respect to the study goal.

$$A = \begin{bmatrix} & Eff & Eco & Comp & Leg & Pot & Stake \\ Ef & 1 & 0.969 & 1.476 & 1.632 & 1.348 & 1.409 \\ Eco & 1.032 & 1 & 1.524 & 1.648 & 1.391 & 1.455 \\ Comp & 0.677 & 0.565 & 1 & 1.105 & 0.913 & 0.955 \\ Leg & 0.613 & 0.594 & 0.905 & 1 & 0.826 & 0.864 \\ Pot & 0.742 & 0.719 & 1.095 & 1.211 & 1 & 1.045 \\ Polt & 0.710 & 0.688 & 1.048 & 1.158 & 0.957 & 1 \end{bmatrix} \text{(Utility group)}$$

$(\lambda_{max} = 6$, N =6, CI=0, RI= 1.24, CR=0)

$$B = \begin{bmatrix} & Eff & Eco & Comp & Leg & Pot & Stake \\ Ef & 1 & 0.800 & 1.091 & 1.333 & 1.500 & 1.714 \\ Eco & 1.250 & 1 & 1.364 & 1.667 & 1.875 & 2.143 \\ Comp & 0.917 & 0.733 & 1 & 1.222 & 1.375 & 1.571 \\ Leg & 0.750 & 0.600 & 0.818 & 1 & 1.125 & 1.286 \\ Pot & 0.667 & 0.533 & 0.727 & 0.889 & 1 & 1.143 \\ Polt & 0.583 & 0.467 & 0.636 & 0.778 & 0.875 & 1 \end{bmatrix} \text{(Regulatory group)}$$

$(\lambda_{max} = 6$, N =6, CI=0, RI= 1.24, CR=0)

$C =$ (Consumer Group)

	Eff	*Eco*	*Comp*	*Leg*	*Pot*	*Stake*
Ef	1	1.043	1.333	1.500	1.143	0.923
Eco	0.958	1	1.278	1.438	1.095	0.885
Comp	0.750	0.783	1	1.125	0.857	0.692
Leg	0.667	0.696	0.889	1	0.752	0.615
Pot	0.675	0.913	1.167	1.313	1	0.808
Polt	1.083	1.130	1.444	1.625	1.238	1

($\lambda_{max} = 6$, N =6, CI=0, RI= 1.24, CR=0)

Table 7.2 Criteria weights for each stakeholder group

Evaluation Criteria	*Utility group weighting*	*Regulators group weighting*	*Consumers group weighting*
Effectiveness	0.209	0.194	0.188
Economic feasibility	0.216	0.242	0.180
Compliance flexibility	0.142	0.177	0.141
Legal feasibility	0.128	0.145	0.125
Potential for market transformation	0.155	0.129	0.164
Stakeholder acceptance	0.149	0.113	0.203
Total	1.000	1.000	1.000

For each stakeholder group, the sum of the priority weights for the criteria is 1. The higher the value given to a particular criterion, the greater is its perceived importance with respect to the study goal. For example, participants from the utility group indicated that the criterion effectiveness (The ability of the DSM implementation strategy to achieve the goal of promoting DSM programmes) was the most important criterion in choosing an alternative DSM implementation strategy.

The representatives from regulatory group also weighted the criteria economic feasibility (0.242) and effectiveness (0.194) as more important than the other criteria. The criteria compliance flexibility (0.177) and legal feasibility (0.145) were given moderate importance, as the respondents from this group are primarily policy advocates whose focus is modifying laws and regulations. Compliance flexibility was also relatively important to this group, receiving a weighting vector of 0.177. This result is consistent with the interview comments by regulators emphasizing the flexibility of the utility in adopting a strategy matching with the existing business objectives.

Of least relative importance to the utility as well as the regulatory group was stakeholder acceptance. This suggests that constrains in adopting the DSM implementation strategy by stakeholders was not as important an evaluation criterion. This was not surprising because many of the experts interviewed from this group said they believed that the utility industry is under the restructuring phase in India and they are likely to get more autonomy in implementing the innovative policy measures to improve the performance of the utility.

As a group, the consumers weighted the evaluation criteria more evenly than either of the other two groups (i.e., low of 0.125 and a high of 0.203). A weight of 0.203 was given to the stakeholder acceptance criterion, followed by effectiveness and economic feasibility. Representatives of this group also mentioned all three of these criteria repeatedly during the discussions. The remaining criteria were weighted relatively equally. These survey results suggest that economic feasibility and effectiveness are slightly more important than the other evaluation criteria considered. It is interesting to note that both the utility and regulators group selected the same criteria as their top two most important evaluation criteria. For both groups, economic feasibility was the most important decision criterion, followed by effectiveness criterion.

It must be remembered that the criteria weights in Table 7.2 demonstrate relative importance and not absolute importance. The fact that a criterion is weighted as having less importance than other criteria in the table does not necessarily mean it has no or very little importance. In fact, given that the evaluation criteria included in the survey were based on those that emerged from the literature and interviews with experts in this strategy selection debate, it is more likely than not that most if not all of the criteria had some importance to each of the stakeholder groups.

7.6 COMPARISON OF ALTERNATIVE STRATEGIES

After determining the relative importance of the six evaluation criteria, the next step was to relate these criteria to the alternative implementation strategies. The participants were asked to provide relative importance on DSM implementation strategies with respect to specified criteria (See appendix C, Section C). The AHP uses an eigenvalue method to produce a vector of composite weights that serve as ratings of decision elements in achieving the problem goal. Pair-wise comparison of alternative strategies, namely dedicated funds (DF), public benefit charges (PBC), revenue regulation (RR), technical support (TS), obligation to perform DSM (OBP), tax exemption and incentives (TI), promoting through industry associations (PIA) and promoting through Energy Service Companies (ESCO) is carried out for all the six criteria and for each stakeholder group. Following these, 18 matrices of 8 x 8 are formulated. A sample pair vise comparison matrix for alternative strategies against the effectiveness criteria computed for consumer group is shown bellow.

	DF	*PBC*	*RR*	*TS*	*OBP*	*TI*	*PIA*	*ESCO*
DF	1	1.471	1.389	1.136	1.316	1.563	1.471	1.562
PBC	0.680	1	0.944	0.773	0.895	1.063	1.000	1.062
RR	0.720	1.059	1	0.818	0.947	1.125	1.059	1.125
TS	0.880	1.294	1.222	1	1.158	1.375	1.294	1.375
OBP	0.760	1.118	1.056	0.864	1	1.188	1.118	1.187
TI	0.640	0.941	0.889	0.727	0.842	1	0.941	1.000
OBP	0.680	1.000	0.944	0.773	0.895	1.063	1	1.062
ESCO	0.640	0.941	0.889	0.727	0.842	1.000	0.941	1

(λ_{max} = 8, N=8, CI=0, RI= 1.41, CR=0)

Corresponding set of priority weights of strategies for all decision making groups with respect to each criterion were computed. Small changes in pair-wise comparison matrix imply small changes in maximum eigenvector value (λ_{max}) of the matrix. It is also necessary to test the consistency because of the varied importance of each hierarchy. Consistency ratios (CR) are computed for the judgments of evaluation as well as on entire hierarchical structure. The consistency ratio of less than 0.1 is acceptable. Consistency ratio is the ratio of Consistency Index (CI) and Average Random Index (RI) where RI is CI for randomly generated reciprocal matrix. For a matrix of size N, Consistency Index is calculated as $CI = (\lambda_{max} - N)/(N - 1)$.

Tables 7.3-7.5 present the preference weights for each of the DSM implementation strategies with respect to each evaluation criterion for each stakeholder group. The highest rated alternative is the one that best meets the evaluation criteria.

The strategy preference value for each alternative strategy was calculated by multiplying each column of alternative priority vectors by the priority value of the corresponding criterion and then adding across each row.

The dedicated funds strategy was the most favored among respondents from utility group. This strategy not surprisingly, was most preferred because of limited availability of capital for investment in DSM programs. The utility group demonstrated a clear preference for this strategy, rating it as the preferred strategy for four of the six evaluation criteria. The only two criteria for which the dedicated funds did not rank highest were legal feasibility and compliance flexibility. With respect to legal feasibility, the utility industry preferred the tax exemption, and in terms of compliance flexibility, the technical support and promotion through ESCOs were given the highest preference.

As shown in Table 7.4, the preferred strategy of the respondents from regulatory group is the technical support strategy. It indicates that consumers do not have enough exposure with proven cost effective DSM technologies. As a result they perceive these technologies to be unreliable. There is a need to provide technical support to consumers through pilot demonstration projects to gain experience and build confidence in terms of reliability and performance of these technologies. The regulators placed second preference to obligation to perform and third preference to tax exemption strategies. This was not surprising because the regulators feel that the major barrier in DSM implementation is not the economic factors. It may be noted that regulators put highest weightage (0.242) to economic feasibility criteria, but overall the strategy preference were given to technical support and obligation to perform. It indicates that regulators perceive that it may be made mandatory to utility to perform certain level of DSM in different sectors.

Like the utility group, the respondents from consumers group also preferred the dedicated funds strategy (0.169). Both the utility group and consumers group preferred the technical support strategy for their second priority.

Sensitivity analyses was conducted for regulatory group who gave less preference to the dedicated funds strategy to determine if changing a group's evaluation of the strategy with respect to one or a combination of the six evaluation criteria would significantly alter the ranking of the strategy. The most critical issues that would need to be addressed to increase the comfort level of these groups with respect to this strategy are legal feasibility, Compliance flexibility and stakeholder acceptance. However, the sensitivity analyses revealed that optimizing this strategy for all three groups would be very difficult. Thus, although the utility and consumer groups preferred this strategy over others, it would have an extremely hard time getting buy-in or support from the regulatory group.

Table 7.3 Utility group strategy preferences

Alternative Strategies	*Evaluation Criteria*						
	Effectiveness	Economic feasibility	Compliance flexibility	Legal feasibility	Potential for market transformation	Stakeholder acceptance	Strategy preference
	0.209	0.216	0.142	0.128	0.155	0.149	
Dedicated funds	0.032	0.031	0.016	0.017	0.023	0.020	0.138
Public benefit charges	0.026	0.027	0.017	0.016	0.021	0.020	0.127
Revenue regulation	0.027	0.025	0.017	0.017	0.017	0.018	0.120
Technical support	0.029	0.029	0.020	0.016	0.020	0.019	0.134
Obligation to perform.	0.025	0.022	0.016	0.017	0.021	0.019	0.121
Tax exemption	0.024	0.028	0.016	0.018	0.019	0.020	0.125
Promotion through Industry associations	0.023	0.03	0.019	0.013	0.019	0.016	0.119
Promotion through ESCOs	0.023	0.025	0.020	0.015	0.015	0.017	0.115

Note: The weights of the evaluation criteria are given below the titles.

Table 7.4 Regulators group strategy preferences

Alternative Strategies	*Evaluation Criteria*						
	Effectiveness	Economic feasibility	Compliance flexibility	Legal feasibility	Potential for market transformation	Stakeholder acceptance	Strategy preference
	0.194	0.242	0.177	0.145	0.129	0.113	
Dedicated funds	0.023	0.03	0.019	0.018	0.017	0.013	0.119
Public benefit charges	0.032	0.03	0.023	0.015	0.017	0.014	0.13
Revenue regulation	0.018	0.042	0.023	0.015	0.013	0.014	0.125
Technical support	0.032	0.039	0.028	0.029	0.023	0.018	0.169
Obligation to perform.	0.027	0.036	0.033	0.022	0.023	0.014	0.155
Tax exemption	0.027	0.03	0.021	0.022	0.017	0.015	0.132
Promotion through Industry associations	0.021	0.024	0.019	0.015	0.013	0.014	0.105
Promotion through ESCOs	0.014	0.012	0.012	0.011	0.007	0.011	0.066

Note: The weights of the evaluation criteria are given below the titles.

Table 7.5 Consumer group strategy preferences

Alternative Strategies	*Evaluation Criteria*						
	Effective-ness	Economic feasibility	Compliance flexibility	Legal feasibility	Potential for market transformation	Stakeholder acceptance	Strategy preference
	0.188	0.180	0.141	0.125	0.164	0.203	
Dedicated funds	0.031	0.034	0.022	0.018	0.029	0.034	0.169
Public benefit charges	0.021	0.020	0.015	0.018	0.021	0.025	0.121
Revenue regulation	0.023	0.018	0.015	0.016	0.018	0.025	0.115
Technical support	0.028	0.029	0.020	0.016	0.020	0.028	0.141
Obligation to perform.	0.024	0.020	0.016	0.016	0.020	0.025	0.121
Tax exemption	0.020	0.018	0.014	0.017	0.022	0.021	0.112
Promotion through Industry associations	0.021	0.023	0.019	0.017	0.017	0.021	0.119
Promotion through ESCOs	0.020	0.019	0.018	0.015	0.017	0.024	0.114

Note: The weights of the evaluation criteria are given below the titles.

preference, respectively. The least preferred strategy was also the same for utility and regulators group. In case of consumers group the AHP results indicated that the promotion through ESCOs followed by the tax exemptions strategies were the least preferred, but the ranking approach had the promotion through ESCOs as least preferred strategy.

The respondents from consumer group almost unanimously ranked the dedicated funds strategy as their most preferred alternative (mean: 1.14; SD: 0.377). Only two respondents did not believe it to be the best strategy, with one ranking it second. Both the AHP and ranking approaches produced the same top two strategy preferences for the consumers group. The two least preferred strategies were different. The AHP calculated the promotion through ESCOs and tax exemption as seventh and eighth in the priority ranking, while the ranking results concluded the opposite.

Strategy rankings among the regulatory group displayed the least consensus. The technical support strategy was the most highly ranked within this group (mean: 2.12; SD: 2.41), though one respondent ranked it as the least preferred. The public benefit charges was the next most preferred strategy (mean: 2.37; SD: 1.76) by the group, but there was relatively little within group agreement on the status of this strategy. Sixty two percent ranked the public benefit charges as the most preferred strategy, 25 percent ranked it second, and 12.5 percent ranked it last. Again the limited size of the group (i.e., eight participants) makes drawing conclusions difficult.

The similarity in strategy preferences of each group using both the multicriteria (i.e., AHP) and ranking approaches indicates that, little if anything of the holistic perspective is lost, if the AHP approach is used. In fact, the AHP offers much more knowledge to the policy analyst than the simpler ranking approach. Finding out which criteria and perceptions of the strategies are driving the strategy preferences within each stakeholder group gives the analyst greater insight into the ways to resolve differences between the groups.

Certain DSM implementation strategies under consideration in this study were not popular with any of the three stakeholder groups. In particular, the promotion through ESCOs scored poorly with respect to all the criteria across the three stakeholder groups. This strategy would help in better marketing and field installation of energy efficiency devices. This strategy was the least preferred among the utility and the regulatory group and is ranked second to last among consumer group. Although this strategy appear to be a viable solution for actual marketing and field implementation of energy efficiency devices, but presently the ESCO market in India is not fully developed. Further the major saving potential exists in the agriculture and domestic sectors where this strategy may not be successful.

Certain DSM implementation strategies under consideration in this study were highly popular with all the three stakeholder groups. In particular, the dedicated funds strategy consistently scored high priority with respect to all the criteria across the three stakeholder groups. The main advantage of this strategy is that it can easily be adapted, for example the distribution process of the funds can be easily changed if the performance of utility is not satisfactory. There are also a number of drawbacks associated with this strategy: it does not contribute significantly to transform the utility into providers of energy efficiency services; its implementation might imply high transaction costs, for example for tendering and application procedures; it usually requires the establishment of new institutions or new functions in existing institutions.

Table 7.6 Comparison of AHP and ranking approaches

	Utility		*Regulators*		*Consumers*	
	AHP	Ranking	AHP	Ranking	AHP	Ranking
Most preferred	Dedicated funds	Dedicated funds	Technical support	Technical support	Dedicated funds	Dedicated funds
	Technical support	Technical support	Obligation to perform.	Public benefit charges	Technical support	Technical support
	Public benefit charges	Revenue regulation	Tax exemptions	Obligation to perform	Public benefit charges	Obligation to perform
	Tax exemptions	Public benefit charges	Public benefit charges	Tax exemptions	Obligation to perform.	Revenue regulation
	Obligation to perform.	Obligation to perform	Revenue regulation	Dedicated funds	Promotion through industry associations	Public benefit charges
	Revenue regulation	Tax exemptions	Dedicated funds	Promotion through Industry associations	Revenue regulation	Promotion through Industry associations
	Promotion through Industry associations	Promotion through Industry associations	Promotion through Industry associations	Revenue regulation	Promotion through ESCOs	Tax exemptions
Least preferred	Promotion through ESCOs	Promotion through ESCOs	Promotion through ESCOs	Promotion through ESCOs	Tax exemptions	Promotion through ESCOs

Chapter 8

CONCLUSIONS AND RECOMMENDATIONS

8.1 CONCLUSIONS

In this study the potential for different DSM programmes have been estimated using an end-use forecasting model, LEAP. The model has been applied for a utility in the state of Rajasthan in northern India. Five scenarios have been built by assuming different combinations of technological options, such as, DSM, T&D loss reduction, renewable energy power generation, etc. The ability of these scenarios for deferring the new capacity additions has been illustrated and the extent of benefits has been quantified in terms energy, peak demand, capacity requirements, environmental emissions and system cost reductions.

Despite the large energy saving potential and clear economic benefits, utility face a number of barriers in implementing DSM. An attempt has been made to identify the major barriers for DSM implementation. For this purpose, a series of in-depth interviews have been conducted with the top utility officials and experts. The financial impact of DSM activities on the utility has been analysed in the short run and long run perspective. Two different types of electricity industry structures, namely unbundled electricity distribution utility (Discom) purchasing electricity from power pool and a vertically integrated electricity utility, generating its own power, having its own transmission network and its own distribution network have been analysed. A questionnaire based survey has also been conducted to evaluate a range of DSM implementation strategies from the perspectives of different stakeholders.

The major conclusions drawn from the study are presented in three parts, namely, major issues in Rajasthan power sector, assessment of DSM potential, and barriers and implementation strategies for DSM.

8.1.1 Major Issues in Rajasthan Power Sector

1. Analysis of technical and financial performance of Rajasthan power shows that low technical efficiency, high supply cost and uneconomic prices of electricity are the principal reasons for heavy losses in the utility. The average cost of supply is higher as compared to average tariff (Tables 3.5 and 3.6). Higher tariff in industrial and commercial sectors has gradually shifted these consumers towards captive generation. Consequently the losses to the utility have considerably increased in recent years.
2. The level of subsidy as a percentage of revenue has increased from 31 % in 1993-94 to almost 66 % in year 2001-02 (Figure 3.5). This has led the utility into a financial crisis. The inadequate capital has hampered the revamping and augmentation of the existing power system.
3. The average cost composition shows that fuel cost constitute about 64 % of the total cost and interest on borrowed capital is huge and it adds to almost 19 % (Figure 3.3). The higher interest on the borrowed capital has led to increase in the unit cost of electricity generation.

Faster growth in domestic and agriculture consumers and inadequate planning for capacity addition is expected to increase the gap between the electricity demand and supply. Thus study suggests DSM as a best alternative for easing the imminent energy crises.

8.1.2 DSM Potential

1. The study has examined a number of DSM programmes for Rajasthan power sector. The analysis shows that the CFL programme is highly attractive to the utility, as the cost of saved energy and cost of saved capacity is minimum for this programme i.e. Rs. 0.20 / kWh and Rs. 5,100 /kW respectively (Table 4.16).
2. In the reference scenario, results from the LEAP model reveal that the total energy and peak demand are expected to increase up to 50,301 GWh and 8,203 MW respectively in the year 2012 (Table 4.17). The capacity requirements are expected to increase to 10,853 MW. This will need a cumulative total capital expenditure of about Rs. 251.9 billion (in present value).
3. DSM, T&D and IRP scenarios results in a reduced energy demand of 2,910 GWh, 2,585 GWh, and 5,495 GWh respectively, peak demand is reduced by 692 MW, 421 MW, and 1102 MW respectively, the cumulative system cost savings of Rs. 7.0 billion, Rs. 4.2 billion, and Rs. 7.3 billion respectively by the year 2012 (Fig 4.5-4.16). .
4. In spite of higher capacity requirements in RET scenario, the overall system planning cost for the plan period is lower, because the running costs of the renewable energy based power plants (Wind and ISCC) is significantly lower than

the conventional candidate power plants. This scenario also results in considerable reduction in CO_2 emissions.

The results of the study suggest that all the technological options such as DSM, T&D loss reduction renewable energy based power generation, should be attempted simultaneously. Investments in these options costs are far less than the increasing costs of electricity supply. There is thus a real basis for consideration of these options for international funding.

8.1.3 Barriers and Implementation Strategies

1. In-depth interview with the top utility officials and experts clearly reveal that lack of planning, institutional barriers, lack of expertise, non scientific tariff, lack of incentives to utility, lack of essential information to end-users, severe capital shortages, high price of energy efficient equipments, mistrust between consumers and utility, and perception of risk are the major barriers in DSM implementation in Rajasthan power sector (Table 5.1).
2. Present tariff does not provide appropriate signals to consumer for shifting towards conservation. Thus there is a need for tariff reforms to improve prospects of DSM.
3. Consumers do not have enough experience with proven cost effective energy-efficiency technologies. As a result the end-users perceive energy efficiency technologies to be unreliable, particularly, if they have not installed the technology measure. There is a need to develop pilot demonstration projects to build confidence of consumers in terms of reliability and performance of energy efficiency technologies.

4. The financial impact analysis of DSM implementation on different actors shows that performing DSM through Discom is better than for vertically integrated utility. The higher net lost revenue is experienced by vertically integrated utilities, while the lower net lost revenue is experienced by the Discoms. Typically, all the energy companies are better off by performing the DSM in agriculture sector.
5. Energy performance contracting through ESCOs is suggested as a viable alternative to implement DSM programmes. However, since the ESCO industry is under developing phase in India, governments have to play an active role to stimulate their activities.
6. The study identified eight different strategies for DSM implementation, which include: dedicated funds, public benefit charges, revenue regulation, technical support, obligation to perform DSM, tax exemption and incentives, promoting through industry associations, and promoting through energy service companies (ESCOs).
7. These strategies were evaluated with reference to different criteria that include: effectiveness, economic feasibility, compliance flexibility, legal feasibility, potential for market transformation, stakeholder acceptance. Dedicated funds and technical support have been found to be most preferred strategies among all the stakeholders.
8. Currently there is no central agency to develop an integrated resource plan at state level.The state government should form a separate group under it's planning wing to conduct such feasibility studies.

There is a need to set up new policy initiatives, minimum energy-efficiency standards, regulations, etc. to promote the DSM in the state. Therefore, it is highly imperative to formulate a comprehensive package of measures for raising the efficiency in all spheres of electricity use within a closely co-ordinated framework.

8.2 RECOMMENDATIONS

1. There is a need to set up new policy initiatives, minimum energy-efficiency standards, regulations, etc. to promote the DSM. Therefore, it is highly imperative to formulate a comprehensive package of measures for raising the efficiency in all spheres of electricity use within a closely co-ordinated framework.
2. It is imperative that the government, utility and regulators should work together to frame a national directive on DSM implementation. Without such co-operation, it is unlikely that any meaningful headway can be made.
3. If utilities are made to invest in DSM programmes, there must be incentives to do so. The regulators should investigate ways of ensuring that these incentives can be offered. The regulators should also facilitate the creation of a culture within the electricity utility that regard DSM as a public good yielding benefit to the society.
4. Experience of Indian electricity utilities in undertaking DSM programmes is very limited. As the electricity industry moves towards being restructured, Discoms should continue to gain experience and build new human capacity in this area.
5. Demonstration through pilot projects should be undertaken by the utility to show the social benefits associated with DSM programmes on a project by project basis.

6. Serious considerations should be given to the establishment of financing and/or other regulatory mechanisms that allow utility to recover cost and/or make a profit from DSM investments.

8.3 FUTURE SCOPE OF WORK

1. In the present study, an assessment of the economic and environmental implications of DSM programmes related to Rajasthan power sector, has been carried out. There is a need to conduct similar studies in other states to generalise the results. This will help the policy makers to frame a national DSM plan.
2. DSM has been applied in the electricity sector only. The DSM strategies can be applied in other sectors such as: transport sector, cooking sector etc. For example, in transport sector DSM can be applied by the strategies such as, replacing the old inefficient vehicles by energy efficient vehicles or by switching from one mode of transport to other mode.
3. Though the final results of the analysis show great benefits of DSM implementation in terms of energy and environmental savings, these savings are very sensitive to the time of use of equipments. Hence, it is suggested that a detailed analysis should be carried out to incorporate the impact of DSM on the daily load profile of the utility.
4. DSM options such as, time of use rates/ differential tariffs in different consumer categories may also be included in further studies.

It is expected that the study findings would assist in the formulation of one or more versions of a more fully elaborated DSM planning and implementation.

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APPENDIX -A

LIST OF EXPERTS INTERVIEWED FOR THE STUDY

Interviewee	*Number of interviews*
Secretary, Department of Energy, Government of Rajasthan	1
Secretary, Rajasthan Energy Regulatory Commission, Government of Rajasthan	1
Deputy Secretary, Rajasthan Energy Regulatory Commission, Government of Rajasthan	1
Member, Rajasthan Energy Regulatory Commission, Government of Rajasthan	1
Consultant, Rajasthan Energy Regulatory Commission, Government of Rajasthan	1
Superintendent Engineer, Transmission Company, Jaipur.	1
Superintendent Engineer, DSM Cell, Jaipur Discom, Jaipur.	1
Executive Engineer, DSM Cell, Jaipur Discom, Jaipur.	1
Assistant Engineer, DSM Cell, Jaipur Discom, Jaipur.	1
Engineer, DSM Cell, Jaipur Discom, Jaipur.	4
Director, Consumers Unity Savings Trust (CUTS), Jaipur	1
Consultant, Rajasthan Chambers of Commerce and Industries, Jaipur	1
Consultant, Advent Associates Jaipur	1
Assistant Director I, Central Electricity Authority, New Delhi	1
Chief Engineer, Central Electricity Authority, New Delhi	1
Sr. Manager, NHPC Ltd.	1
Asstt. Engineer, Rajasthan Vidyut Prasaran Nigam, Jaipur	1
Total	**20**

A SUMMARY OF AHP METHODOLOGY

The analytic hierarchy process (AHP) introduced by Saaty [1] is a structured approach for dealing with complicated multi-attribute decision problems.

Assume that n probabilistic phrases are being considered by a group of experts. The goal is to provide judgment on the relative weight of these probabilistic phrases. The following is a method of deriving, from relative values associated with pairs of phrases, a set of weights to be associated with individual probabilistic phrases.

Let $c_1, c_2, \ldots, c_n$ be the set of n phrases. The quantified judgments on pairs of phrases $c_i; c_j$ are represented by an n×n matrix:

$$A = (a_{ij}) \quad (i, j = 1, 2, 3 \ldots, n)$$

If c_i is judged to be equally probable as c_j, then $a_{ij} = 1$

If c_i is judged to be more probable than c_j, then $a_{ij} > 1$

If c_i is judged to be less probable than c_j, then $a_{ij} < 1$

$$a_{ij} = 1/a_{ji} \qquad a_{ij} \neq 0$$

Thus the matrix is a reciprocal matrix (the entry a_{ij} is the inverse of the entry a_{ji})

a_{ij} reflects the relative probability of c_i compared with phrase c_j

$a_{12} = 1.25$ indicates that c_1 is 1.25 times as probable as c_2

The vector which represents the priorities of the n phrases can be found by computing the normalized eigenvector corresponding to the maximum eigenvalue of the pairwise comparison matrix A. An eigenvalue of the matrix A is defined as λ which satisfies the following matrix equation: $Aw = \lambda w$

λ is a constant which is called the eigenvalue associated with a given eigenvector w.

... that the eigenvector which indicates the priorities of n phrases is the one associated with the maximum eigenvalue (λ_{max}) of the matrix A. Since the sum of the weights should sum to I, the normalized eigenvector is used. Saaty suggests a measure of consistency for the pairwise comparisons. When the judgments are perfectly consistent, the maximum eigenvalue λ should equal n, the number of phrases that are compared. In general, the responses will not be perfectly consistent, implying that the maximum eigenvalue is greater than n. The larger this eigenvalue, the greater the amount of inconsistency. The deviation from consistency which is called consistency index (CI) is represented by .$(\lambda_{max}-n)/(n-1)$. Next, the following random index (RI) table for matrices of order 1-10 using a sample size of 100 is used to generate a consistency ratio (CR), which is the ratio of CI to the average RI for the same order matrix. A CI of 0.10 or less is considered acceptable.

N	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*
R.I.	0	0	.58	.90	1.12	1.32	1.41	1.45	1.49	1.51

QUESTIONNAIRE

Your Name:
Designation:
E-mail:

Organization:
Phone/Fax:

Section A:

Ranking of Alternative DSM Implementation Strategies

Please rank the following eight DSM implementation strategies, assigning 1 to your most preferred strategy and 8 to your least preferred strategy. Please assign a different number between 1and 8 to each strategy, using all numbers:

Alternative strategy	**Preference Rank**
Dedicated funds	______
Public benefit charges	______
Revenue regulation	______
Technical support	______
Obligation to perform	______
Tax exemption	______
Promotion through Industry associations	______
Promotion through ESCOs	______

Section B:

Criteria Importance Weighting

For selecting an appropriate DSM implementation strategy following criteria are being considered. Please indicate the priorities you would like to assign to the criteria mentioned below. Please mark a tick (√) against each of the rows as per your judgment. **Legend: VH:** Very High, **H:** High, **M:** Medium, **L:** Low, **VL:** Very Low

Criteria	***Importance Level as per your Judgment***				
	VH	*VH*	*VH*	*VH*	*VH*
Effectiveness					
Economic feasibility					
Compliance flexibility					
Legal feasibility					
Potential for market transformation					
Stakeholder acceptance					

LIST OF PUBLICATIONS

JOURNAL

- **Vashishtha**, S. and Ramachandran, M. "Planning for Demand Side Management Programs in Indian Utilities- A case study of Rajasthan". Pacific and Asian Journal of Energy. 2003; 13(1): 25-36.
- **Vashishtha**, S. and Ramachandran, M. "DSM plan for residential sector in Rajasthan". Bulletin on energy efficiency. Winrock International, 2003; 3 (4): 18-21
- **Vashishtha**, S. and Ramachandran, M. "Policy Scenarios for Demand Side Management Programs in Rajasthan". International Journal for Global Energy Issues. 2003; 20 (2): 155-167
- **Vashishtha**, S. and Ramachandran, M. "Multicriteria evaluation of DSM implementation strategies in Indian power sector". Energy. [Accepted for Publication]
- **Vashishtha**, S. and Ramachandran, M. "Problems and Prospects in Restructured Indian Electricity Utilities: A case of Rajasthan" Resources and Sustainable Development. [Communicated]
- **Vashishtha**, S. and Ramachandran, M. "Barriers and Implementation Strategies for Demand Side Management (DSM) Programmes in Indian Electricity Utilities: A case of Rajasthan Power Sector ". Utilities Policy. [Communicated]

CONFERENCE AND SEMINAR PROCEEDINGS

- **Vashishtha**, S. and Ramachandran, M "Barriers and Implementation Strategies for DSM Programmes in Restructured Indian Electricity Scenario: A case of Rajasthan power sector. International conference on Electricity Supply Industry in Transition: Issues and Prospects. 14-16 January, 2004. Asian Institute of Technology, Bangkok, Thailand. PP 15-90
- **Vashishtha**, S. Naresh Kamra and Ramachandran, M. "Awareness ,Barriers and Implementability of DSM Option in Industrial Sector of Rajasthan.". International conference on Energy and Environmental Technologies for Sustainable Development 8-11 October, 2003. Malviya National Institute of Technology, Jaipur. PP:97-103
- **Vashishtha**, S. and Ramachandran, M. "Demand Side Management Plan for Residential Sector in Rajasthan.". National renewable energy convention and International conference on new millennium- alternative energy solution for sustainable development. 17-19 January, 2003. PSG Institute of Technology Coimbtore.
- **Vashishtha**, S. and Ramachandran, M. "Planning for DSM programs in Rajasthan power sector" Inaugural lecture presented in Energy conservation week in Jaipur Vidyut Vitran Nigam, Jaipur. 9th February, 2003.

- **Vashishtha**, S. and Ramachandran, M. "Integrating Renewable Energy Technologies in Power Sector Planning in India". International Conference on Renewable Energy Technologies Planning Commercialization and Financing in India. 18-20 January 2001. Mrs Halena Kaushik Women's College Malsisar.Jhunjhunu. Rajasthan. India. Sponsored by Pace University USA.
- **Vashishtha**, S. and Ramachandran, M. "Demand Side Management in restructured Indian electricity market". National seminar on economics of development in power sector in developing nations. 24-25 November, 2001.Institution of engineers (India) Nagpur local center. PP: 2/19-2/24

BRIEF BIOGRAPHY OF THE CANDIDATE

Sanjay Vashishtha

Sanjay Vashishtha is a graduate in Mechanical Engineering and has done masters degree in Energy Management. He working as Lecturer in Mechanical Engineering Department in Birla Institute of Technology and Science Pilani, since last five years. He has s conducted a number of training programmes to professionals in India and abroad in the area of renewable energy, energy conservation and demand side management. He has been a consultant with World Bank/ USAID for implementing Demand Side Management in Indian utilities..

BRIEF BIOGRAPHY OF THE SUPERVISOR

Prof. M. Ramachandran

Prof. M. Ramachandran, did his Ph.D. in Renewable Energy Management from the Indian Institute of Science, Bangalore. He served the Renewable Energy field in India in various capacities for the past two decades. He set up the Centre for Renewable Energy and Environment Development (CREED) at BITS, Pilani for implementing sponsored projects in Renewable Energy and also developed courses in Renewable Energy, Energy Efficiency and Technology Management and supervised several student projects in these areas. Presently, he is the Director of the BITS, Pilani-Dubai Centre at Dubai, UAE.