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Energy Conservation and Commercialization in Gujarat

REPORT ON DEMAND SIDE MANAGEMENT (DSM) IN GUJARAT

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Energy Conservation and Commercialization (ECO)-III Project

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Abbreviations

APS	Agriculture Pumping System
AUFLS	Automatic Under Frequency Load Shedding
BEE	Bureau of Energy Efficiency
CCE	Cost of Conserved Energy
CCP	Cost of Conserved Peak Capacity
CET	Conventional Energy Technology
CFL	Compact Fluorescent Lamp
DGVCL	Dakshin Gujarat Vij Company Limited
EET	Energy Efficiency Technology
GETCO	Gujarat Energy Transmission Corporation Limited
GHG	Green House Gases
GIDC	Gujarat Industrial Development Corporation
GIPCL	Gujarat Industries Power Corporation Limited
GIS	Geographical Information System
GMDCL	Gujarat Mineral Development Corporation Limited
GPEC	Gujarat Paguthan Energy Corporation Private Limited
GSDP	Gujarat State Domestic Product
GSECL	Gujarat State Electricity Corporation Limited
GUVNL	Gujarat Urga Vikas Nigan Limited
GWh	Giga Watt Hour
HT	High Tension
kWh	Kilo Watt Hour
LT	Low Tension
MGVCL	Madhya Gujarat Vij Company Limited
MW	Mega Watt
NPC	Nuclear Power Corporation
NTPC	National Thermal Power Corporation
PGVCL	Pashchim Gujarat Vij Company Limited
REC	Rural Electrification Corporation
RES	Renewable Energy Sources
SLDC	State Load Dispatch Centre
SSVNL	Sardar Sarovar Vidut Nigam Limited
T & D	Transmission and Distribution
UGVCL	Uttar Gujarat Vij Company Limited

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(Chief of Party)

Executive summary

End-use electricity efficiency improvements offer an inexpensive way to reduce power shortages. In Gujarat, which is a relatively well off industrialized state, the economic potential for cost-effective end-use energy efficiency (EE) improvements could be large enough to eliminate the state's electricity shortages. The present study estimates demand side management (DSM) efficiency improvement potential targeted at (1) short term efficiency improvement (agricultural pump rectification) that can provide immediate relief, and (2) long term efficiency improvement (appliance standards such as AC & refrigerator, new agricultural pumps purchase and pump replacement). The base year is taken as 2006-07.

The methodology includes the calculation of cost of conserved energy (CCE) for each technology. The incremental capital cost is the additional cost of EE technology compared to a conventional technology while the EE technology saves a certain amount of energy every year over a period of its lifetime. Thus, CCE (Rs/kWh) is obtained by dividing the annualized incremental cost (Rs/year) of EE technology by its annual energy savings (kWh/year).

GUVNL catered the maximum peak power shortage of about 3554 MW in the month of November for year 2006-07, while shortage of 3528 MW in the month of March for year 2007-08. Average monthly shortages were 2632 MW for year 2007-08 and 2077 MW for year 2006-07 (WRPC, 2008a & 2008b).

Load shedding data for residential and commercial sector has been collected via telephonic interviews (primary surveys) in more than 30 cities/towns in Gujarat. It has been seen that load shedding in residential and commercial sector of Gujarat is 1.63% for large cities (population above 10 lakhs), 2.3% for medium cities (population between 1 to 10 lakhs) and 10.96% for small towns (population below 1 lakh). There is 8 hours/day of power supply for agricultural sector in Gujarat, while one day/week of power staggering for the industrial sector.

Primary survey was conducted at authorized dealers of various air conditioner (AC) and refrigerator brands to collect their sales data and reports for residential and commercial sectors of Gujarat. Air conditioner sales have increased at 20% per year during the last 5 years in Gujarat and at 30% per annum in Ahmedabad. Refrigerator sales have increased at 9% per annum for Gujarat and at 30% per annum in Ahmedabad during the last 5 years. The share of BEE star rated AC and refrigerators has been picking up since last 2 years, with their share of total sales being 50% and 85% respectively for year 2008-09.

Annual electricity saved by one energy efficient (4 star rated) AC against EE 2-star rated one is 394 kWh in residential sector and 444 kWh in commercial sector, the difference attributed to differential usage patterns. Similarly, annual electricity saved by one energy efficient 4 star rated refrigerator against the non-star rated one is 166 kWh in both the residential and commercial sectors. In this study we evaluate the impact of increased penetration of BEE star rated appliances on electricity savings for entire Gujarat for the next 10 years. These savings result in a CCE (Rs/kWh) of 2.86 for residential ACs, 2.54 for commercial ACs and 0.50 for refrigerators used in residential and commercial sectors at 10% societal discount rate. While CCE (Rs/kWh) is 3.91 for residential ACs, 3.48 for commercial ACs and 2.53 for refrigerators used in residential and commercial sectors at 25% individual discount rate.

In agriculture sector, we focused on small (5 hp) pump sets with three different types of EE measures - new efficient pumps purchased instead of substandard new pumps; rectification of the existing pump set fittings (having low efficiency of water delivery) by replacing pipes and foot valves; and replacement of existing 10 hp substandard pumps by standard 5 hp efficient pumps. The average electricity saved per pump set system per annum work out to be 936 kWh, 444 kWh and 1776 kWh respectively for these three options. These savings result in a CCE of 0.28 Rs/kWh for new pump purchase, 0.76 Rs/kWh for rectified pump and 1.72 Rs/kWh for pump replacement at 25% individual discount rate.

Annual electricity consumption in agriculture sector may vary from season to season due to different cropping patterns, monsoons and irrigation methods adopted by farmers but we have not explicitly considered these analyses in our studies. However using time-series data on power consumption in agriculture sector in our study captures this indirectly.

In this study we evaluate the impact of increased penetration of BEE star rated ACs, refrigerators and efficient agriculture pump sets on electricity savings for entire Gujarat for the next 10 years. The annual energy savings from the selected energy efficient technologies are about 8767 GWh over a period of 10 years, while the estimated peak power savings are about 1814 MW. Agriculture pump sets provide 80% of annual energy savings, while air conditioners provide 14% and refrigerators 6%. The peak power savings contributions are 81%, 15% and 4% respectively.

It is observed that the annual energy saved (GWh) from the selected energy efficiency technologies in future years could remove the energy shortages completely. Also, the peak power saved (MW) from demand side also implies the proportionately lower investment to build new power plants on pro-rata basis.

1. Introduction

Electricity is central to economic development. For Indian economy, the elasticity of electric power growth with respect to GDP growth has been consistently above unity until recently. Indian power sector is coal dominated, which is a domestically abundant resource. This also makes it very greenhouse gas (GHG) emission intensive. India imports over 70 per cent of her oil and almost half of her natural gas requirements. Energy security and high import bills are therefore prime concerns. The rapidly growing Indian economy is vulnerable to disruptions in the supply of energy. The inability of the electricity grid to supply reliable power, particularly to business consumers, has prompted increased use of captive power generation that often uses diesel fuel. These vulnerabilities are being addressed through diversification of energy imports, the development of indigenous energy sources, and, last but not least, reducing the intensity of energy use of the Indian economy. In this report, we focus on ways to stretch the existing electricity supply capacity by making energy use more efficient for the state of Gujarat by taking examples of air-conditioners, refrigerators and agriculture pump-sets. More efficient use of energy thus has the potential to reduce the nation's vulnerability in both the imported fuels and electricity markets.

India's total generation capacity is in excess of 140 GW (MoP, 2007). The central and state governments in India have carried out many legislative and regulatory reforms since the mid-1990s which involve establishment of independent electricity regulatory commissions and increased participation of the private sector in generation and distribution of electricity. As a consequence of these reforms in the electric power sector, and also in the overall economy, the productivity of electricity use has increased since 1991, and electricity use per unit of economic output has remained relatively unchanged since then. Despite these reforms, and the large generation capacity, electricity shortages are endemic throughout the country. There was a power shortage of about 16.2 GW or 15.2% of the peak demand (up to Jan. 2008), and an energy shortage of 54.5 GWh or 9 % of the requirement during the year 2007-2008 (MoP, 2007). Shortages of this magnitude can significantly constrain industrial activity, reduce economic growth, and/or require businesses to utilize more expensive back-up generation. Reduced economic output also means that these businesses pay less tax revenue to governments at all levels. The Indian central and state governments are faced with fiscal deficits that are made worse by the reduced economic growth caused by the lack of electricity service to businesses.

It is noted that an increase in electricity supply could have substantial tax revenue benefit to the government (Sathaye and Roy, 2005). Increasing the supply of electricity would require higher investment in generation of electricity, and possibly for its transmission and distribution. Part of the reason for the electricity shortage, however, is the lack of access to capital for cash-strapped electric utility companies that are unable to generate adequate revenue to cover their costs of supply. Improving end-use electricity efficiency in this context can offer a much less expensive alternative for providing the desired electricity service (Sathaye and Roy, 2005). We use the energy efficiency measures by analyzing the electricity shortage in Gujarat, India's most industrialized state, and estimate the economic benefits to the consumers. We evaluate the role of energy efficiency as a means to reduce and possibly eliminate electricity shortages, reduce vulnerability to disruptions in the energy markets, increase economic output which would thereby increase GUVNL profit. We conclude that the economic benefits of improving end-use efficiency, to consumers, GUVNL and government are sufficiently large to initiate energy efficiency program to reduce current and long-term electricity shortage in the state.

2. Gujarat state's circumstances

The population of the state of Gujarat was 54.8 million on 1 March 2006 (Census of India, 2008). The state accounts for 6.5 % of India's GDP, and for 10 % of its industrial output for year 2006[2]. It has income per capita of Rs. 30,993 in 2005-06[1], which is relatively higher than most other Indian states. The state's fiscal deficit has worsened in the mid-1990s, and as a proportion of the Gross State Domestic Product (GSDP), it increased from 8.41 % in 2000-2001 to12.17 % in 2005-06. The state's overall deficit now stands at 0.08 % of its GSDP, which is low from 0.16% in 1999-2000 (CMIE 2008). The state's average cost of total debt stands at 9.12 % in 2006-07, which is low from 12.1 % in 2001-02 (Finance Department, 2008).

2.1. Electricity supply and generation

The electricity generation and installed capacity in Gujarat as on 31 March, 2007 are shown in Table 1. The state generates maximum electricity by its own state and private sources, and purchases about 15 % of electricity from central sources, the National Thermal Power Corporation (NTPC) and the Nuclear Power Corporation (NPC). The major entities involved in the generation of electricity in the state are GSECL, SSVNL, GMDCL Torrent Power, Essar Power, GPEC and GIPCL and they account for 84 % of the state's total generation. Thermal generation accounts for almost 87 % of the in-state generation.

Table 1: Electricity generation and installed capacity, Gujarat (2006-07)

Type of Generation	Installed Capacity (MW)	Net Generation (GWh)
Thermal (Coal + Gas + Oil)	8405	47991
Hydro	1795	4845
Wind Power (RES)	570.47	454.91
Nuclear	440	2136
Total (Fuel wise)	**11210.47**	**55426.91**
GSECL (State)	5193	25999
SSVNL (State)	1250	3583
GMDCL (State)	250	344
A.E.C./ Torrent Power (PVT)	490	3546
Essar Power (PVT)	515	3330
GPEC (PVT)	655	4341
GIPCL (PVT)	555	3662
NTPC (Center)	1292	8031
NPC (Center)	440	2136
Wind Power (RES)	570.47	454.91
State's share of NTPC/ NPC	**1732**	**10167**
Total (Ownership wise)	**11210.47**	**55426.91**

Source: CEA (2008) and GEDA (2007).

The growth rate of installed capacity in the state has been increasing over the past 17 years at average annual rate of 5.5 % per year (CMIE 2008). State has added thermal power plant of 40 MW at Dhuvaran during 2007-08 and planned to add major thermal power plants during the next few years (2008-09: 75 MW Kutch Lignite, 2009-10: 250 MW Surat Lignite, 2010-11: 500 MW Sikka, 2011-12:

[1] CMIE source (GDP at constant prices, 1999-00 base year)

490 MW Ukai, 2009-10: 374 MW Utran, 2010-11: 351 MW GSEG Hazira, , 22010-11: 702 MW Pipavav, 2008-10: 1147.5 MW Sugen Torrent, 2009-12: 2640 MW Adani Power, 2011-12: 4000 MW Ultra Mega)[2] (CEA 2009).

2.2. Electricity companies and their service area

Gujarat Urja Vikas Nigam Limited (GUVNL) is established as Gujarat Electricity Board (GEB), to generate, purchase, transmit and distribute electric power in Gujarat. GUVNL is bundled into following six subsidiaries:

1. Gujarat State Electricity Corporation Ltd. (GSECL) – Electricity generation company
2. Gujarat Energy Transmission Company Ltd. (GETCO) - Electricity transmission company
3. Uttar Gujarat Vij Company Ltd. (UGVCL) – Distribution company for Northern part of Gujarat
4. Dakshin Gujarat Vij Company Ltd. (DGVCL) - Distribution company for Southern part of Gujarat
5. Paschim Gujarat Vij Company Ltd. (PGVCL) - Distribution company for Western part of Gujarat
6. Madhya Gujarat Vij Company Ltd. (MGVCL) - Distribution company for Central part of Gujarat

GSECL is responsible for electricity generation in Gujarat while GETCO is responsible for electricity transmission in Gujarat (GSECL 2009). UGVCL distributes electricity in 6 districts namely Sabarkantha, Gandhinagar, Ahmedabad, Mehsana, Patan and Banaskantha. Also, it partly covers Kheda, Anand and Surendranagar districts. It covers 67 talukas, 61 towns and 4617 villages (UGVCL 2009). DGVCL distributes electricity in 7 districts namely Bharuch, Narmada, Surat (except part of Surat City), Tapi, Dangs, Navsari and Valsad covering 37 talukas, 28 towns and 3512 villages (DGVCL 2009). PGVCL distributes electricity in 8 districts namely Rajkot, Jamnagar, Junagadh, Porbandar, Bhuj, Bhavnagar, Surendranagar and Amreli covering total 83 talukas (PGVCL 2009). MGVCL distributes electricity in 5 districts namely, Panchmahal, Kheda, Anand, Vadodara and Dang covering 49 talukas and 4426 villages (MGVCL 2009).

Total revenue, profit after tax and subsidies for these electricity companies for year 2006-07 are tabulated in following Table 2. The profit of GSECL in 2006-07 was only 6.5 % higher than that of the previous year. GUVNL profit (after tax) was only 0.2% of its total revenue, which was lower than any other electricity companies in year 2006-07.

Table 2: Total revenue, profit and subsidies for different electricity companies of Gujarat (2006- 07)

Company	Total Revenue excluding subsidy (Rs. Crores)	Profit after tax (Rs. Crores)	Profit as % of revenue	Subsidy given (Rs. Crores)
GUVNL	11985.3	22.94	0.2%	
GSECL	5374.1	75.37	1.4%	
PGVCL	3541.05	17.59	0.5%	474.2
MGVCL	1799.4	16.95	0.9%	85.47
UGVCL	2380.1	17.17	0.7%	594.8
DGVCL	3278.5	20.23	0.6%	83.34
GETCO	667.4	6.86	1%	

[2] 11th National Electricity Plan, CEA, India

Source: GUVNL (2007), GSECL (2007), PGVCL (2008), MGVCL (2008), UGVCL (2007), DGVCL (2007) & GETCO (2006).

Western region state wise system transmission and distribution losses for year 2003-04 and year 2004-05 are tabulated in following Table 3.

Table 3: Western region statewise system T & D losses

State/U.Ts.	2003-04	2004-05
	% T&D losses	
Gujarat	24.2	30.43
Madhya Pradesh	41.44	41.3
Chattisgarh	42.55	28.06
Maharashtra	34.12	32.4
Goa	45.05	35.97
D. & N. Haveli	15.1	16
Daman & Diu	16.88	15.56

Source: CEA (2006) & CEA (2005).

GUVNL reported T & D losses of 30.43% in 2004-05 as compared to 24.2% in the previous year (see Table 3). Part of this increase may be due to more transparent reporting and reallocation of some other sectoral losses into T&D losses. Thus, GUVNL needed to reduce its transmission and distribution losses and increase the revenue for better financial condition and to minimize the investment for new power generation plants in future. The general trend beyond 2004-05 is towards a reduction in year-on-year T&D losses in Gujarat.

2.3. Electricity consumption and revenue

Statewide, the industrial sector accounts for about 40% share of the total electricity consumption, which is followed by the agriculture sector with 27%. Within GUVNL area, agriculture accounts for 36 % as shown in Table 4. The actual revenue realized from the agriculture sector in 2006-07 was only Rs. 0.55 per kWh (Indiastat 2005), which was lower than the average revenue realized by GUVNL for agriculture (Rs. 0.92 per kWh) and the average cost of electricity supply at Rs. 2.87 per kWh. The industrial and commercial customers pay higher rates of electricity compared to the average cost of supply and are cross subsidizing the agricultural and domestic customers (see Table 4). Thus, domestic, agriculture, and public water works consumers enjoy subsidized electricity rates.

Table 4: Consumption of electricity, Gujarat (2006-2007)

Type	Statewide (GWh)	%	GUVNL (GWh)	%	GUVNL average revenue realization (Rs./kWh)
Domestic heat small light and fans	6097	14.68	4555	14.4	2.95
Commercial heat small light and fans	2154	5.28	1499	4.8	4.72
Industrial	15680	37.77	12527	39.7	4.24 (low voltage) 4.10 (High voltage) 4.96 (E. high voltage)
Agriculture	11016	26.54	11477	36.4	0.92
Public Lighting	202	0.48	166	0.5	3.38
Railways Traction	518	1.25	542	1.7	5.11
Public water works	863	2.08	784	2.5	2.8
Others	4983	12	0	0.0	0
Total	**41513**	**100**	**31550**	**100.0**	**2.87**

Source: Indiastat (2008).

2.4. Electricity Shortage

In 2006-07, GUVNL's maximum peak (gross) demand registered was 8538 MW, and the capacity shortages were of the order of 7.06% to 29.53%. The maximum monthly energy shortage was 19.65% and the total energy shortage was 8381 GWh during year 2006-07 (WRPC 2008).

GUVNL is continuously making efforts to reduce its transmission and distribution losses, which would reduce the electricity shortage and the need for additional power capacity to meet the future electricity demand.

3. Approach

In this analysis, we assess the use of energy efficiency measures as a one way to reduce Gujarat's electricity shortage. This necessitates that we first assess the load shed by GUVNL, and then explore category wise cost-effective potential for energy efficiency improvement.

Data was available only at the aggregate level and hence we allocate it by customer categories through telephonic interviews with utility officials of different cities, towns and villages across the state.

Energy efficiency potential and associated costs for selected efficiency measures such as refrigerators, air conditioners and agricultural pump sets are estimated through market surveys. Typically, three types of potentials have been studied in the literature– technical, economic, and market potential. While, market potential defines the actual penetration level of the technology in the market, economic potential defines the penetration potential at an economic cost of the measure without taking into account various types of market failures. Economic potential of the measures is estimated from the consumer perspective, and then added to it the transaction costs that might be incurred to overcome some of the market failures. The adjustments to the economic cost and potential values get us closer to the market potential. Thus, above concepts clarifies that market potential is subset of economic potential which in turn is a subset of technical potential.

We match the energy efficiency potential and the load shed by customer category, and thus established an economic basis for a program to potentially eliminate the shortage. As load is shed in commercial and industrial sector, the electricity saved by implementing the energy efficiency measures can be utilized by these high tariff customers to support their additional load. Thus, it enables businesses to increase their economic output amount and higher economic output would generate additional tax revenue to governments at all levels. Section 4 below describes our estimates of the load shedding by customer category.

4. Analysis of GUVNL load shedding

We need to first understand the distribution of the load shed by GUVNL as the loss due to electricity shortage varies for different consumers, In the case of industrial consumers, a shortage could result in loss of production or require the use of expensive backup power, while in the case of residential consumers a shortage would cause an inconvenience and economic loss as some customers have to invest in inverters. Also, residential customers are forced to rearrange their consumption due to load shedding.

The following section is arranged as follows. Section 4.1 below describes the GUVNL month wise load profile, which illustrates the severity of electricity shortage throughout the year; section 4.2 describes GUVNL's load shedding plan; and finally section 4.3 describes our procedure for the estimation of the load shed by customer category.

4.1. GUVNL month wise load profile

Energy efficiency measures save energy at different times of the day. For example, energy efficient household Refrigerator typically saves energy through out the day and energy efficient household air conditioner saves energy in the noon and in the night. We will benefit more if energy efficiency measures save energy at a time when the load is being shed.

The following figure 1 gives the anticipated month wise load shedding pattern for the year 2008-2009. The vertical gap between GUVNL supply and demand shows the amount of load shed. As seen in the Figure 1, load shedding will be done throughout the year 2008-09 as electricity demand would be higher than its supply. Amount of load to be shed would be highest in month of October, while lowest in August. Any energy saved during the morning (9 am to 4 pm) and evening (7 pm to 10 pm) in any month will help to reduce peak demand. Also, any energy saved during this 10 hour period (9 am to 4 pm & 7 pm to 10 pm) will reduce the shortages (see Appendix 5).

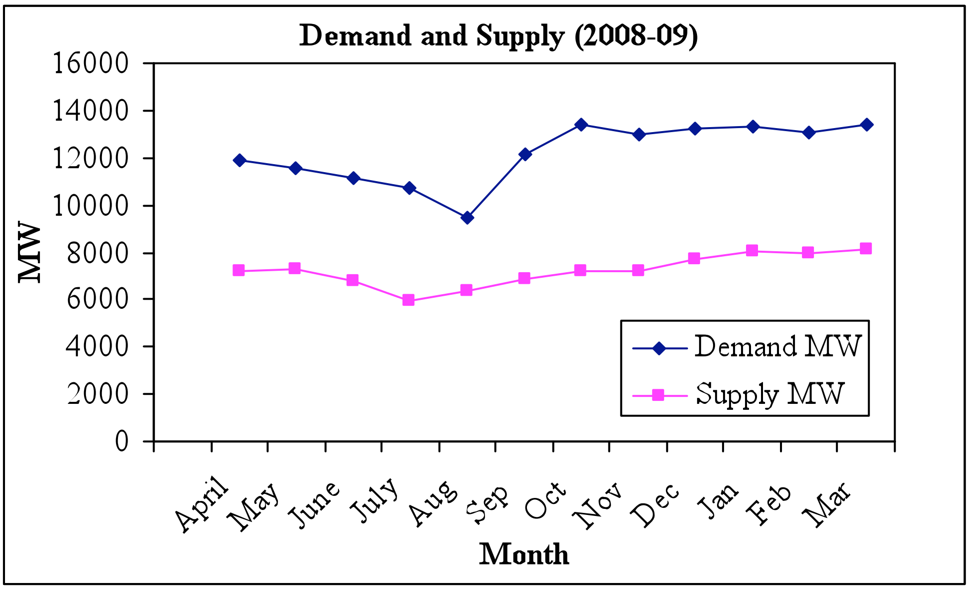

Figure 1: GUVNL system demand and supply, 2008-09 (Anticipated)

Source: CEA (2008b)

4.2. Implementation of GUVNL's load shedding plan

The State Load Dispatch Center (SLDC) at Gotri (Vadodara) is the apex body to ensure integrated operation of the power system in a State. It is responsible for scheduling and dispatch of electricity within a state, in accordance with the distribution licensees or the generating companies operating in the state. It monitors the grid operations, keep accounts of electricity transmitted through the state grid. It exercise supervision and control over the intra-state transmission system; and is responsible for carrying out real time operations for grid control and dispatch of electricity within the State through secure and economic operation of the State grid in accordance with the Grid Standards and the State Grid Code[3]. It also perform the functions of daily generation, load scheduling and issuing dispatch instructions, coordinate with transmission licensee for installation of automatic under frequency load shedding (AUFLS) for automatic tripping of non-critical loads as identified by the distribution licensee and informed to SLDC (GERC 2005).

According to information given by utility officials, SLDC estimates future electricity demand & supply and prepares a load shedding plan. On a given day, SLDC instructs operators of main substations to shed load based on this plan with certain modifications that are based on specific conditions of demand and supply prevailing on that day. Operators at main substations then plan and implement feeder-wise load shedding programs.

Maximum load shedding takes place according to load shed plan. In some cases, the substations are reluctant to implement load shedding programs before the prior notice due to political and social pressures, technical fault and sometime due to weather condition (rain fall etc.). We relied on telephonic interviews with various GUVNL officials and customers of different cities / towns for load shedding information in Gujarat (Refer Appendix 1).

4.3. Estimation of load shedding by customer category

We need to estimate the shed load by customer category, but GUVNL does not collect data by category. Our telephonic interviews with utility officials of different cities in Gujarat towns and villages indicate that some general principles are followed in load shedding to minimize the financial losses to GUVNL. The general principles are as follows:

- Load shedding is generally avoided in residential and commercial sectors of major cities such as Ahmedabad, Surat, and Vadodara as these large cities have high concentration of commercial consumers.
- Although the Gujarat Industrial Development Corporation (GIDC) areas have high concentration of industries, load is shed one day in a week for high tariff and high tension (HT) industrial consumers of GUVNL. Further, commercial consumers pay a high tariff but load shedding for these consumers is difficult to avoid since they are often on the same feeders as residential consumers.
- Generally, majority of the load shedding is being done in rural areas where the load mainly consists of agricultural pumping.

By considering GUVNL's load shedding plan, we estimate the load shedding by different categories of consumers as follows. GUVNL's load shedding plan indicates the per cent load shedding and annual power cut (GWh) in rural as well as urban areas (Table 5). A ratio of urban to rural load to be shed is then worked out from this plan and comes out to be 1:6. This analysis shows that about 86 % of the load is shed in rural areas while the remaining 14 % is in urban areas. Hence, we estimate that out of the total shed load of 8381 GWh in 2006-07, 1,194 GWh was shed in urban areas and 7,188 GWh in rural areas.

[3] SLDC – Gujarat <http://www.sldcguj.com/> & WRLDC (Western Regional Load Dispatch Centre) <http://www.wrldc.com/>

Table 5: GUVNL's load shedding plan (2006-07)

	% Load Shedding (2006-07)	Annual Power Cut (GWh)
Rural Load shedding plan		
Residential and Commercial	13.26	1111
Agricultural Sector	64.67	5420
Industerial Sector	5.6	472
Public water works	1	84
Street lights	1.2	101
Others	0	0
Total Rular	**86**	**7188**
Urban load shedding plan		
Residential and Commercial	1.63	137
Agricultural Sector	2	168
Industerial Sector	8.6	723
Public water works	1	84
Street lights	1	84
Others	0	0
Total Urban	**14**	**1194**
Total Load shed (GWh)	**100**	**8381**

The next step is to estimate the amount of load that is shed by each category of consumer in urban and rural areas. The total shed load is allocated to different categories of consumers on the basis of the consumption subject to load shedding in each category. The consumption subject to load shedding is calculated from the total consumption of each category by making two corrections. First, GIDC consumption is removed from HT and LT industry consumption since GIDC load is shed one day in a week. Next, a certain ratio, assumed based on expert judgment and literature, was applied to this corrected consumption to arrive at the consumption subject to load shedding. For example, for the domestic category, this ratio is 100% indicating that all the domestic consumption is subject to load shedding. For HT industry, this ratio is assumed to be 50% indicating that only half of the non-GIDC HT industry consumption is subject to load shedding. For, total load shed by customer category, first we have found the % load shed for different categories through informal telephonic interviews with customers of different cities/ towns of Gujarat and then allocated load shed by category (GWh) as shown in below Table 6.

Table 6: Consumer category-wise load-shedding allocation (2006-07)

Consumer Category	Consumption (GWh)	Consumption excluding GIDC areas (GWh)	Percentage eligible for load shedding (%)	Consumption Subject to load shedding (GWh)	Load shed by category (GWh)	Load shed by category as % of the total shed load (%)
C1	**C2**	**C3**	**C4**	**C5=C4*C3**	**C6**	**C7**
Urban						
Domestic	3841	3841	100%	3841	110	9%
Commercial	1616	1616	100%	1616	27	2%
L.T. Industry	2466	1875	80%	1500	260	22%
H. T. Industry	7020	5335	50%	2668	463	39%
Agriculture and irrigation	330	330	100%	330	168	14%

Railway	363	363	0%	0	0	0%
Others	2933	2933	50%	1467	168	14%
Total Urban	**18569**	**16293**		**11421**	**1194**	**100%**
Rural						
Domestic	2256	2256	100%	2256	919	13%
Commercial	539	539	100%	539	193	3%
L.T. Industry	805	612	100%	612	109	2%
H. T. Industry	5388	4095	50%	2048	363	5%
Agriculture and irrigation	10686	10686	100%	10686	5420	75%
Railway	155	155	0%	0	0	0%
Others	3115	3115	50%	1557	185	3%
Total Rural	**22944**	**21457**		**17697**	**7188**	**100%**
Total (Rural + Urban)	**41513**	**37750**		**29118**	**8382**	

5. Estimating the cost of energy efficiency measures

The measures that are widely used in each consumer category and likely to have a significant potential for energy efficiency improvement include lighting, refrigeration, air conditioning, water heating, motors, variable speed drives, and agricultural pump sets. In this report, we focus mainly on measures such as refrigeration, air conditioning and agricultural pump sets. Air conditioner is a rapidly rising end use device, where energy efficiency improvement could make a difference. Reason being, its use in the residential as well as commercial sectors is increasing day by day due to increase in per capita income and also due to temperature rise because of climate change. Pump rectification and other measures would provide immediate benefits with a longer-term benefit and enhancement of the supply system reliability.

For the residential as well as commercial sector, we analyze the use of energy efficient refrigerators, and energy efficient air conditioners (Table 8). While in the agricultural sector, we focus on energy efficiency improvements for agricultural pumpsets. In the following discussion we present the methodology used for calculating the cost of conserved energy (CCE), and the cost of conserved peak capacity (CCP).

5.1. Methodology

Table 7 represents the details of formulas used to calculate the CCE and CCP. The first column alphabetizes the row parameters and the last column displays the equation. For example Row C – Equipment life (years) is calculated by dividing equipment life (hours) in row B by usage in hours per year (in row A), and hence the equation for C displays B/A.

The methodology used for calculating the cost of conserved energy and the cost of conserved peak capacity can be described as follows: The additional cost of energy efficient technology (energy efficient technologies) compared to a conventional energy technology (CET) is the incremental capital cost (Row D). This is also the purchase cost or investment needed for improving energy efficiency using that technology. The capacity of energy efficient technologies and CET are chosen in such a way that they have the same useful output (cooling, light, mechanical power, etc.). The energy efficient technologies save a certain amount of energy every year over its lifetime. The cost of conserved energy (CCE) is obtained by dividing the annualized incremental capital cost for the energy technology by the energy saved annually as shown in Row O, and the cost of conserved peak capacity is shown in Row P.

Table 7: Method for calculating the cost of conserved energy (CCE) and capital cost of conserved peak (CCP) capacity

Index	Parameter	Equation
A	Usage (Hours/Yr)	
B	Equipment Life (Hours)	
C	Equipment life (Years)	
D	Incremental Capital Cost (Rs.)	B/A
E	Transaction costs (% of Capital Cost)	
F	Total Investment (Rs.)	D*(1+E)
G	Discount Rate	
H	Capital Recovery Factor (CRF)	G/(1-(1+G)^(-C))
I	Annualized Capital Cost (Rs./Yr)	F*H
J	Load Saving while in operation at end user (watts)	
K	T&D Losses	

Index	Parameter	Equation
L	Annual Energy Saving at the bus bar (kWh/Yr)	J*B/(1-K)
M	Peak Coincidence Factor	
N	Peak Load Saving at the bus bar (Watts)	J*M/(1-K)
O	Cost of Conserved Energy (CCE) (Rs/kWh)	I/L
P	Capital Cost of Conserved Peak Capacity (CCP)	F/N

For example, an 11- 15 W CFL gives the same amount of light output (lumens) as a 60W incandescent lamp[4] (BEE 2009); hence if CFL is used instead of conventional incandescent lamps, 45 – 49 W of power is saved while the CFL is in operation. This power saving will reduce the power shortage, or displace supply side resources if the power is saved at the time when there is no power shortage. A peak coincidence factor is the probability that the energy efficient device will be operating when the system is short of power. Expected load saving is the product of the load saved while in operation and the peak coincidence factor. The cost of peak power saved is calculated by dividing the incremental capital cost by the peak load saving. As there are T & D losses in the system, one unit of energy (or power) saved by the end user saves more than one unit of energy (or power) at the bus bar. This effect is taken into account while calculating the bus bar cost of conserved energy and the cost of conserved peak capacity (Phadke et al., 2005).

5.2. Data and parameter assumptions

The calculation of CCE and CCP requires data on the price, efficiency, and usage of the efficient and conventional technologies. We collected data on retail prices for most of the technologies through telephone and in-person interviews with manufacturers and dealers (wholesale as well as retail dealers, see Appendix 2 & 3 for details on sources of information). Although an individual consumer pays the retail price, large utility or government purchases for efficiency programs are likely to be at the wholesale price. Data on usage and efficiency of these technologies were obtained mainly from manufacturers, dealers, and secondary sources such as reports. In the following section, we describe the data and parameter assumptions separately for each technology considered in this study.

5.2.1. Residential sector

We focus on two end-uses, air conditioning and refrigeration, in this sector. For each end-use, we assess the cost of one representative energy efficient technology. As there were no star rated energy efficient refrigerators and air conditioners in Gujarat market before year 2006-07, we have collected sales data for refrigerator and AC for year 2007-08 and year 2008-09 through market surveys. For refrigeration, we evaluate the use of BEE 4 star rated, energy efficient LG refrigerators, and for air conditioning, the use of BEE 4 star rated, energy efficient LG air conditioners. We collected data on sales, market trends and retail as well as wholesale costs of these technologies during the month of October 2008 through in-person and telephonic interviews with authorized dealers, and manufacturers in the city of Ahmedabad, Gujarat. The data are thus indicative of the technology costs borne by urban dwellers, End-use efficiency and retail market price data for the residential sector are reported in Table 8.

Energy efficient refrigerators

The average electricity consumption of a 190-200 liter direct cool, non star rated (conventional) refrigerator sold in the Indian market is about 1.33 kWh per day (Approx. 486 kWh per year). A commercially available energy efficient, 4 star rated refrigerator (made by LG) consumes about 0.88 kWh per day (320 kWh per year), and costs about Rs. 1000 – 2500 more depending upon the brand of the conventional refrigerator. The higher cost and electricity consumption of a refrigerator are

[4] Bachat Lamp Yojna - CDM based CFL scheme, BEE, India.

consistent with that reported from analysis of specific improvements for a typical refrigerator. We assume an incremental cost of Rs. 2500 for an energy efficient refrigerator. Refrigerators operate continually and cycle throughout the day. A compressor activation rate for Indian refrigerators is 38% (Phadke et. al., 2005). Since the refrigerators cycle operate throughout the day, the peak coincidence factor for refrigerators is equal to the number of hours (10 hours) of power shortage in the day divided by the total number of hours (24 hours) which worked out to be 0.42 (see Appendix 5). The use of an efficient refrigerator results in an annual electricity saving of 166 kWh for residential as well as commercial consumers (see Table 8A & 8B).

Energy efficient air conditioners

The average electricity consumption of non star rated (conventional), 1.5 TR split air conditioner sold in the Indian market is about 2.512 kW/hr. The commercially available energy efficient 4 star, 3 star and 2 star rated air conditioner (made by LG) consume about 1.78, 1.88 and 2.024 kW/hr and retails for split AC is Rs. 2000-10,000 more depending upon the brand and star rating of the conventional split air conditioner. The higher cost and electricity consumption of air conditioner are consistent with that reported from analysis of specific improvements for a typical air conditioner. We assume an incremental cost of Rs.6000 between 4 starred and 2 starred AC, and Rs.8000 between 4 starred and non starred AC. Air conditioners operate continually and cycle for about 6-12 hours in a day except winter season. The compressor activation rate is of 70 - 80 % for Indian air conditioners. Since the air conditioners cycle for 8-12 hours in a day, the peak coincidence factor for air conditioner is taken 0.42 (see Appendix 5). The use of 4 starred energy efficient AC over non starred AC results in the annual electricity saving of 1167 kWh in residential sector and 1312 kWh in the commercial sector (see Table 8B). While, the use of 4 starred EE AC over 2 starred AC results in annual electricity savings of 394 kWh in residential sector and 444 kWh in the commercial sector (see Table 8A).

5.2.2. Commercial sector

For the commercial sector, we consider the same two energy efficiency measures — energy efficient air conditioners and energy efficient refrigerators (Table 8). For these two measures, estimates of incremental capital cost are the same as the residential sector, but estimates of usage are different. Cost estimates, efficiency ratio and assumptions for energy efficient refrigerators and energy efficient air conditioners are same as in the case of residential sector.

Table 8 A: Data on selected energy efficiency measures (baseline of 2 star rated to 4 star rated AC) in the residential and commercial sectors

	Residential				Commercial			
	Air Conditioners*		Refrigerators**		Air Conditioners		Refrigerators**	
Measure/ Technology	**2 Star rated AC**	**4 Star rated AC**	**Non star rated Refrigerator**	**4 Star rated Refrigerator**	**2 Star rated AC**	**4 Star rated AC**	**Non Star rated Refrigerator**	**4 Star rated Refrigerator**
Power requirement per Unit (W)	2024	1785	147	97	2024	1785	147	97
Measure Life (Years or Hours)	10	10	15	15	10	10	15	15
Usage (Hours/Year)	1600	1600	3300	3300	1800	1800	3300	3300
Retail market price (Rs./ Unit)	24000	30000	9500	12000	22000	30000	9500	12000
Annual electricity use (kWh/year)	3243	2849	486	320	3648	3205	486	320
Peak Coincidence Factor	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42

Table 8 B: Data on selected energy efficiency measures (baseline of non star rated to 4 star rated AC) in the residential and commercial sectors

	Residential				Commercial			
	Air Conditioners*		Refrigerators**		Air Conditioners		Refrigerators**	
Measure/ Technology	**2 Star rated AC**	**4 Star rated AC**	**Non star rated Refrigerator**	**4 Star rated Refrigerator**	**2 Star rated AC**	**4 Star rated AC**	**Non Star rated Refrigerator**	**4 Star rated Refrigerator**
Power requirement per Unit (W)	2512	1785	147	97	2512	1785	147	97
Measure Life (Years or Hours)	10	10	15	15	10	10	15	15
Usage (Hours/Year)	1600	1600	3300	3300	1800	1800	3300	3300
Retail market price (Rs./ Unit)	22000	30000	9500	12000	22000	30000	9500	12000
Annual electricity use (kWh/year)	4015	2849	486	320	4517	3205	486	320
Peak Coincidence Factor	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42

Notes:

* 1.5 ton capacity of split air conditioner

** 200 liter capacity of direct cool refrigerator

5.2.3. Agriculture sector

In the agriculture sector, we focus on small (5 hp) agricultural pump sets (APS), which constitute majority of the agricultural electricity consumption (Table 9). Monitoring results of REC's pilot projects found that the agricultural pumping system (APS) in India has plenty of scope for energy saving (CIRE 2008). Numerous field studies have revealed that about 90% of the pump sets used in farms are inefficient and wasting crores of rupees worth of power and oil. The several technical reasons for inefficiency include — fault installation, undersized pipes, high friction foot valves, poor maintenance and substandard models of pumps. Thus, there is a scope of improving the efficiency of APS by 30-50 % by taking corrective measures (GEDA 2006). As the electricity tariffs for farmers are very low (presently in Gujarat the electricity rate is at 55 Paise/kWh for farmers), neither the farmer nor the pump dealer has an incentive to install efficient APS. Farmers also lack access to credit and information about the efficiency of pump sets and its impact on costs (Phadke et. al., 2005).

We consider three different types of energy efficiency measures for APS — (1) purchasing new energy efficient pump set instead of substandard new pump set (2) rectification (retrofitting) of the existing APS by replacing pipes and the foot valve, and (3) replacement of the existing 10 hp sub standard pump with 5 hp standard energy efficient pump.

Cost effectiveness of these measures varies depending on the situation. For example, if the existing pump is not much old and is of a standard brand (hence is likely to be more efficient) then pump replacement may not be cost effective. Other measures such as pipe and foot value replacement may result in larger efficiency improvement at a nominal cost. It is important to avoid blanket replacement of the entire APS as some programs have done since 1980 and target energy efficiency measures taking the current situation into consideration (Phadke et. al., 2005, GEDA 2006).

Purchasing an energy efficient new pump instead of sub standard new pump

This measure applies to new purchases. Many companies sell low cost, sub standard quality and brands of pumps. As the electricity tariff is low (almost free to Gujarat farmers), electricity consumption and efficiency is generally not considered as a criterion in a farmer's pump selection process. Dealers have an incentive to sell oversized pumps with maximum head and as a result, often an inappropriate size and type of pump gets selected. Monitoring results of REC's pilot projects have shown that installing energy efficient new pump set instead of sub standard new pump set can save energy up to 20 % to 30 % (CIRE 2008, GEDA 2006). We assume a conservative, 26 % improvement in energy when energy efficient new pump sets are selected instead of sub standard new pump sets. Pumps that meet the ISI mark (such as Kirloskar) cost 30 to 50% more than substandard quality pumps. For a 5 horsepower ISI mark pump, a farmer would have to pay an incremental cost of Rs. 5000 to Rs. 7000 per pump. Use of an efficient pump can decrease electricity consumption by 936 kWh per year (see Table 9 & Figure 2).

Table 9: Data on selected energy efficiency measures for agricultural water pumping

	New Pump Purchase		**Pump Rectification**		**Pump Replacement**	
Measure/ Technology	**Sub Standard new pump**	**Efficient new pump***	**Existing pump**	**Pump after rectification****	**Existing Pump**	**Efficient new Pump*****
Power requirement (kW/unit)	3.7 (5 hp)	3.7 (5 hp)	3.7 (5 hp)	3.7 (5 hp)	3.7 (5 hp)	3.7 (5 hp)
Load while in Operation (kW)	3.0	2.22	3.7	3.33	3.7	2.22
Measure Life (Years)	8	8	8	8	8	8
Usage (Hours/Year)	1200	1200	1200	1200	1200	1200
Retail market price (Rs./ Unit)	7000	13000	0	2500	1000	13000
Peak Coincidence Factor	0.25	0.25	0.25	0.25	0.25	0.25
Annual electricity use (kWh/year)	3600	2664	4440	3996	4440	2664

Notes:

* Efficient new pump purchase saves energy up to 20-30 %

** Pump rectification saves energy up to 10-15% (Replacing the foot valves and pipes of existing pump)

*** Pump replacement saves energy up to 40-50 % (Replacing 10 hp pump by 5 hp pump)

Where, A: Electricity savings for new pump purchase, B: Electricity savings for pump rectification and C: Electricity savings for pump replacement

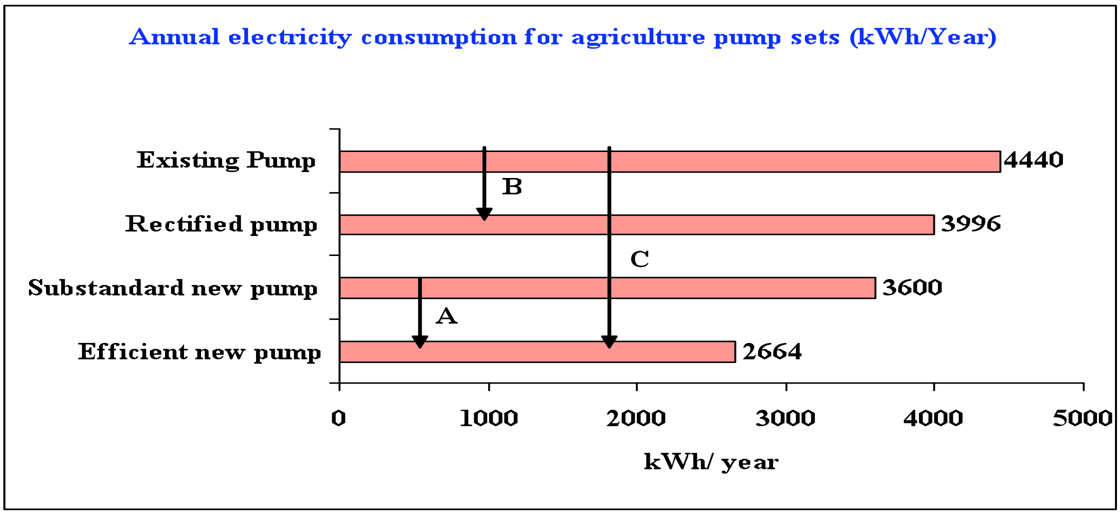

Figure 2: Annual electricity consumption (kWh/year) by selected energy efficiency measures for agriculture water pumping

Pump rectification (retrofitting)

Monitoring results of REC's pilot projects have found that in the case of most pump sets, undersized pipes and high friction foot valves are used. This greatly increases the frictional losses. Replacing the existing undersized pipes with appropriate size and new rigid low friction pipes and replacing high-friction foot valves with low-friction and low head foot valves can improve efficiency of APS by 10-15 % (GEDA 2006, CIRE 2008). We take an efficiency improvement of 10 % by pump rectification. The cost of such rectification is around Rs. 2000-3000; this cost is very sensitive to the length of the piping. We consider the incremental cost of Rs. 2500 for pump rectification. Rectification can decrease electricity consumption by 444 kWh per year (see Table 9 & Figure 2).

Pump replacement

In some cases, the efficiency of an existing pump is so low that it is worth replacing it with a new energy efficient one. This low efficiency could be the result of a combination of factors like a sub-standard quality pump, inappropriate/over size, multiple motor rewinding, and older vintage (Phadke et. al., 2005). Efficiency improvements of the order of 40 % to 50 % are possible by replacing 10 hp pump sets by 5 hp monoblock energy efficient pump sets (CIRE 2008). In this case, the incremental capital cost is around Rs. 12,000 for a 3.5 kW (5 hp) pump. We assume that 50% of the existing pumps are worth replacing. Pump replacement can decrease electricity consumption by 1776 kWh/year (see Table 9 & Figure 2).

We have assumed that substandard pump would have to be replaced after every 5 years of its operation, while EE standard pump could last up to 8 -10 years. Average rewinding of the pump is assumed to be done every third year. Standard EE new pump is assumed to require very less maintenance during the first 3- 4 years if its operation (Table 10). Load shedding is extensive in agricultural areas and the sector seldom gets power during the day; hence most of the APS consumption is during the night time. We estimate that 75 % of the APS consumption happens during the 8-hour (10 pm to 6 am) off-peak period, and only 25 % of the consumption is on peak, which results in a peak coincidence factor of 0.25 (Phadke et. al., 2005).

Table 10: Typical agriculture pump set (5 hp) maintenance cost

Description	Data
Pump rewinding frequency (without voltage fluctuation)	3-4 years
Pump rewinding cost	Rs. 1500-2500/-
Foot valve (for 2.5" to 3" pipe diameter) cost	Rs. 600-750/-

2" UPVC pipe cost per feet	Rs. 60-70/-
Pump rectification frequency	3-4 years
Pump rectification cost	Rs. 2500-3000/-
Old pump salvage value	Rs. 1000-2000/-
Maintenance cost of substandard pumpset	Rs. 2500-3000/-
Life of substandard pumpset	Max. 4-5 years
Cost of Substandard pumpset	Rs. 7000-7500/-
Maintenance cost of EE standard pumpset after 4 years	Rs. 1500-2000/-
Life of EE standard pumpset	8-10 years
Cost of EE standard pumpset	Rs. 12000-14000/-

Note: The data listed in above table 10 are based on our interaction with some pump manufacturers, traders and users.

Micro Irrigation System (MIS)

MIS are modern irrigation systems which include drip irrigation, sprinkler irrigation and sub surface irrigation (porous type). MIS could provide considerable savings in total water and energy demands from agriculture sector. MIS would further reduce electricity demand since enhanced energy efficiency on supply side (as per the 3 options above) would result in further energy savings. These irrigation systems are however not very prevalent in India at present but Gujarat is among the leading states in this field, although the area covered under drip irrigation is 0.18% (see Table 11) with respect to net irrigated area.

GGRC (Gujarat Green Revolutionary Company) is promoting MIS to the farmers of Gujarat as an implementing agency on behalf of Government of Gujarat and Government of India to bring second green revolution in consonance with the agriculture policy of Gujarat Vision 2010 (GGRC 2009).

Table 11: Leading statewise area coverage under Drip Irrigation in India (2005-06)

State	Net cultivated area ('000 Ha)	Total area covered under Drip Irrigation (Ha)	% of Drip Irrigation area wrt Net Irrigated area
Andhra Pradesh	10410	111242	1.1
Tamil Nadu	5172	35728.5	0.69
Maharashtra	17619	111996	0.64
Karnataka	10031	23995.97	0.24
Gujarat	9622	17678	0.18
Uttar Pradesh	5522	987.71	0.05
Punjab	4250	839	0.019
Haryana	3566	516.5	0.014
Madhya Pradesh	14459	1899.87	0.012
India (Average)	149165	309466.4	0.21

Source: Indiastat (2009)

6. Estimation of net benefits

Energy efficiency measures will result in benefits to the consumer, society (government), and in some circumstances to the utility company. We discuss the direct benefits to consumers. The indirect benefits will arise because of increased economic output in industries that supply or consume products from businesses that are affected by the electricity shortage.

6.1. Benefits to the consumer

A consumer benefits arise from the saved electricity at a cost that is less than the electricity tariff. The cost of electricity saved is also known as the cost of conserved energy (CCE). Electricity savings reduce the probability of load shedding, which in turn reduces the probability that a consumer will experience a loss of electricity supply. Residential consumers experience a welfare loss due to this cut in supply, but businesses face loss of production and/or resort to backup generation to make up for this reduction (Phadke et. al., 2005).

The capital cost (purchase price) per kW of each end-use technology may be compared with that of building a new power plant. A typical coal power plant in India costs between Rs. 32,000 to Rs. 40,000 per kW (Sathaye and Phadke, 2005). All the energy efficiency measures that we report in Table 12A and 12B cost much less than that even after including a transaction cost and assuming a conservative high purchase price of the energy-efficient technology. The electricity savings in Table 12A and 12B are based on the data shown in Tables 8A and 9. The CCE computed using these data is also shown in Table 12A and 12B, and these values may be compared with the average electricity tariff paid by consumer. In all instances, except pump replacement in the agricultural sector, the CCE is lower than the tariff. Thus, energy efficiency measures are economically attractive from an end-user perspective.

A sensitivity analysis was conducted for real discount rate of 10% and 25% (see Table 12A and 12B). The cost of conserved energy (CCE) increases as the discount rate increases, since the annualized capital cost of equipments increase with higher discount rates. At 10% societal discount rate, CCE (Rs/ kWh) for AC measure (baseline of using 4 starred AC over non star AC) is 0.97 and 0.86 for residential and commercial sector respectively. While at 25% individual discount rate, CCE (Rs/ kWh) for AC measure (baseline of using 4 starred AC over non star AC) is 1.83 and 1.63 for residential and commercial sector respectively.

Table 12 A: Cost of energy efficiency technologies from societal perspective at 10% discount rate

End use device	Incremental purchase cost **	Electricity Savings	Lifetime	Discount rate (Real)	CCE ***	Electricity tariff (As on 1/4/2007)
	(Rs.)	(kWh/yr/unit)	(years)	(%)	(Rs./kWh)	(Rs./kWh)
Residential						
Air Conditioners*	4536	394	10	10	1.98	4.45
Refrigerators	598	166	15	10	0.50	4.45
Commercial						
Air Conditioners*	4536	444	10	10	1.76	5.85
Refrigerators	598	166	15	10	0.50	5.85
Agriculture IPS						
New Unit	-2683	936	8	10	-0.57	0.55
Rectification	-374	444	8	10	-0.17	0.55
Replacement	7453	1776	8	10	0.83	0.55

Table 12 B: Cost of energy efficiency technologies from individual perspective at 25% discount rate

End use device	Incremental purchase cost **	Electricity Savings	Lifetime	Discount rate (Real)	CCE ***	Electricity tarrif (As on 1/4/2007)
	(Rs.)	(kWh/yr/unit)	(years)	(%)	(Rs./kWh)	(Rs./kWh)
Residential						
Air Conditioners*	7198	394	10	25	3.91	4.45
Refrigerators	1535	166	15	25	2.53	4.45
Commercial						
Air Conditioners*	7198	444	10	25	3.48	5.85
Refrigerators	1535	166	15	25	2.53	5.85
Agriculture IPS						
New Unit	828	936	8	25	0.28	0.55
Rectification	1057	444	8	25	0.76	0.55
Replacement	9599	1776	8	25	1.72	0.55

Notes:

* For **air conditioner measure**, baseline considered of using 4 starred AC over 2 starred AC.

** **Incremental purchase cost** of using a new product instead of old product is obtained by subtracting the net present value of number of old products replaced over a period of X years (where, X is average life of the new product) from the price of new product.

*** The **CCE** should ideally be compared with the marginal electricity tariff, which would be higher than the average values shown in Table 12A and 12B. Since the CCE is lower in all non-agricultural cases (except pump replacement), thus the energy efficiency measures are cost effective for the selected non-agricultural measures would still hold.

For 10% discount rate, which is a societal average discount rate for a range of 8-12%, the CCE is negative for new pump purchase and pump rectification in agriculture sector. This is due to the (incremental) net present values of the maintenance difference and purchase cost difference being negative. This indicates, from a societal perspective, that it is energy efficient to convert inefficient substandard agriculture pump set to EE standard pump set. These are low-hanging fruits which should be plucked with a net negative cost (positive benefit) to the society.

7. Projecting future energy savings

Scenarios are neither forecasts nor predictions. They provide a coherent, internally consistent and plausible description of a possible future by exploring various trajectories of change that lead to a number of possible alternatives. While projecting the future energy savings, it is assumed that in the long run as the economy modernizes the growth rates are likely to get plateaued. This trend of increased growth rate followed by a saturating trend is best depicted by the logistic curve, which in turn captures the market transformation dynamics.

The benefit will materialize over a period of years with gradual adoption of the energy efficient technologies over the conventional one. In this section, we investigate the potential for savings over a ten year period. The projected annual energy saving and peak load reduction can form the basis for a program of energy efficiency measures in Gujarat.

Energy savings from the installation of energy efficiency measures will accrue over the lifetime of each measure. We assume that at the end of its life an energy efficient technology will be replaced by another equivalent measure. In this section, we estimate the energy savings (GWh) and peak load reduction (MW) from the consumer purchase and installation of energy efficient technologies over the next ten years. In order to make this projection, we collected data of sales, growth rate for each measure through market surveys. Then we estimated and compared the market penetration and electricity consumption of conventional and energy efficient technologies. The approach for this estimation is described below.

7.1. Approach

In order to estimate the future impact on electricity demand, we need to estimate the penetration rate of each end-use device. Device purchases may be categorized as those for (1) replacement of existing devices at the end of their life, and (2) satisfying new consumer demand. The latter demand could arise either from the same consumer purchasing additional devices, or due to the formation of new households and/or businesses. The rate of former types of purchases would be determined by the life of device. For example, the annual sales of a device with a 10 year life would be 10% of its equilibrium saturation value (Phadke et. al., 2005).

Not all eligible conventional end-use devices may be substituted by energy efficient ones. In some cases, the efficient devices may not fit the rest of the system at the installation site, and there may be other technological obstacles (cold starts, severe voltage fluctuation, etc.), and due to market failures (lack of information, access to credit, principal agent problems, organizational rigidities, etc.) there may be barriers to their purchase. The upper limit on their penetration will thus be less than 100% of the opportunity set (Phadke et. al., 2005).

We start with the assumption that all devices are at their equilibrium level in the base year 2006-07, and hence the annual penetration rate of each device is simply the inverse of the life of the device. Devices that have a lifetime longer than 10 years never get fully replaced. In parallel, new devices continue to be bought to satisfy the demand arising from expanding households and businesses. The energy saved by each energy efficient technologies is aggregated to arrive at the total energy saved annually. Since we have already estimated the peak coincidence factor and load saving for each energy efficient technologies, we then readily estimate capacity savings given the energy savings.

The potential for energy savings may be estimated from a consumer financial perspective i.e. energy efficiency measures will be implemented if the cost of saved electricity is lower than the tariff. Using this perspective would mean, however, that the potential for agricultural pump replacement measure is nil (Table 12A and 12B).

The following section is arranged as follows. Section 7.2 describes the procedure for projecting growth rates of consumption; section 7.3 for estimating the consumption of new devices; section 7.4 estimates the energy saved (GWh) ; and finally section 7.5 estimates the peak power saving (MW) by energy efficient devices. This section provides a basis for determining peak power (MW) saved to promote energy efficiency program in Gujarat and thus eliminate the need for establishing the new power plants to meet the future electricity demand.

7.2. Projecting growth rates of end-use consumption

We project the future growth rate of consumption for each consumer category on the basis of data provided by authorized dealers of air conditioner and refrigerators over the next 10 years. For agricultural pump sets, we project the growth rate on the basis of secondary data available over the next 10 years. Within a consumer category, consumption of different end use devices grows at different rates. Some end use technologies such as air conditioner are increasingly becoming popular, and are growing at a higher rate of about 20% per year. While refrigerator growth rate is assumed to be 9% per annum and that of APS is at 5% per annum. We have selected different growth rates for different technologies but the average growth rate matches the historical growth rate estimated for that consumer category. The assumptions for growth rate are consistent with historical patterns of growth of appliances sales and ownership data. Further, the growth rates are finally reconciled through discussions with sectoral experts.

7.3. Estimating the electricity consumption of new end-use devices

New devices are purchased either to satisfy new consumer demand as households and businesses expand, or to replace an existing one at the end of its life. The new demand is estimated through the information provided by authorized dealers as well as from the historical growth rate. At equilibrium, the replacement rate of appliance is the inverse of the life of the appliance. The lifetime of each device is estimated from data and information obtained through an informal survey of dealers and manufacturers that are listed in Appendix 2 & 3.

7.4. Estimating the energy saved by energy-efficiency measures each year

Energy saved by energy efficiency measures each year is estimated in the following manner.

1. Annual energy savings for an end use = Consumption of conventional stock that is to be replaced by an energy efficient technology * percentage energy savings
2. Consumption of conventional stock that is to be replaced by an energy efficient technology = Cumulative annual consumption of the conventional technology that is to be replaced by an energy efficient technology (we assume that if an energy efficient technology is retired, it is replaced by the same efficient technology)
3. Consumption of a conventional technology replaced by an energy efficient technology every year = Consumption of new appliances every year *percentage of energy efficient appliances sold every year (which is called as the penetration rate)

Estimation of the penetration rate of Energy Efficient Technologies (EETs)

The maximum saturation level (expressed as % of complete market saturation) and the time required to reach this level critically depends on the cost-effectiveness of EETs relative to the electricity tariff, and also on the government policies used to promote their penetration. The saturation level will be higher and the penetration time will be faster for EETs that have a lower CCE. The saturation level and the time required to reach it are assumed in such a manner that it reflects the relative cost effectiveness of EETs.

Table 13 shows the base year penetration rate, saturation penetration rate, and the time required to reach the saturation level for different EETs. We assume that the penetration rate grows almost linearly to reach the saturation level. The base penetration rate is based on our qualitative understanding of the current popularity of EETs as well as from market surveys. Since we have fixed the saturation penetration rates and the time to reach the saturation penetration rates, the values of the base penetration rate will not affect our estimates of potential energy savings.

Energy saved by the retrofitted energy efficiency measures in the agriculture sector is estimated somewhat differently (although the logic behind assuming certain penetration rates is the same) than the above estimation procedure, which applies to new purchases. In the agricultural sector, 90% of the pumps are inefficient and hence it is cost-effective to either replace them or rectify them. We assume that about 50 % of the current stock of the pumps are worth replacing and will be replaced over a period of 8 years. Similarly, we assume that 80 % of the current stock of APS is eligible for rectification and this replacement is done over a period of 8 years (Phadke et al., 2005, GEDA 2006).

Table 13: Penetration rates for selected energy efficiency measures

End use Sector	Growth Rate (%)**	Retirement rate of old appliances (%)	Base-year penetration rate* (%)	Saturation penetration rate**(%)	Years to reach saturation penetration (%)
Residential Sector					
Air Conditioners	15	10	25	82	6.5
Refrigerators	9	7	15	80	10
Commercial Sector					
Air Conditioners	23	10	25	82	5.5
Refrigerators	10	7	15	80	10
Agricultural Sector					
New pump sets	5	10	20	80	10
Rectification	5	10	10	80	10
Replacement	5	10	10	50	4

Notes:

* **Base year penetration rate:** It is the fraction of newly purchased appliances that are energy efficient appliances in the base year. In the case of retrofit energy efficiency measures (rectification of APS or replacing the highly inefficient pumps), it is the existing stock retrofitted or replaced in the base year.

** **Saturation penetration rate**: It is the maximum possible percentage of the new appliances purchased that are energy efficient appliances. In the case of retrofit energy efficiency measures (rectification of APS or replacing the highly inefficient pumps), it is the maximum possible fraction of the existing stock retrofitted or replaced.

Following the above procedure, we estimate the energy savings that can be achieved each year (Table 14).

Table 14: Annual energy saved (GWh) by energy efficiency technologies

Year of the Program	1	2	3	4	5	6	7	8	9
End use Sector	**GWh Saved**								
Residential Sector									
Air Conditioners	8	19	38	67	106	151	203	263	331
Refrigerators	6	43	87	142	201	264	331	404	481
Commercial Sector									
Air Conditioners	20	50	100	177	279	398	533	690	869
Refrigerators	0.7	4.8	9.7	15.7	22.3	29.3	36.8	44.9	53.5

Agricultural Sector									
New IPS	51	160	330	568	881	1242	1654	2119	2640
Pump Rectification	88	190	309	445	599	770	959	1167	1394
IPS Replacement	195	421	679	973	1306	1673	2076	2517	2998
Total	**369**	**887**	**1553**	**2388**	**3395**	**4527**	**5793**	**7203**	**8767**

7.5. Peak power saved by energy efficiency measures

The peak power saved by an energy efficiency technology is the product of load saving when the energy efficiency technology is in use and peak coincidence factor. For each energy efficiency technology, we have already estimated the annual energy savings (see Table 12 A and 12B). The total peak load savings = (Expected peak power saved per unit of energy efficiency technology/Annual energy savings per unit of energy efficiency technology)*total energy savings achieved by that energy efficiency technology. Table 15 shows that the estimated savings are about 1814 MW from the implementation of the selected energy efficiency measures (with baseline of using 4-starred ACs over 2 starred ACs) over a period of 10 years, while with baseline of using 4-starred air conditioners over non starred air conditioners estimated savings are about 3211 MW from the implementation of the selected energy efficiency measures over a period of 10 years.

Table 15: Peak power saved by selected energy efficiency measures

Year of the Program	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
End use Sector	**Peak MW Saved**								
Residential Sector									
Air Conditioners	1.9	4.8	9.6	17.1	27.1	38.5	51.7	66.8	84.2
Refrigerators	0.8	5.4	11.1	17.9	25.4	33.4	41.9	51.1	60.9
Commercial Sector									
Air Conditioners	4.5	11.2	22.5	39.9	63.2	89.9	120.7	156.0	196.7
Refrigerators	0.1	0.6	1.2	2.0	2.8	3.7	4.7	5.7	6.8
Agricultural Sector									
New IPS	10.7	33.2	68.7	118.4	183.6	258.8	344.5	441.4	549.9
Pump Rectification	18.3	39.7	64.4	92.6	124.8	160.5	199.8	243.1	290.4
IPS Replacement	40.7	87.7	141.6	202.8	272.1	348.5	432.5	524.4	624.6
Total	**77**	**183**	**319**	**419**	**699**	**933**	**1196**	**1488**	**1814**

Tables 14 and 15 show that substantial energy (GWh) and capacity (MW) can be saved relatively quickly. The current level of shortages can be completely removed within a few years depending on the policies used to promote energy efficient technologies.

8. Programs for the promotion of energy efficiency measures

Gujarat has already taken many steps towards demand side management and energy efficiency improvement. Government of Gujarat has sponsored "Jyoti Gram Yojna" scheme in 2005 to make three phase 24 hours power supply available to all rural areas. Gujarat has established separate feeders for residential sector and for agriculture feed in rural areas. It supplies three phase, 8 hours of continuous and adequate power to agriculture sector and three phase, 24 hours of power supply (without possibility to use phase converter) for residential purposes with specially designed transformers in rural areas. About 30% of agriculture consumers are metered in Gujarat. Gujarat is also promoting Micro Irrigation System (MIS), mainly for new agriculture consumers by providing about 50% subsidy.

PGVCL has very high agriculture load of about 35% of total consumption. It has installed small capacity transformers for agriculture power supply by replacing large transformers and thus decreasing energy losses in western Gujarat. Every year about 20,000 to 23,000 new agriculture connections are installed with single transformer of desired capacity to reduce energy losses. It has also installed remote checking system to collect real time data for electricity consumption by all HT and about 30% of LT industrial consumers. Different feeders were re-grouped in smaller load (24 groups of 100 MW instead of 5 groups of 500 MW) to improve management of load-curves.

DGVCL has about 75% electricity consumption from HT and LT industries, with about 80% of the industries running with power factor less than 0.8. So, DGVCL has also established a group (group of 5 officers) to create awareness about DSM and energy efficiency for its consumers.

UGVCL has installed capacitors in agriculture sector of Mehsana and Gandhinagar district. It has replaced about 85,000 hp of agriculture load with new efficient pumps. It has also received more than 3300 applications for installation of new EE pump sets by replacing the existing inefficient pump sets where 33% cost has to be borne by farmers, 33% by utility and rest as subsidy given by government.

MGVCL has segregated electricity load in agricultural sector by supplying electricity to 13 district wise groups of 50 MW during different time period in a day. It has done metering of transformers supplying electricity to urban areas and currently doing metering of transformers supplying electricity to rural area.

GUVNL is reducing LT lines and increasing HT lines every year with 60 substations in Gujarat. It has implemented GIS to optimize load management in Baroda city. It has optimized load management with real time data available online in all utility companies through enterprise resource management.

Torrent Power supplies electricity to Ahmedabad, Gandhinagar and Surat. At the company level, it has reduced energy losses by using energy efficient transformers. At consumer level, it creates awareness to use EE pump set in residential and commercial complexes and EE motors in industries.

Further, our analysis of energy efficiency measures in Gujarat indicates that all the measures studied are cost effective from a societal perspective, residential/commercial measures are cost effective from a consumer perspective as well, and agricultural measures are cost effective from a utility perspective also. Yet, the penetration level of these measures is low compared to the potential identified through earlier surveys and that estimated in our analysis. The reasons could be many and varied.

In the US and other industrialized countries, and in some developing countries, energy efficiency programs are being pursued to address this shortcoming. Such programs are run by utility companies, public-private partnerships, and state and federal government agencies. The rationale for these programs is that the energy efficiency gap is caused by market failures that act as barriers to the efficient use of energy (Phaldke et al., 2005).

Agricultural consumers have highly subsidized electricity tariffs, and hence little or no incentive to undertake energy efficiency measures. Also, from utilities' past experiences, it was found that many of the farmers were not ready to replace their old inefficient pumps even when they had to pay only one third (33%) of the total cost of new efficient pump. May be it is a combination of behavioral and economic issue for farmers. It would be cost effective for GUVNL and Gujarat government to bear the full cost of the energy efficiency measures in agricultural pumping. For example, in the case of a program of pump rectification (i.e. replacing the undersized pipes and high friction foot valves), the cost of conserved energy is Rs. 0.76 per kWh (at 25% discount rate). One kWh saved in the agricultural sector thus saves Rs. 2.87/kWh (average revenue realized by GUVNL per unit), which results in a net cost reduction of Rs 1.56/kWh with agricultural electricity tariff of Rs. 0.55/kWh. The distribution of savings between GUVNL and the Gujarat government will depend upon how much of the revenue shortfall is covered through direct subsidy (from the government) and cross subsidy (from other GUVNL consumer categories). To tackle the behavioral aspects of this issue, we could create awareness in the farmers via "Gram Panchayats" on benefits of adopting and implementing energy efficiency measures in agriculture sector. The utilities may even consider buying-back the old pump sets from the farmers at market-driven salvage value, to reduce behavioral barriers. The proportionally high savings per kWh warrant a strong program that includes rebates and even direct replacement/retrofitting of the existing pump sets.

A second example is a **Residential Program** that will target medium and high consumption households. In most cases medium and high income consumers purchase non-star, or 1 or 2 star-rated ACs currently because 4 and 5 starred split ACs have higher capital cost of about Rs. 8,000 - 10,000 than that of non star rated ones. Further window air conditioners are available with maximum 2 star-rating in the market. The cost differential between split and window ACs of same capacity vary from Rs. 8,000 - 12,000 depending on brand and star rating. A program could be designed in such a way that utility/government provide incentives to AC manufacturers for manufacturing 4 and 5 star rated split and window ACs in bulk and then rebates/discounts be provided to consumers for replacement of old non starred ACs by 4 or 5 starred products, and also on new purchases for 4 or 5 starred ACs.

Refrigerators are available with 3, 4 and 5 star ratings for various brands in the market and there is a maximum sale of 4 star rated refrigerators for the year 2008-09 (see Appendix-3). A program could be designed in such a way that utility/government should develop a buy back policy for replacement of old non star-rated refrigerator with 5 star-rated refrigerator at rebates of about Rs. 4,000 - 6,000 to the consumers to cover the price differential. Also, the new refrigerator purchases should be promoted for 5 star-rated machines by providing highest and attractive rebates/discounts to 5 star-rated refrigerators.

Utility-run energy efficiency programs can also effectively reduce the price of energy efficiency measures through their bulk procurement. Such programs would reduce various transaction costs (such as search costs, installation costs etc.) incurred by individual consumers. Bulk purchase has the potential to reduce the purchase cost by 30 – 40 % compared to the retail price. Since utilities are in regular contact with consumers for metering, billing, and repairs, and can collate information about their consumption patterns, so that they could implement programs at a lower cost compared to acquisition of such devices by individual entities.

9. Conclusions

It can be concluded that the energy efficiency measures studied - refrigerators, air conditioners and agricultural pump sets are attractive candidates in terms of potential electricity savings to conduct energy efficiency programs in Gujarat.

However, the use of the saved electricity from selected energy efficiency measures is a policy issue. These savings could be provided as additional power to high-end consumers such as commercial and industrial sectors, which would pay higher rate for this additional power than low-end consumers who provide these savings.

Alternatively, the power saved from selected EE measures could also be supplied to fulfill the social agenda of the government such as providing 1 kWh electricity per day to every rural household. These consumers would not be able to pay anywhere near the high-end consumers. However, the provision of electricity is an enabling condition for enhancing productivity and income generation. Electricity access, affordability and rural household income levels are linked particularly in relation to lighting. There are studies conducted internationally (World Bank, UNEP & UNDP) which indicate the enhanced income generation and development of human resources due to increase in electricity consumption at household level.

It is also observed that the annual energy saved (GWh) by the energy efficiency technologies in future years could remove the energy shortages completely. Also, peak power saved (MW) on demand side through energy efficiency measures implies proportionately lower investment to build new power plants on pro-rata basis.

Further research is required to understand how the state government could possibly benefit in terms of sales tax revenue because of reduced subsidies as a result of lower electricity demand in the residential and agriculture sectors, and resale of electricity to deprived commercial and industrial consumers. It will also be interesting to examine how the direct and indirect magnitude of revenues is going to affect the revenue deficits.

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Appendices

1. Load shedding

1.1. Methodology

Load shedding data has been collected through primary surveys. These were conducted via telephonic interviews in more than 30 cities/towns in Gujarat. The cities are classified as large cities (those having population above 10 lacs), medium cities (population between 1-10 lacs) and small towns/rural areas (population less than 1 lac).

The data was also matched with available information on power cuts and load shedding. Although secondary data from power utilities would be more reliable for load shedding information, this was not readily available for each city, town and village.

1.2. Results

It has been seen that load shedding in Residential & Commercial sector of Gujarat for large cities is almost 1.63%, for medium cities is almost 2.3%, and for small towns/rural areas is almost 10.96%.

The annual load shedding in Agriculture sector of Gujarat is almost 66.67% and annual load shedding in Industrial sector is almost 14.25%. Table 1, Table 2 and Table 3 present detailed results from the primary survey.

Table 1: Load shedding in residential and commercial sector of different cities/towns/villages of Gujarat

Sr. No.	Name of city/town	Type of city/town/village	Average Load Shedding (Hrs/year)
1	Bhavnagar	Large	24
2	Navsari	Large	124
3	Baroda	Large	114
4	Surat	Large	104
5	Gandhinagar	Large	24
6	Surendranagar	Large	260
7	Ahmedabad	Large	24
8	Mehsana	Large	54
9	Jamnagar Town	Large	600
10	Rajkot	Large	104
Total load shed in large cities (Hrs/year)			**1432**
Total power supply in large cities/annum			**87600**
% Average load shed in large cities			**1.63%**
11	Jetpur	Medium	24
12	Morvi	Medium	472
13	Junagadh	Medium	104
14	Gandhidham	Medium	319.5
15	Vallabh Vidyanagar	Medium	102
16	Palanpur	Medium	186

Total load shed in medium cities (Hrs/year)			**1207.5**
Total power supply in medium cities/annum			**52560**
% Average load shed in medium cities			**2.30%**
17	Malvav	Small	5840
18	Mahua	Small	24
19	Padari	Small	5840
20	Kadi	Small	202
21	Keshod	Small	416
22	Shika	Small	284
23	Modasa	Small	248
24	Bareja	Small	40
25	Gondal	Small	208
26	Lakhtar	Small	416
27	Anjar	Small	319.5
28	Adipur	Small	319.5
29	Sanand	Small	24
30	Bajwa	Small	195
31	Vapi	Small	24
Total load shed in small towns (Hrs/year)			**14400**
Total power supply in small towns/annum			**131400**
% Average load shed in small towns			**10.96%**

Table 2: Load shedding in Agriculture sector of Gujarat

Total power supply in agricultural sector (Hrs/day)	8
Total load shed in agricultural sector (Hrs/day)	16
Total load shed in agricultural sector (Hrs /year)	5840
Total power supply in agricultural sector (Hrs /year)	8760
% Average load shed in agricultural sector	**66.67%**

Table 3: Load shedding in Industrial sector of Gujarat

Total power supply in industrial sector (Hrs/week)	144
Total load shed in industrial sector (Hrs/week)	24
Total load shed in industrial sector (Hrs /year)	1248
Total power supply in industrial sector (Hrs /year)	8760
% Average load shed in industrial sector	**14.25**

2. Primary survey conducted for data on Air conditioners market

2.1. Methodology

Primary survey was conducted at authorized dealers of various AC brands, namely LG, Carrier, Voltas, Videocon, Blue star. These brands cover almost 90% of AC market in gujarat. We conducted detailed interviews with each of them and also collected their sale figures and reports.

The following dealers were contacted, along with some other retailers.

1. Mr. Mangesh Raut

   Area sales Manager,

   LG Electronics Pvt ltd,

   Ahmedabad.

2. Mr. Sandeep Sanghavi

   Director, Treasurer (ISHRAE)

   Samantar Sales & Services Pvt. Ltd.

   Ahmedabad.

3. Mr. Sandeep Jain

   Business Manager,

   Voltas limited,

   Ahmedabad.

4. Mr. Sunil Bhatia

   Business Manager,

   Carrier Air conditioning and Refrigeration limited,

   Ahmedabad.

5. Mr. Mohan Pillai

   Authorized Dealer of Blue star AC & Refrigeration,

   M.A. Air conditioning,

   Ahmedabad.

2.2. Results for Air conditioner market for year 2008-09

Total sales of AC in Gujarat for year 2008-09 = 1.5 Lacs

Maximum sale of AC capacity = 1.5 Tr

%Total sale of AC in Ahmedabad in residential & commercial sector = 55-60%

% Sale of Split AC in Gujarat by LG in residential & commercial sector = 70%

% Sale of Window AC in Gujarat by LG in residential & commercial Sector = 30%

% Sale of Branded AC in residential & commercial sector = 100%

Table 4: Primary data collected for AC through survey

Brands	L.G.	Voltas	Carrier	Blue Star	Samsung	Videocon	Hitachi	Daikin	O-General	Others
% Total sale of AC in Gujarat, Sources: LG Company	27	15	10	6	15	6	7	4	3	7
% Total sale of AC in Gujarat, Source: Videocon Company	30	18	15	12	22	4				3
% Total sale of AC in Gujarat, Source: Carrier Company			14							
% Total sale of AC in Gujarat, Source: Voltas Company		19.5								
Average % sales of AC in Gujarat,	28.5	17.5	13	9	18.5	4.0	3	1	1	4.5

Table 5: % Sale of 1.5 Tr split and window AC for different brands

Brands/Star rating	Non- star	1 - Star	2 - Star	3 - Star	4 - Star	5 - Star
L.G.	0%	0%	75%	10%	15%	0%
Voltas	19%	3%	0%	60%	13%	5%
Carrier	0%	89%	7%	0%	3%	1%
Blue Star	0%	85%	5%	10%	0%	0%

3. Primary survey conducted for data on refrigerators market

3.1. Methodology

Primary survey was conducted at authorized dealers of various refrigerator brands, namely LG, Whirlpool, Videocon and Samsung. These brands cover almost 90% of refrigerator market in Gujarat. We conducted detailed interviews with each of them and also collected their sales figures and reports.

The following dealers were contacted, along with some other retailers.

1. Mr. Abhiral Bhansali

   Area sales Manager,

   LG Electronics Pvt ltd, Ahmedabad.

2. Mr. Latish Patel

Regional Manager,

Next Retail India Ltd

Ashram Road,

Ahmedabad.

3. Mr. Anand Vegad

Sales Manager,

Next Retail India Ltd,

Bodakdev,

Ahmedabad.

3.2. Results: Refrigerator market for year 2008 - 09

Total sales of all volumes of fridge in Gujarat for year 2008-09 = 3.0 Lacs

Maximum sale of fridge capacity = 175- 200 liters

%Total sale of fridge in Ahmedabad in residential & commercial sector = 30%

% Sale of Frost free fridge in Gujarat by LG in residential & commercial sector = 40%

% Sale of Direct cool fridge in Gujarat by LG in residential & commercial Sector = 60%

% Sale of Star rated fridge in residential & commercial sector = 85%

Sale of Non star rated fridge in residential & commercial sector = 15%

Table 6: Primary data collected for refrigerator through survey

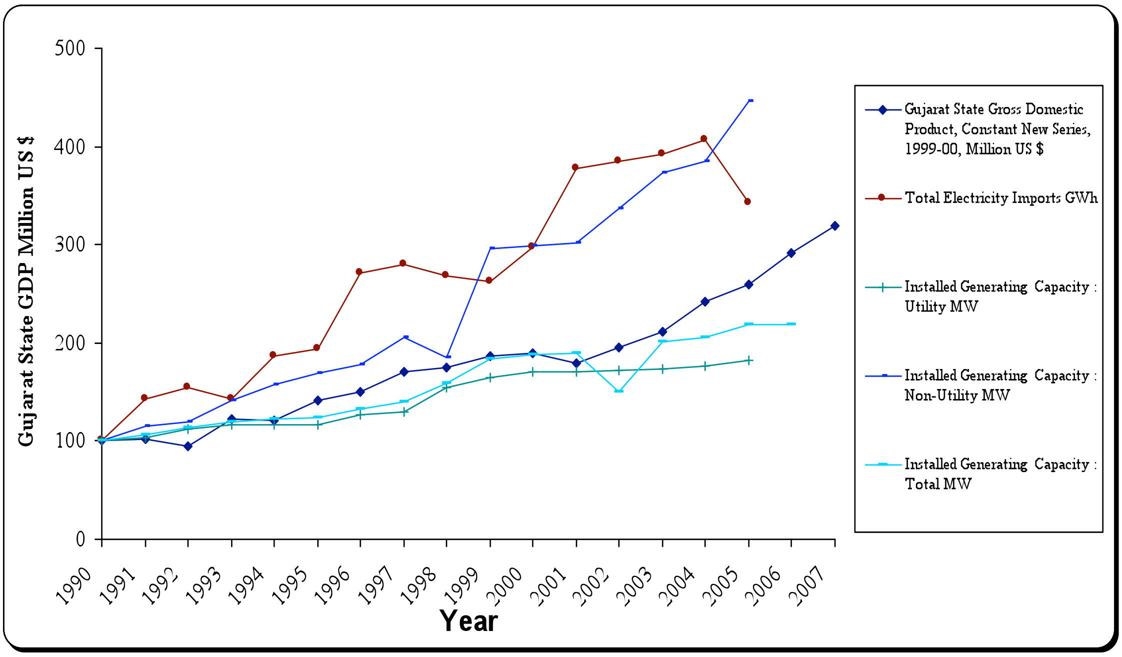
Total sale of all volumes of fridge (All brands) for year 2008-09 in Gujarat (In numbers)	300000	
Maximum sale of fridge capacity in Gujarat	175-200 Liters	
% Total sale of fridge in Gujarat by LG in Residential sector	30%	90000
	Fridge sold by LG Co.	
	%	**Numbers**
% Total sale of fridge in Ahmadabad by LG in Residential and commercial sector	30	27,000
% Sale of 3 Star rated fridge in Gujarat by LG in Residential and commercial sector	10	10,000
% Sale of 4 Star rated fridge in Gujarat by LG in Residential and commercial sector	80	80,000
% Sale of 5 Star rated fridge in Gujarat by LG in Residential and commercial sector	10	10,000
% Total sale of Frost Free Fridge in Ahmadabad by LG in Residential and commercial sector	40	10,800
% Total sale of Direct Cool fridge in Ahmadabad by LG in Residential and commercial sector	60	16,200
% Total sale of Frost Free Fridge in Gujarat by LG in Residential and commercial sector	25	22,500
% Total sale of Direct Cool fridge in Gujarat by LG in Residential and commercial sector	75	67,500

4. Gross State Domestic Product (GSDP) data for Gujarat

Table 7: GSDP data for Gujarat

Year	Gujarat State Gross Domestic Product, Constant New Series, 1999-00, Rs. Crore	Gujarat State Gross Domestic Product, Constant New Series, 1999-00, Million US $	Electricity Generation GWh	Total Electricity Imports GWh	Installed Generating Capacity: Utility MW	Installed Generating Capacity: Non-Utility MW	Installed Generating Capacity: Total MW
1990	100	100	100	100	100	100	100
1991	102	102	103	144	104	116	106
1992	95	95.39	106	154	112	119	113
1993	122	122.46	117	143	116	142	119
1994	120	120.26	123	186	117	157	122
1995	142	141.93	127	194	117	169	124
1996	150	149.73	133	271	126	177	133
1997	171	171.04	139	280	129	205	140
1998	175	174.65	156	269	155	185	159
1999	187	187.19	177	262	165	296	183
2000	189	189.1	190	297	171	299	189
2001	180	179.87	187	377	171	302	189
2002	195	194.98	190	385	172	337	151
2003	211	210.86	192	392	174	373	201
2004	242	242.01	200	407	177	385	205
2005	260	259.88	232	343	182	447	218
2006	292	291.51	0	0	0	0	219

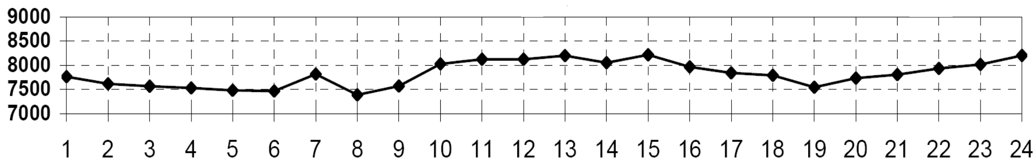
Source: CMIE (2008), Exchange rate (As on Date 14/11/2008): 1 US$ = 49.41 INR



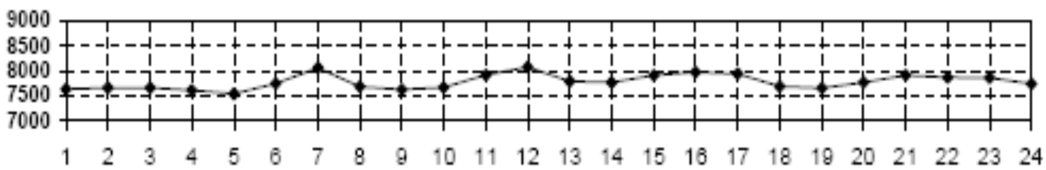
5. Peak coincidence factor:

Peak coincidence factor is the percentage of load shedding that occurs during the peak electricity demand in one day. The following charts represents month-wise hourly demand curves for Gujarat on regional peak day for year 2007-08 (WRPC 2009).

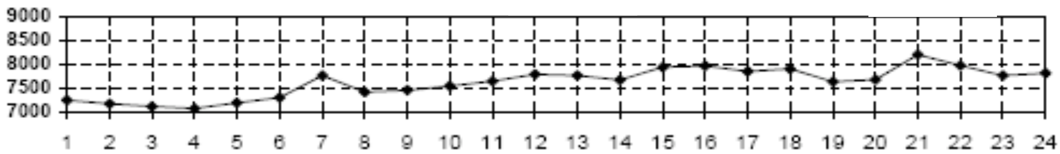
- **Hourly demand curve on regional peak day for April 2007:**



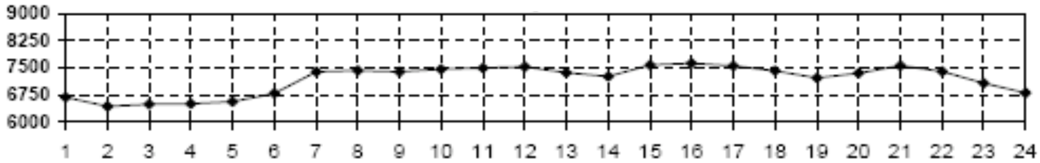
- **Hourly demand curve on regional peak day for May 2007:**



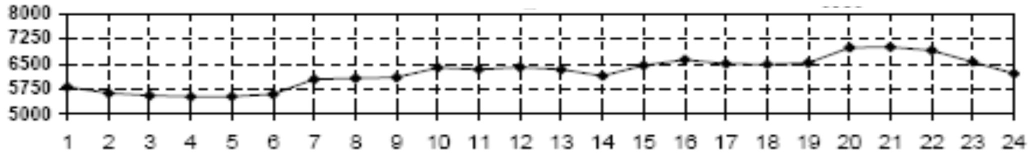
- **Hourly demand curve on regional peak day for June 2007:**



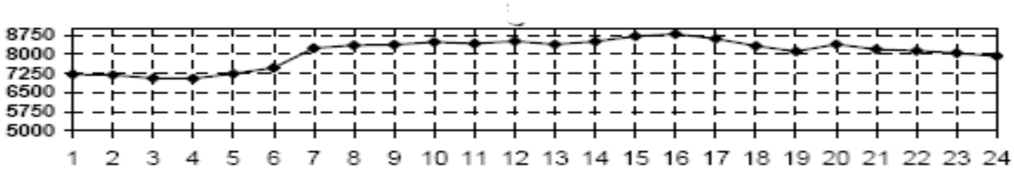
- **Hourly demand curve on regional peak day for July 2007:**



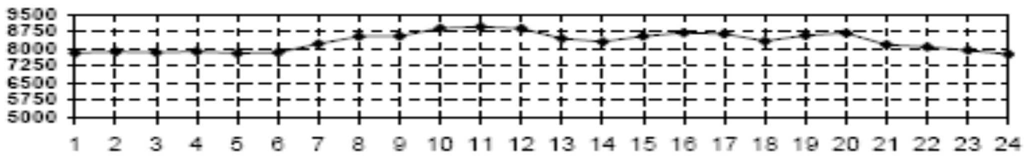
- **Hourly demand curve on regional peak day for August 2007:**



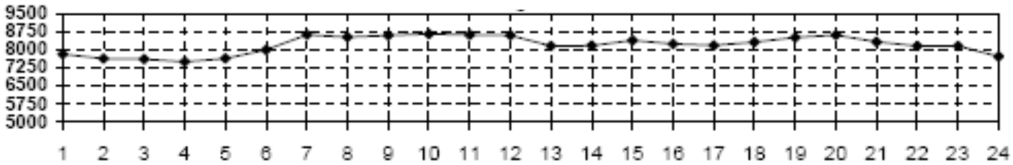
- **Hourly demand curve on regional peak day for September 2007:**



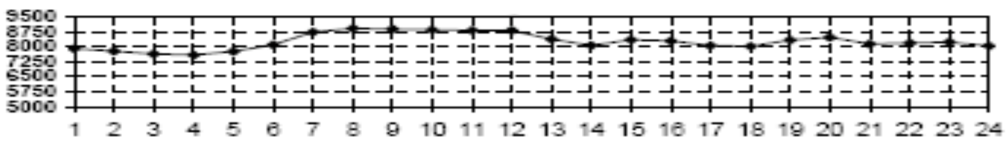
- **Hourly demand curve on regional peak day for October 2007:**



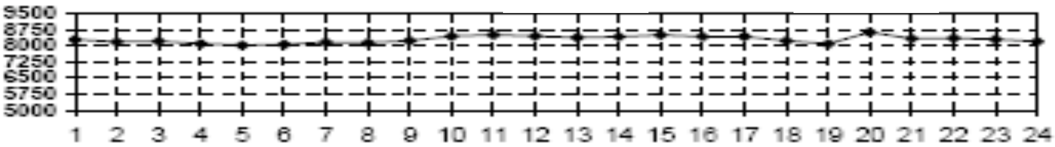
- **Hourly demand curve on regional peak day for December 2007:**



- **Hourly demand curve on regional peak day for January 2008:**



- **Hourly demand curve on regional peak day for March 2008:**



The above month-wise hourly demand curves indicate that the maximum demand occurs in the morning to afternoon (9 am to 4 pm) and in the evening (7 pm to 10 pm) throughout the year. Assuming that load shedding takes place during the peak load period, the load is shed for almost 10 hrs (9 am to 4 pm & 7 pm to 10 pm) in a day. Therefore, the peak coincidence factor for the residential and commercial sector is 0.42 (10 hours of load shed/24 hours in a day). Expert opinion was also taken to validate our assessment.

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