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Case Studies of DSM projects implemented in India

- DELP Puducherry
- BLY Kerala
- Auto DR Project
- Portfolio of projects in Mumbai
- AgDSM

2016

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Executive Summary

The first project reported on demand side management (DSM) in India is in the agriculture sector from the state of Gujarat in 1978. This was succeeded by several initiatives concentrating on replacement of old and inefficient pump sets with new efficient pump sets. DSM initiative in lighting took place in 2004 with BESCOM implementing a project involving replacement of incandescent lamps with energy efficient compact florescent lamps (CFL). From 2010, there has been a steep rise in DSM activity across the country with release of regulations by many states starting with Maharashtra.

Details of about 85 DSM programs from the literature, information in public domain in the form of reports and published articles were compiled and presented in a report titled "Demand Side Management in India – Landscape Assessment" by the project team. Many notable pilot projects were demonstrated and have been scaled up with satisfactory success with different technologies in various sectors. In this context, it is important that the project details regarding design, implementation and lessons learned are systematically documented for peer reviews and future reference.

This report summarizes the experiences of utilities, implementing agencies and customers for some of the flagship projects implemented so far in the demand side management space in India. The projects covered include (a) DSM based Efficient Lighting Program (DELP) implemented in Puducherry, (b) TPDDL auto-DR Project in New Delhi (c) Portfolio of DSM projects implemented by various distribution companies in the state of Maharashtra and (d) Summary of agricultural DSM projects implemented in India.

The details presented in this report are from published articles, reports available in the public domain and from the information collected from various offices (cited at appropriate places). If some projects are found to be missing, that has occurred inadvertently, and we would be grateful if such information is passed on to us for future compilation. The project team would like to acknowledge the support from regulatory commissions, utilities, distribution companies, designated agencies of various states in the country.

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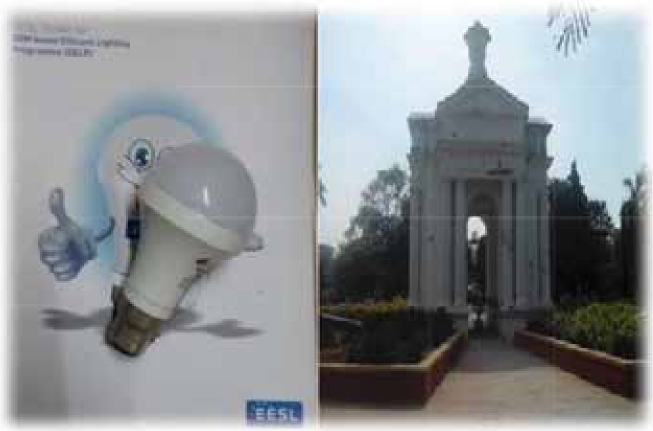
1.0: DSM Based Efficient Lighting Program (DELP) Puducherry

Project location: Puducherry

Duration of visit: 20-21st May, 2015.



1.1: Introduction

DSM based Efficient Lighting Program (DELP) was launched by EESL in collaboration with the electricity department, Government of Puducherry (PED) on 7 Feb, 2014 as a standard offer program in Puducherry. Under the scheme, each household can replace a maximum of three Incandescent Lamps (ICLs) with LED bulbs at a one-time payment of Rs. 10/bulb. The scheme was meant for domestic customers and 2.45 lakh households were enrolled in the project. Web based monitoring system was used to capture project savings using 200 sample LED bulbs, selected on a random basis. This monitoring system recorded rated wattage and hours of usage in real time hours of usage in real time and annual savings in the project was reported to be about 48.88 MU.

This report presents the project performance as evaluated during the site visit. One to one meetings with customers from different income groups and staff of the executing agency were conducted. Shops selling LED bulbs and ICLs were also a part of the survey, and this helped us to understand the market impact of the project.

1.2: Project Details

Technical Specifications:

This project focused on replacement of 60W incandescent lamp (ICL) with energy efficient LED bulb. The technical specifications of the LED bulb are given in Table 1.1.

Table 1.1: LED bulb Specifications

Wattage	Type	Color Temperature	Life	CRI	THD	Power factor	Surge protection	Lumen depreciation rate
7W	Cool White	5700 K	35000 Hrs	>80	<20%	>0.95	>2.5kV	70% at 25000 Hrs

Cost Recovery:

One-time payment of Rs. 10/bulb was charged with maximum of three ICLs replaced. The remaining money is recovered through Puducherry Electricity Department (PED).

Implementing agency: Energy Efficiency Services Limited, New Delhi and Electricity Department, Government of Puducherry (PED)

Vendor: Ecolite Technologies, Gurgaon based LED manufacturer.

Number of households enrolled: 2.45 lakh.

<table>
<tr><th>Parameters</th><th colspan="10">Calculations</th></tr>
<tr><td>Cost of LED bulb including transportation, insurance, storage & distribution cost.</td><td colspan="10">Rs. (310+10=320)/bulb</td></tr>
<tr><td>Total number of bulbs to be distributed under the scheme</td><td colspan="10">735000</td></tr>
<tr><td>Cost recovered from customers</td><td colspan="10">Rs. 10/bulb</td></tr>
<tr><td>Project cost (Net investment by EESL)</td><td colspan="10">Rs. [(320-10)*735000] = Rs. 22.785 Crore</td></tr>
<tr><td>Debt (70% of project cost)</td><td colspan="10">Rs. 15.9495 Crore {to be arranged by EESL}</td></tr>
<tr><td>Equity (30% of project cost)</td><td colspan="10">Rs. 6.8355 Crore {to be arranged by EESL}</td></tr>
<tr><td>Interest on Loan</td><td colspan="10">12.5%</td></tr>
<tr><td>Return on Equity</td><td colspan="10">15.5%</td></tr>
<tr><td>Annual maintenance cost</td><td colspan="10">3% of project cost (including replacement warranty cost for 2 years by EESL)</td></tr>
<tr><td>Financial savings deemed to have been accrued to PED for the 10 years by saving energy sold at subsidized rate. Rs.(4.40-2.55 = 1.85)/unit</td><td colspan="10">Annual energy saving = 40.90 Million Units
Rs. (1.85*4.09*10 = 75.665) Crore</td></tr>
<tr><td rowspan="2">DELP SOP price (in Rs./kWh) for 10 years</td><td>I</td><td>II</td><td>III</td><td>IV</td><td>V</td><td>VI</td><td>VII</td><td>VIII</td><td>IX</td><td>X</td></tr>
<tr><td>1.23</td><td>1.17</td><td>1.11</td><td>1.04</td><td>0.98</td><td>0.92</td><td>0.86</td><td>0.79</td><td>0.73</td><td>0.67</td></tr>
<tr><td rowspan="3">Total payment by PED to EESL over 10 years excluding taxes(in Rs. Crore)</td><td colspan="10">Rs. 46.41 Crore</td></tr>
<tr><td>I</td><td>II</td><td>III</td><td>IV</td><td>V</td><td>VI</td><td>VII</td><td>VIII</td><td>IX</td><td>X</td></tr>
<tr><td>6.02</td><td>5.71</td><td>5.40</td><td>5.10</td><td>4.79</td><td>4.49</td><td>4.18</td><td>3.88</td><td>3.57</td><td>3.27</td></tr>
<tr><td colspan="11">PED has planned to recover the annual payout to be made to EESL through ARR for the respective year.</td></tr>
</table>

Eligibility criteria for enrollment: Domestic category with electricity bill arrears less than Rs. 1000.

Warranty period for LED replacement: First 8 years provided by Vendor and the subsequent 2 years by EESL/PED.

EM & V Method Adapted: In this project, deemed savings approach is adapted and hence the overall savings are calculated by taking product of power with number of hours of consumptions. However, to see the performance of the installed bulbs a web based monitoring system is built. This would monitor 200 LED bulbs installed at a government quarters at Muthailpet, Puducherry. Each of these bulbs is equipped with RFID tags and 5 RF transmitters are installed at these quarters.

RF Antennas and transmitters installed in government quarters

1.3: Distribution Phases:

Pondicherry Electricity Department (PED) maintains an online database of each household identified by a unique policy number which can be accessed through a web portal remotely. It is ensured that a maximum of 3 LED bulbs are replaced per policy number only, when the arrears are cleared. This helped in facilitating the project enrollment process and mitigating the issue of many customers with huge arrears asking to be enrolled. The online database also helped in simultaneous enrollment of customers and distribution of LED bulbs. The bulbs are distributed in three phases and so far about 6.5 lakh LED bulbs were distributed to the consumers.

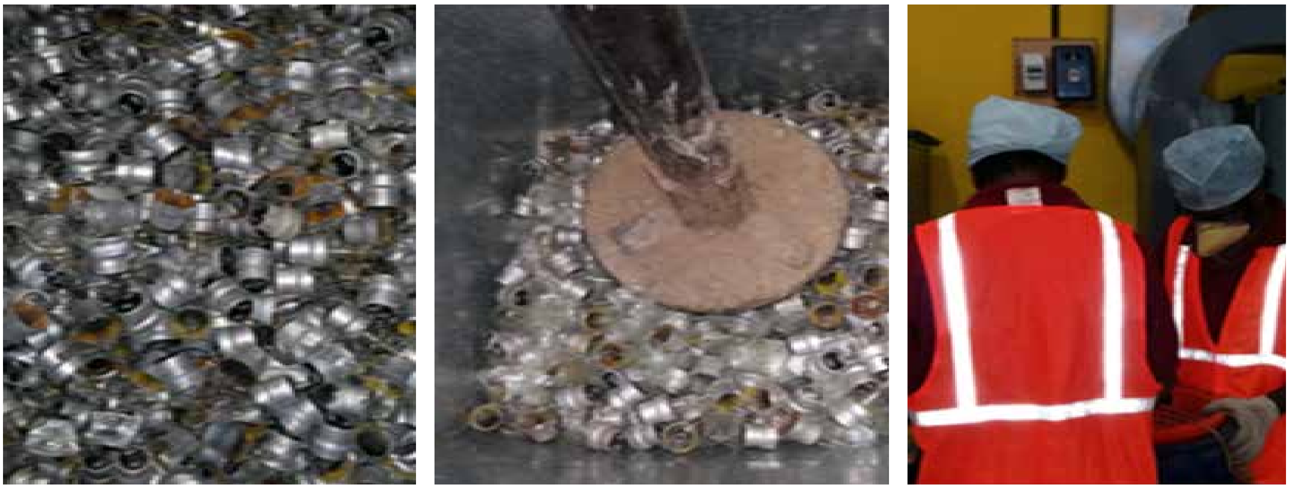
LED bulbs distribution through counters set up by PED & EESL

Phase I *(February 2014 to March 2014)*: Door to door enrollment and distribution was done. Arrears were checked (online using tablet devices) to enroll the customers. A team consisting of 30 people from vendor's side, 1 project in charge from EESL and 3 employees of PED carried out the first phase successfully. Vehicle announcement of the scheme was also done during this phase.

Phase II *(June 2014 to August 2014)*: PED helped EESL to put approximately twenty counters at their offices and places like marriage halls, malls, etc. every day for about a month. Newspaper, TV, radio and vehicle announcements were used to spread scheme awareness before and during this distribution phase. Maximum LED bulbs were distributed during this phase.

Phase III *(Started in Nov - Dec, 2014)*: One counter was setup at a substation office of PED at Marapalam. Low turnout during this phase caused the distribution process to be curtailed for the time being. As per the vendor knowledge, PED requested EESL to start a new distribution phase. However, EESL suggested that PED should acquire the bulbs and distribute it to the consumers.

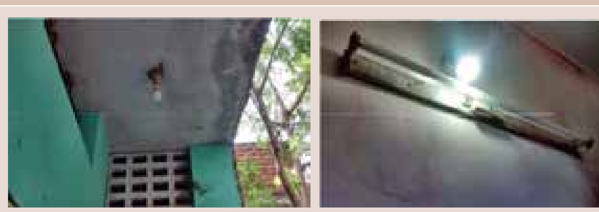
Disposal mechanism: ICL bulbs collected during distribution phase were sent for disposal to M/s Ecobirdd Recycling, Bangalore.



ICL crushing and disposal at Ecobirdd Recycling, Bangalore

1.4: Customer's Perspective:

Three houses were visited during the survey and it was ensured that they cover the major income groups in the domestic LT category.

Respondent 1	Fisherman community
Name	Gnanapragasam L. (Mr. Arula raja N. was present during the survey)
Policy No.	06-27-01-00494
Tariff Plan	A2
Address	Plot No. 32, Ravu Gramin Tottam, Ganesh Nagar, Muthialpet.
Number of Bulbs replaced	3 bulbs (2 outside which is off during day time and one in kitchen which is on as per usage). The consumer collected the bulb through counter at PED office.
Comments	• Better quality of light as compared to ICL. • Electricity Bills reduced approximately by an amount of Rs. 75 to 100. • Came to know about the scheme through friends and TV advertisement. • Currently not using any ICL in the house. • Informed other residents about the program. • Customer is ready to pay Rs. 140 for the LED bulb in absence of similar schemes.
Complaints	None. No faults occurred.
Photographs	

Respondent 2	Clerk in Pondicherry Court
Name	Mr. Kalya Murthy
Policy No.	08-44-03-0230
Tariff Plan	A2
Address	The CEO, (3) IX Cross, Periyar Nagar
Number of Bulbs replaced	• 3 bulbs (1 bulb outside the living space and 2 inside). • Received the LED bulb during door to door distribution phase.
Comments	• Electricity bill amount reduced by Rs. 100 approximately. • Currently using 1 ICL ("Zero watt bulb") in house. • Better light as compared to ICL. • Willing to pay Rs. 100 for similar bulb in absence of such scheme.
Complaints	None. No faults occurred.
Photographs	 

Respondent 3	Retired civil services official
Name	Mr. C. Kannaiappan
Policy No.	07-39-01-0025, 07-39-01-0024, 07-39-01-0026 (3 connection in total)
Tariff Plan	A2
Address	24 Thirumalnagar, Pondicherry- 605013
Number of Bulbs replaced	6 bulbs
Comments	• Was not using ICL before, had only CFLs and FTLs in house. • Ready to pay the current market cost of LED in absence of such scheme. • Electricity bill amount has reduced. • He also educated few people about the original cost and energy savings potential of the LED bulb.

Respondent 3	Retired civil services official
Complaints	• The ballast cover in the LED bulb came out for 5 bulbs and he didn't know about the toll free number provided to put across any warranty complaints. • The customer felt that general awareness about warranty and other aspects of the scheme (such as original cost of the bulb) was missing and more could have been done in this area. • But once he put across the compliant for faulty LED bulbs, replacement was quick and no problems were found later. • He also found few people throwing the fused LED bulbs and selling it as scrap because they were not aware about the cost of the bulb and the associated warranty.
Photographs	

1.5: Complaint addressal during warranty period

Fused bulbs are liable for replacement under warranty provided in the scheme. Households can call a toll-free number to seek replacement of faulty bulbs and they are routed to contact a local personnel working for Ecolite (Vendor) who visits the household and replaces the faulty bulb.

There are several shops who handle warranty issue on behalf of the vendor. This gives flexibility to the consumer to visit the nearest shop. Currently there are 5 shops (2 shops in Pondicherry, 1 in Karaikal and 1 in Mahe) in total. They collect the fused bulbs from customers and replace them with new ones and send the faulty pieces to Ecolite main office in Gurgaon.

One replacement shop in Pondicherry that handles warranty issues was visited to know his perspective about the scheme. Summary of discussion is given below.

Respondent 4	Replacement Shop for fused LED bulb
Name	Mr. Suresh
Shop Name:	MKV Enterprises
Address	Shop No. 114, Savarirayalu street, Puducherry -1.
Average number of bulbs replaced per month	• It is very difficult to comment on the average replacement. • There were months with no replacement and months with replacement as high as 50 bulbs.
Comments	• The sale of LED bulbs very low owing to high cost before the scheme started. • At present there is no sale, many consumers (a particular segment) are expecting more distribution of led bulbs. • Syska and Philips are two LED brands in market and cost has reduced in last two years but the sale is very poor.
Complaints	None.

Respondent 4	Replacement Shop for fused LED bulb
Photographs	

1.6: Sale of ICLs in Pondicherry:

One small shop was visited to know the impact of DELP scheme on the sale of ICLs in the market.

Respondent 5	Shop selling ICL
Name	Mr. Anand
Nature of Business	Grocery shop
Address	Muthialpet
Average number of ICLs sold per month before the scheme	25 to 30 ICLs per month
Average number of ICLs sold per month after the launch of scheme	• 5 to 6 ICLs per month • The shopkeeper felt that distribution of LED at this price has affected the sale of ICLs.
Brand of ICL being sold, cost and Wattage	Crompton greaves, Rs. 10/ ICL & 60 W
Complaints	Sale is less as he sells only ICLs and no other bulbs.
Photographs	

1.7: Estimation of Energy Savings

Parameters	Calculations
Power savings per ICL replacement with LED bulb	(60-7)= 53 Watt
Total number of bulbs to be distributed	735000
Operating Days in a year	300
Operating hrs in a day	3.5
Total energy saved (MU #) per annum	(53*735000*300*3.5)/(10^6) = 40.90
T& D losses	12.85%

#MU: Million Units

1.8: Conclusions

Certain challenges still remain that can be countered in the upcoming projects. It was found that all the 200 samples with RFID tags were installed in one place rather than distributed over the entire project site which could have led to more accurate assessment of usage pattern of customers. Moreover, there were cases where the LED bulbs distributed to owner of the households were not given to tenants who actually pay the electricity bill. It was also found that some customers lack the general awareness about the warranty associated with the LED bulbs. One noteworthy outcome of the scheme has been clearing of electricity bill arrears by defaulters so that they can also be eligible to be enrolled in the project.

DELP in Puducherry has effectively demonstrated the potential of EPC (Energy Performance Contracting) model in India and has helped domestic lighting sector in leapfrogging to advanced lighting solutions through super-efficient LED lighting.

DELP in Puducherry has effectively demonstrated the potential of EPC (Energy Performance Contracting) model in India and has helped domestic lighting sector in leapfrogging to advanced lighting solutions through super-efficient LED lighting. The collaboration between EESL with PED indicates a paradigm shift in energy policy that will provide a level playing field to energy efficiency as an energy resource as compared to other supply side alternatives.

The project team would like to extend their sincere thanks to following people who helped us in conducting the survey and documenting this report in present form.

- Ms. Neelima Jain. Program Co-ordinator, EESL.
- Mr. Suresh, Project In Charge, DELP Puducherry.
- Mr. Sathish Murugan, Ecolite Technologies.
- Mr. Chandran, Consultant, DELP Puducherry.
- All households who shared their perspective during the survey and allowed it to be documented.

2.0: DSM Projects in Kerala

Project location: Kerala

Duration of visit: 22- 25th May, 2015.

2.1: Introduction

BLY program by Kerala state presents a success story as far as demonstration of successful EE (Energy Efficiency) and DSM (Demand Side Management) initiative is concerned. EMC (Energy Management Centre) has been adjudged the best State Designated Agency (SDA) for four years for its exemplary work in the field of energy efficiency and energy conservation.

Bachat Lamp Yojana (BLY) witnessed unparalleled success in terms of consumer participation in Kerala. BLY scheme along with SAVE campaign and the proposed DELP program details are detailed in the present report.

2.2: Bachat Lamp Yojana: (2010-2011)

Energy Management Centre (EMC) Thiruvananthapuram, in collaboration with Kerala State Electricity Board (KSEB) distributed about 12.7 million compact fluorescent lamps (CFLs) under Bachat Lamp Yojana (BLY) scheme. The project was registered under in UNFCCC under the Clean Development Mechanism (CDM) in 2010.

Two CFLs were distributed in exchange of two ICLs per domestic connection in the entire state of Kerala covering 20 electrical divisions of KSEB. The ICLs were collected by KSEB from the consumers. The following table documents major project details that surfaced during the site visits and meetings conducted with officials of EMC & KSEB.

Project Details	Bachat Lamp Yojana, Kerala
ICL Wattage	60 W
CFL specifications	Wattage: 14 W Power Factor: >0.85 Luminous flux: 760 lumen Color Temperature: 6500K THD: 3rd<2.4 mA, 5th<1.9mA, 7th<1mA Life: 6000 burning Hrs
Warranty Period	1 Year
Vendor	M/S Phillips

<table>
<tr><th>Project Details</th><th colspan="3">Bachat Lamp Yojana, Kerala</th></tr>
<tr><td rowspan="2">Implementing Agency</td><td colspan="3">Energy Management Centre & KSEB
• KSEB has initially called for tenders for CDM based CFL programme "BLY" in Nov. 2009
• Three firms shortlisted, but, none shown keen interest in implementing the project.</td></tr>
<tr><td colspan="3">• KSEB cancelled the bid and discussed with BEE to overcome the situation.
• EMC was identified as right agency to implement the project and registered as an investor in the BLY programme.</td></tr>
<tr><td>Replacement mechanism</td><td colspan="3">2 working ICLs replaced with 2 CFLs per residential connection at a cost of Rs. 15 per CFL</td></tr>
<tr><td rowspan="5">Distribution phases</td><td>Area & No. of project circle</td><td>No. of CFL distributed</td><td>% Coverage</td></tr>
<tr><td>South (6)</td><td>35,28,478</td><td>82.56</td></tr>
<tr><td>Central (7)</td><td>40,71,566</td><td>79.55</td></tr>
<tr><td>North (10)</td><td>50,13,976</td><td>83.19</td></tr>
<tr><td>Total (23)</td><td>1,26,14,020</td><td>81.81</td></tr>
<tr><td>Project Funding</td><td colspan="3">The total project cost is Rs. 95 Crore
• EMC received interest free loan of Rs 40 Crore from the Government of Kerala, which it will repay through the receipt of money from the sale of Certified Emission Reductions (CERs).
• It also received a loan amount of Rs 55 Crore at an interest rate of 13.5% from the Kerala State Electricity Board.</td></tr>
<tr><td>M&V adopted</td><td colspan="3">• No GSM based meter were used as proposed.
• Usage rate of 3.5 Hrs /day was used to estimate the savings.
• A sample of 1250 domestic consumers were selected from each of the 20 project areas of KSEB and details of the project participants were collected from these households using a structured questionnaire[1].</td></tr>
<tr><td>ICL disposal agency</td><td colspan="3">• Ecobirdd Recycling Pvt. Ltd.
• Indian pollution Control Association (IPCA)
• Global e-Waste Management and Service (GEMS) Recycling Pvt. Ltd.</td></tr>
<tr><td>Savings achieved</td><td colspan="3">• It is estimated that this project resulted in demand savings of 300 MW during the peak hours of March and April 2010.</td></tr>
<tr><td>Project Cost recovery</td><td colspan="3">• The project investor is allowed to claim the carbon credits achieved through the replacement of 60 W ICLs with 14 W CFLs.
• These carbon credits are called Certified Emission Reductions and are issued by the CDM executive board by emission reductions achieved by CDM projects.
• 1 CER is issued for verified reduction in emissions by 1 tonne of Carbon dioxide.
• These CERs can be traded in international markets; the most active ones include Europe, Japan, Canada and New Zealand; where the buyers of these credits have to comply with their emission limitation targets. Most of the sellers are from developing countries like India, Brazil, etc.
• During the registration of BLY under CDM, the cost of 1 CER was approximately 10 EURO. The project money was expected to be recovered through the sale of these CERs.</td></tr>
</table>

[1] A detailed M&V report of the BLY project prepared by Datamation Consultants Pvt. Ltd, New Delhi is available with EMC, Kerala.

Project Details	Bachat Lamp Yojana, Kerala
Project Closure Details	• The project was curtailed in Kerala and wasn't successful in getting vendors because the price of 1 CER fell considerable to 2 - 3 Euro and currently stands at 0.5 Euro/CER. The investment is no longer profitable and discourages investor to put funds in BLY and schemes under CDM. • At present EMC has about 8 lakh CERs. The present cost of CER in market is not appreciable for EMC to recover the project cost.

2.3: Additional Programs Taken up by EMC, Kerala

2.3.1: SAVE (Serve as a Volunteer for Energy) program: (2008-2009)

EMC in association with Malayala Manorama, the largest circulating newspaper daily in Kerala, organized an event for students and general public to spread awareness about the need for energy conservation. Quiz, essay competition and other programs were conducted and participants were requested to register for the SAVE program. The program required the registered participants to send their electricity bills to EMC for a period of few months and the participants who reduced their energy consumption by the maximum amount were to receive cash prizes. The program witnessed good response and about 18000 readers enrolled for the program and cash prizes worth Rs. 15 lakh were distributed with first prize of Rs.1 lakh. EMC used its own funds to implement the program and 217 Million units were saved by the participants as per the meter reading in bills.

This simple yet innovative program urged the consumers to compete for lowering their energy consumption to get the maximum financial incentive. The success of the program demonstrated its replicability for other geographical locations in the country. This program indirectly used a basic DR (Demand Response) model in which no complex technology was used but the customers at the demand side responded to the incentive signal sent by EMC. Similar energy conservation schemes can be structured on these lines at other places in the country.

2.3.2: DELP Kerala: Proposed Project

The project team met Mr. Ajay Kumar, Assistant Engineer (ESCOT), KSEB (through Mr. K M Dharesan Unnithan, Director, EMC, Kerala). In this meeting it was informed that KSEB has agreed to implement DELP in Kerala in association with EESL with few changes to the conventional approach followed by other utilities in the Country. BLY model will be used for DELP in Kerala. DELP is proposed to be implemented in three categories as follows:

First: Free of cost to customers in BPL (Below Poverty Line) category. Energy tariff is Rs. 1.5/unit.

Second: Customers above poverty line and consumption below 120 units per month will get LED bulbs at subsidized price (not decided yet) recovered through 12 month EMI. Average energy tariff is second and third category is Rs. 6/unit.

Third: Customers with energy consumption above 120 units will have to make full upfront payment for the subsidized price of the LED bulb (yet to be decided).

9 W LED bulbs will be distributed under the proposed project and operating hours of 3.5 Hrs per day, similar to BLY, will be used to estimate savings and repay loans.

Tender for the project is yet to be floated and the distribution phases will most probably start during the upcoming state election in Kerala.

2.4: Conclusion

The project team would like to extend their sincere thanks to the following people who shared their inputs and data regarding the DSM projects and helped in documenting the report in present form.

- Mr. K. M. Dharesan Unnithan, Director, Energy Management Centre, Kerala
- Mr. Ajay Kumar, Assistant engineer, ESCOT, Corporate Planning, KSEB, Kerala.

3.0: TPDDL Auto-DR Project

Project location: Delhi

Implementing Utility: Tata Power Delhi Distribution Limited

Technology Partners: Honeywell, IBM & Landis+Gyr.

3.1: Introduction

The goal of the TPDDL pilot program was to establish technology effectiveness of Automated Demand Response. The project aimed to empower consumers to analyze their consumption patterns closely and optimize their energy consumption through a dedicated customer portal.

Tata power Delhi Distribution Limited (TPDDL), one of the four electricity utilities in the state of Delhi. Honeywell, IBM and Landis+Gyr, a third party MDMS (Meter Data management System) vendor, were the technology partners for the project. The program lasted over a period of six months (May to October 2014) and witnessed participation from a total of 173 commercial and industrial customers.

Utility customers having a load greater than 100 kilowatts (kW) and a consolidated connected load of over 400 MW were included in the project. The project encompassed about one hundred 11 kV feeders, fed from 40 substations spread across the utility's distribution territory.

This report documents the project details along with deployment lessons and technical challenges encountered during the project.

3.2: Objective of the Project:

The goal of the TPDDL pilot program was to establish technology effectiveness of Automated Demand Response. The project aimed to empower consumers to analyze their consumption patterns closely and optimize their energy consumption through a dedicated customer portal. Through the customer portal, consumers were provided options to set threshold values for key parameters, like load and power factor, and received alerts once these thresholds were crossed either through their customer portal account or on their mobile phones through SMS. The smart meters installed at the consumer's premises and integrated with the control center provided TPDDL with instant information on outages and other factors related to the quality of power. This helped TPDDL to improve the reliability of power and to manage peak power demand more optimally, and avoid expensive power purchase during the peak hours. It further allowed the utility to effectively manage grid emergencies and will help in building the new age distribution network capability.

3.3: Technology Background

Demand Response Automation Server (DRAS) is the central communication network that was used by the utility to manage DR program participants, understand device communication status, and initiate and

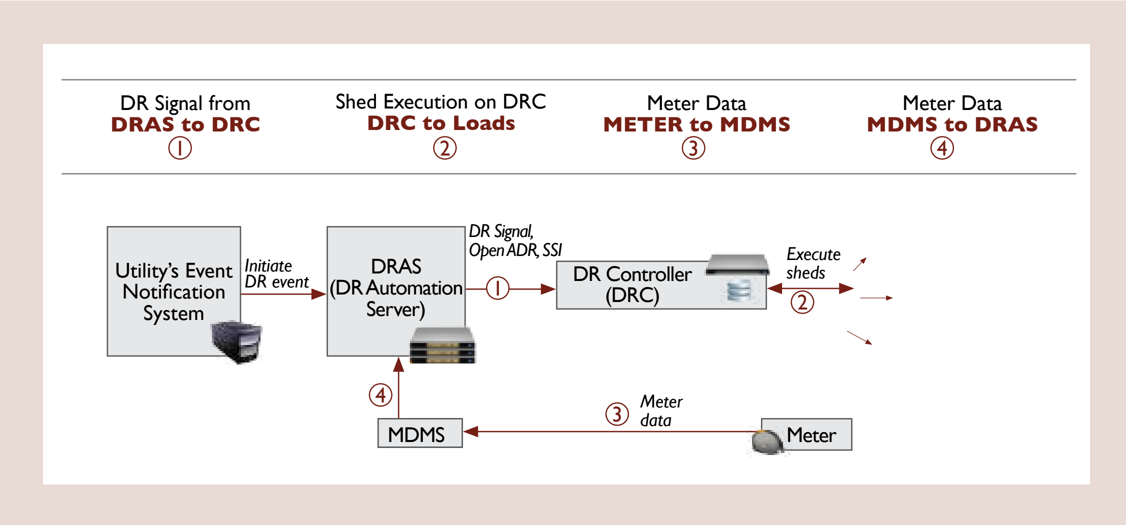


Figure 3.1: *Auto-DR deployment topology between the utility and a customer [1].*

manage Auto-DR curtailment events. Upon the event initiation, OpenADR[2] signals are communicated to each facility's Energy Management System (EMS), automatically initiating shed strategies predefined and implemented in collaboration with the customer. The OpenADR Gateway receives load shed events and communicates the shed events to the shed strategies configured at the site for reducing the current demand from that site [1].

DRAS is integrated with the utility's event notification system. The events are converted in DR signals, and are transmitted to the demand response controller/gateways at the customer site. The DR controller then shuts down or modulates the loads based on the shed strategies configured or commissioned in the site for each load. The meter data is integrated through the Meter Data Management System (MDMS) interface, where the entire consumer's meter data is integrated with each site. The meter ID of each customer is used to associate the gateway with the meter data to calculate the telemetry, baseline, and calculated demand. The AutoDR deployment strategy between the utility and a customer is shown in Figure 3.1.

3.4: Estimation of potential and value of the project

The DR potential by customer categories in the state of Delhi was estimated to provide the scale of DR as a future energy resource, and also understands the data requirements that could increase the accuracy of results.

The key requirements in estimating DR potential are data on aggregate load profiles, energy use during peak periods, and peak demands of different consumer categories within a utility. Equation [1] was used to estimate DR potential for each customer category and equation [2] estimated the total DR potential for each customer category from the peak demand for that category.

DR Potential = (Aggregated customer peak demand) * (DR as % of peak load) * (Participation rate) * (Response rate) (1)

$DR_C - PDC * \widehat{DR\%}_C$ (2)

Where,

PD_C: Peak demand for a category across a jurisdiction= $\dfrac{AE_C}{\widehat{LF}_C * 876\ Oh}$ (3)

[2] OpenADR is a communications data model designed to facilitate sending and receiving DR signals between a utility or independent system operator (ISO) and electric customers. This data model interacts with facility's Energy Management System (EMS) that are preprogrammed to take action based on a DR signal, enabling a DR event to be fully automated, with no manual intervention.

$\widehat{LF}_C$: Load factor of pilot participants of a category = $\frac{AE_C}{\widehat{PD}_C}$ (4)

DR_C: Technical demand response potential without considering participation rates

C: Customer category

AD_C: Average aggregate demand of pilot participants

$\widehat{PD}_C$: Peak aggregate demand of pilot participants

LF_C : Load factor of pilot participants of a category

AE_C : Average electricity consumption for a category across a jurisdiction

$\widehat{DR\%}_C$: Demand response as percentage of peak demand estimated from the pilot program

The total non-coincident technical DR potential for the various industrial customer categories across Delhi is approximately 25 megawatts (MW) but should not be interpreted as an upper bound as there were some assumptions. Assuming load factors of 0.5 and 0.3, and demand reduction of 7% and 26% relative to their aggregate peak demand (parameters estimated from the pilot program participants). It was estimated that the commercial and retail store customer categories could provide a demand response of approximately 20 MW and 50 MW, respectively, if future DR participants in these categories were to account for 10% each of the total non-domestic electricity consumption.

The pumping stations that participated in the pilot program provided a demand reduction of 15% relative to their aggregate coincident peak demand. Assuming a load factor of 0.25 and participation rates between 20% and 50% in this load category, the demand response potential could be in the range of 6 - 15 megawatts.

These estimates should be considered as indicative and further detailed analyses with better data are necessary to arrive at more accurate estimates [2]. Figure 3.2 shows the DR potential of customers of industrial category in Delhi.

Understanding the economics of DR, especially in the context of a particular utility and electricity sector, is important in order to determine the appropriate incentives for evoking and meeting the expected levels of DR. The objective of Demand Response being peak load reduction, savings in UI mechanism and avoided purchases in the wholesale DAM becomes the basis for the economic valuation of a DR program. It is assumed that the frequency of the system and DAM prices are determined exogenously.

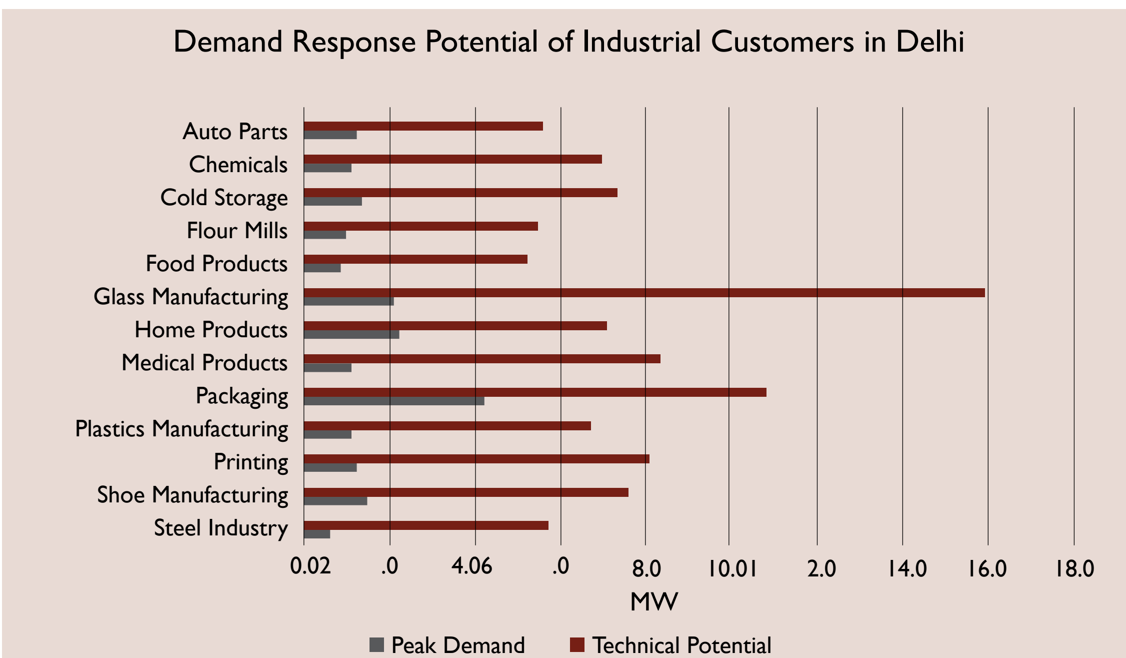


Figure 3.2: *Demand Response potential of certain Industrial customers in Delhi [2].*

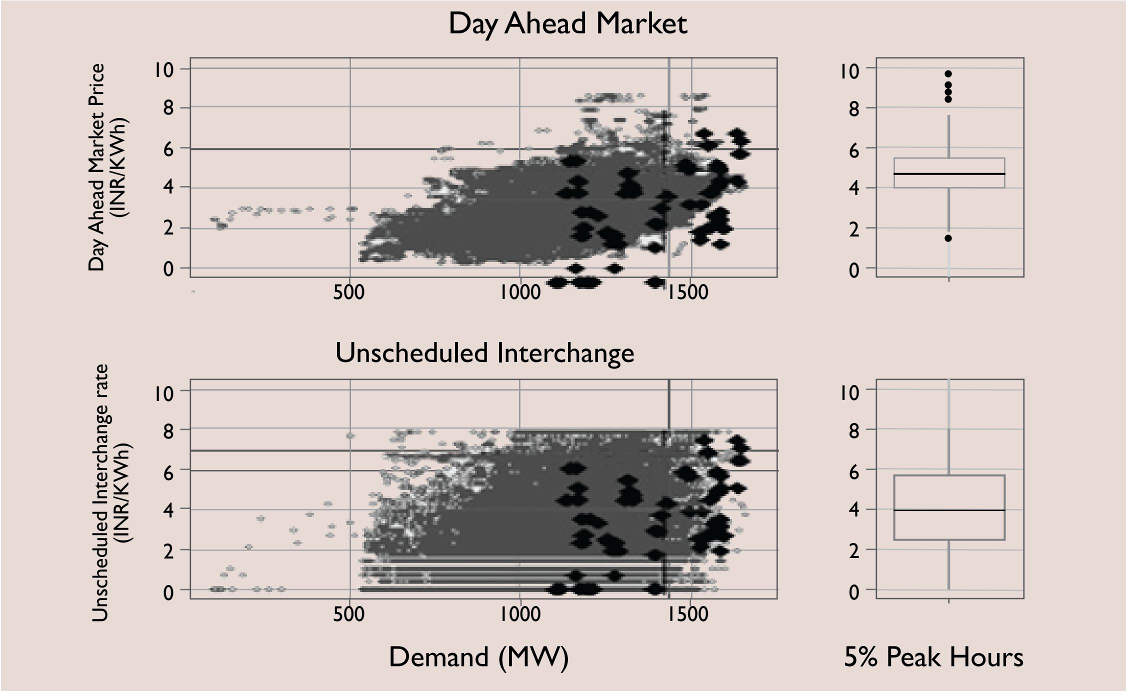


Figure 3.3: *Correlation between DAM prices & UI rates against TPDDL's demand [2].*

The DAM prices from the India Energy Exchange (IEX) and the UI rates that are based on system frequency over the six-month duration of TPDDL's pilot program were used to show their variation against TPDDL's demand, as well as the DR events from the pilot program in Figure 3.3. TPDDL's demand was found to be moderately correlated to India Energy Exchange's day-ahead market (DAM) prices and poorly correlated to UI penalty rates based on system frequency (Data from May–Oct 2014). Vertical lines mark the top 5% peak demand hours for TPDDL. Horizontal lines mark the top 5% of hours with the highest DAM price or UI rate. Dark markers represent demand response events from the pilot program. Box plots show the distribution of DAM prices and UI rates in the top 5% peak demand hours.

A DR event called during the top 5% peak hours for TPDDL (events that fall to the right of the vertical lines in Figure 1.3.3) would have resulted in an average savings of INR 4 per kWh from the UI mechanism or INR 4.5 per kWh from avoided purchases in the wholesale DAM (as shown in box plots in Figure 1.3.3). While these avoided costs are approximately equal to TPDDL's weighted average cost of generation of INR 4.2 per kWh, additional savings can result due to avoided transmission charges and losses. The hours of high DAM prices and UI rates, a sign of overall stress in the Indian national grid (events that fall at the top of the horizontal line), are not closely correlated to the peak demand hours of TPDDL. Calling a DR event during the top 5% hours with the highest DAM prices or UI rates could have resulted in savings of at least INR 6 or INR 7 per kWh or higher through DAM or UI, respectively.

DR events that were called during the top 5% hours with the highest DAM prices or UI rates, which may not always coincide with TPDDL's peak demand hours, could result in savings of INR 6 per kWh and above in generation costs, as well as avoided transmission charges and losses during the DR events. The quantum of DR that can be elicited from their customers depends highly on the incentives provided by the utility. While the pilot study did not offer varying prices for DR, in the future, TPDDL and other utilities may offer price-based incentives to elicit different levels of DR.

A total of 173 customers with various types of load characteristics were grouped together in different categories such as, cold storage, commercial, education, flour mill, hospital, industrial, pumping, retail, and others.

3.5: M&V Methodology

A total of 173 customers with various types of load characteristics were grouped together in different categories such as, cold storage, commercial, education, flour mill, hospital, industrial, pumping, retail, and others. The assessment of the AutoDR performance was carried out for each of the load categories. A smart meter was installed at each customer's facility to measure the energy use at 15-minute intervals. Baseline loads for all AutoDR test events were calculated using two models: simple average over the highest 5 out of 10 recent good baseline days (5/10 baseline), with and without morning adjustment (MA), which are described below.

- 5 out of 10 baseline model (5/10): The 5 days with the highest average load during the event period were selected from the previous 10 days of good data (excluding weekends, holidays, a DR event day, and any operation off day). The average of the load over these five days was calculated for each time interval.
- 5 out of 10 baseline model with MA (5/10 MA): The morning adjustment is a ratio of (a) the average load of the first three of four hours before the event to (b) the average load of the same hours from the selected five baseline days. The adjustment factor is limited to ±20% of the customer baseline.

The 5/10 MA baseline is included as a reference, as it is shown to reduce the bias and improve the accuracy of DR estimates for facilities that have variable load and where energy use is sensitive to weather changes. This reference allows better characterization of AutoDR performance for any future studies.

Table 3.1: Number of customers and peak demand of each consumer category [3]

Customer Category	No. of Customers	Meter data received	Peak demand (kW)
Cold Storage	6	6	1131
Commercial	12	11	4646
Education	7	3	1936
Flour Mills	27	25	7265
Industrial	94	77	10044
Hospitals	2	2	1434
Others	17	14	1889
Pumping	4	3	556
Retail stores	4	3	62
All	173	144	25259

HVAC loads in a building are affected significantly by the outside weather condition (e.g., outside air temperature, humidity, solar radiation). For building loads with high weather sensitivity, the average baseline model may underestimate or overestimate the DR shed if the AutoDR event day is much warmer or colder than previous baseline days. 5/10 MA baseline is used as a proxy to understand the AutoDR performance impacts for weather changes and load variability [3].

Data from 144 meters were recorded from all the participants for evaluating the project performance. Table 3.1 shows the number of customers and the peak demand of each sector category. The industrial, flour mill, and commercial sectors comprise the largest percentage of customers, about 77%, excluding the "others" sector, which includes unidentified customer types. These three sectors also have the highest peak demand, which accounts for nearly 87% of the aggregated peak demand (over 25 MW). In the industrial consumer sector there are ten sub-level sectors that include manufacturers of food, glass, packaging, plastic, printing, shoes, and other goods.

Of the aggregated demand, as shown in Figure 3.4, the 95th and 99th percentile of the demand are 21477 MW and 23322 MW, respectively. This means that the reduction of load during the top 70 hours would eliminate the need for 7.7%, or 1937 kW, of the system demand for the customers.

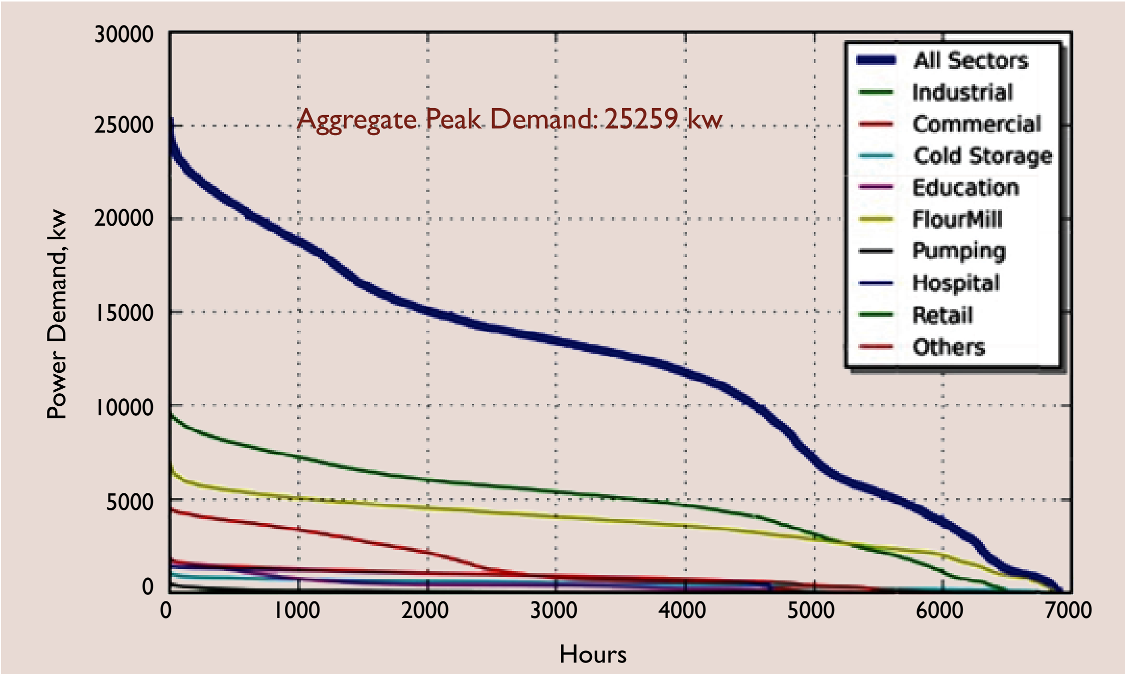


Figure 3.4: *Load Duration Curve of Each Customer Sector and Aggregated Load [3].*

3.6: Deployment Challenges

This being the first ADR deployment project for the implementing agencies, the technical and management team faced major challenges which are enumerated below.

1. Inter-operability challenges involving the integration MDMS with DRAS for mapping the meter data of all consumers to the gateway and in the customer portal.
2. Due to low network bandwidth associated with GSM networks, there were issues transferring the large amount of data from multiple sites to and fro from the DRAS to the gateway.
3. The segregation of critical and non-critical loads under the single site posed a major challenge because of the inconsistent consumption patterns of the most of the consumer sites.
4. Inconsistency between some of the customers schedule with the common system-level calendar and holiday schedules made it difficult to configure their DR.
5. Internet availability at the customer's site posed another bottleneck which was sorted out by installing GSM modems to enable the communication of ARD gateways with the DRAS server.
6. Lack of power back-up for the AutoDR controller, in most cases, led to addition of the UPS which increased the deployment cost.
7. In most consumer sites, such as flour mills and other production industries, the loads, such as pumps and motors, are not monitored through the automation system. These loads were controlled manually using electrical panels. When DR controller receives the shed events, it was not possible to detect the loads which are in ON status and for such loads triggering the appropriate shutdown commands posed a challenge. To overcome this integration issue, the team developed a small relay assembly, which can monitor the status of the load and drive the events received from the DR controller to respective loads which are in the ON state.
8. The project was implemented without any price based incentives. Presence of regulatory policies regarding an incentive mechanism could have encouraged more participation.

3.7: Project performance

The DR technologies used during the pilot project successfully enabled an interoperable DR signaling infrastructure to the utilities. The controllers in the facilities used these signals to automate their responses.

This ADR pilot project provided an opportunity to instill confidence and trust of DR technologies on the part of government and private utilities, and also enable consumers to participate in demand response programs.

Energy use data for 144 commercial and industrial customers at a 15-minute time resolution from May 2014 to October 2014 were used to estimate the demand reduction during these AutoDR events for each consumer category by computing the 75th percentile of the maximum DR shed over all the DR events using a 5/10 baseline with a morning adjustment factor. During this time period, TPDDL executed 17 AutoDR events, ranging from 0.5 to 1 hour each. The maximum demand reduction (75th percentile) as a share of each category's coincident peak demand during May to October 2014 ranged from 2% (for Education) to 28% (for Packaging).

It was found that the flour mill, industrial, and commercial sectors contribute the largest of AutoDR load shed, and can shed up to 1,637 kW, 972 kW, and 360 kW, respectively, for 5/10 baseline (representing 19%, 10%, and 8% of each sector's peak demand on the AutoDR baseline day).

The aggregated customer load can shed 10% of the aggregated peak demand at the 75th percentiles of all AutoDR performance for both 5/10 and 5/10 MA baselines.

3.8: Conclusion

This ADR pilot project provided an opportunity to instill confidence and trust of DR technologies on the part of government and private utilities, and also enable consumers to participate in demand response programs. The project demonstrated that ADR technologies can provide value to both customers and utilities to leverage the load flexibility as a cost-effective solution to the increase in the generation capacity and can lead to capital expenditures deferral, both in generation capacity and in transmission & distribution upgrades. The technical deployment lessons and challenges will help in encountering issues of large scale implementation of this project and other similar projects with much clarity and expertise.

The project team would like to extend their sincere thanks to Mr G. Ganesh Das for arranging visits to the control station and sites where the AMI technology has been deployed and also sharing the TPDDL perspective about the project.

3.9: References

[1] Rajesh V. Poojary, Girish Ghatikar, G. Ganesh Das, Sujay Kumar Saha, "Open Automated Demand Response: Industry Value to Indian Utilities and Knowledge from the Deployment," India Smart Grid Week (ISGW) 2015.

[2] Ranjit Deshmukh, Girish Ghatikar, Rongxin Yin, G. Ganesh Das, Sujay Kumar Saha, "Estimation of Potential and Value of Demand Response for Industrial and Commercial Consumers in Delhi," India Smart Grid Week (ISGW) 2015.

[3] Rongxin Yin, Girish Ghatikar, Ranjit Deshmukh, Aamir Hussain Khan, "Findings from an Advanced Demand Response Smart Grid Project to Improve Electricity Reliability in India," India Smart Grid Week (ISGW) 2015.

4.0: Portfolio of DSM projects implemented by DISCOMs in Mumbai

Project location: Mumbai

4.1: Introduction

Mumbai has been one of the active zones as far as number of DSM pilot projects implemented is concerned. It is one of the few cities in India to have both public and private distribution licensees supplying power, thus leading to a competitive market which has advantages for utilities undertaking DSM Programs. The electrical utilities operating in Mumbai are listed in the Table 4.1.

Table 4.1: Distribution Utilities in Mumbai

Utility Name	Acronym	Public/Private
Brihanmumbai Electricity Supply and Transport Undertaking	BEST	Public
Maharashtra State Electricity Distribution Co. Ltd.	MSEDCL	Public
Reliance Infra Distribution Ltd.	R-Infra	Private
The Tata Power Company Ltd	TPC	Private

The Maharashtra Electricity Regulatory Commission (MERC) has promoted DSM through notification of two major regulations, namely, MERC (Demand Side Management Implementation Framework) Regulations, 2010 and MERC DSM (Cost Effectiveness Assessment) Regulations, 2010, being the first state in India to do so. The regulations mandate the licensees to make DSM a part of their day-to-day operations and allow the licensees to recover their DSM costs from their Annual Revenue Requirement (ARR) while ensuring cost-effectiveness of the approved programs. A DSM Consultative Committee has also been formed under the regulations with Secretary, MERC as the Chairman, to assist the Commission in helping the utilities achieve their targets.

The programs implemented in Mumbai have a common base design. The Distribution Licensee (DL) provides rebate to the consumers willing to participate in the program by replacing their existing appliance with a new energy efficient device from market and with a BEE certified label. The rebate is in terms of price for purchase of the new appliance. The utility selects set of vendors through standard bidding process i.e., vendor(s) with lowest bid prices meeting technical requirements. The customers are generally selected on first come first serve basis. The supplier/vendor hires a third party agency to execute the program and the rebate is paid by the utility to the vendor after replacement. As these new appliances come with standard warranty and hence the consumer gets the benefit of rebate along with energy savings.

This report documents the details of DSM projects implemented by DISCOMs in Mumbai and provides a comparative analysis of the efforts and outcomes of the initiatives taken by utilities in context of DSM.

4.2: Tata Power: Mumbai Distribution

Tata Power, Mumbai Distribution, has implemented several DSM pilot projects targeting customers from residential, commercial and industrial category. It carries out its Residential DSM projects under the initiative called "My Mumbai Green Mumbai". This initiative gives an opportunity to Mumbai consumers to exchange their inefficient electrical appliances for new energy efficient appliances. Tata Power has partnered with leading consumer appliance manufacturers for energy efficient equipment. TPC-D carries out energy audits for Industrial and Commercial consumers by mapping their power consumption pattern and offering specific recommendations to improve the process and equipment efficiency. It has also launched initiatives such as Demand Response and Thermal Energy Storage programs, which motivate the consumers to shift load from peak to off peak. The tables below briefly document the various project details and their outcomes in brief.

<table>
<tr><th></th><th colspan="4">Energy efficient Lighting programme</th></tr>
<tr><td>DSM objective</td><td colspan="4">Strategic conservation through replacement of T12 & T8 FTLs (Magnetic ballast) with T5 FTL (Electronic ballast).</td></tr>
<tr><td rowspan="5">Technology comparison (FTL)</td><td>Comparison Indices</td><td>T12</td><td>T8</td><td>T5</td></tr>
<tr><td>Lamp Rating (Watt)</td><td>40</td><td>36</td><td>28</td></tr>
<tr><td>Life (Burning Hours)</td><td>5000</td><td>5000</td><td>10000</td></tr>
<tr><td>Luminous efficacy (Lumens /Watt)</td><td>60</td><td>60</td><td>>77</td></tr>
<tr><td>Ballast Used</td><td>Magnetic</td><td>Magnetic/ Electronic</td><td>Electronic</td></tr>
<tr><td rowspan="7">Technology comparison (Ballast)</td><td>Comparison Indices</td><td>Electronic Ballast</td><td colspan="2">Magnetic Ballast</td></tr>
<tr><td>Rating (Watt)</td><td>~ 3</td><td colspan="2">~ 12</td></tr>
<tr><td>Power factor</td><td>≥ 0.9</td><td colspan="2">0.5</td></tr>
<tr><td>THD</td><td>< 10 %</td><td colspan="2">NA</td></tr>
<tr><td>Life (years)</td><td>10</td><td colspan="2">>10</td></tr>
<tr><td>Starter requirement</td><td>No</td><td colspan="2">Yes</td></tr>
<tr><td>Instant Start</td><td>Yes</td><td colspan="2">No</td></tr>
<tr><td>T5 FTL specifications</td><td colspan="4">Wattage: 28 W
Life : 2 years</td></tr>
<tr><td rowspan="6">Target customer category & maximum no. of eligible T5 FTls</td><td>Residential</td><td colspan="3">Commercial/Industrial (connected load)</td></tr>
<tr><td rowspan="5">All LT connections : 3 FTLs</td><td colspan="3">0-10 kW : 10 FTLs</td></tr>
<tr><td colspan="3">20-50 kW : 20 FTLs</td></tr>
<tr><td colspan="3">50-100 kW : 50 FTLs</td></tr>
<tr><td colspan="3">100-300 kW : 150 FTLs</td></tr>
<tr><td colspan="3">>300 kW : 250 FTLs</td></tr>
<tr><td>Vendor</td><td colspan="4">Osram India Pvt. Ltd.</td></tr>
<tr><td>Budget approved</td><td colspan="4">116.50 lakh approved by MERC on 24th Nov, 2009.</td></tr>
<tr><td>No. of units replaced</td><td colspan="4">4353 units replaced with Rs. 7.76 Lakh given as rebate to participants.</td></tr>
</table>

<table>
<tr><th></th><th colspan="5">Energy efficient Lighting programme</th></tr>
<tr><td rowspan="5">Cost sharing</td><td>Product details</td><td>Customer category</td><td>Total Cost per FTL without rebate (Rs./unit)</td><td>Customer contribution</td><td>Tata Power contribution</td></tr>
<tr><td rowspan="2">Osram make Helios Putty T5 IQ</td><td>Residential</td><td rowspan="2">500</td><td>300</td><td>200</td></tr>
<tr><td>Non-Residential</td><td>350</td><td>150</td></tr>
<tr><td rowspan="2">Osram make Helios Connect T5 IQ</td><td>Residential</td><td rowspan="2">610</td><td>410</td><td>200</td></tr>
<tr><td>Non-Residential</td><td>460</td><td>150</td></tr>
<tr><td>M&V methodology</td><td colspan="5">• A random test on the life of the lamp was mandated on approximately 0.5% FTLs brought from various dealers in the city. The tests were conducted by an independent entity accredited by NABL.
• Physical verification of installation of FTLs of sample of customers in addition to the random testing requirements was performed. M&V agency installed hour meters on sample of up to one percent of the FTL's replaced. Further monitoring of hours of energy consumption for the period of one year to study the effectiveness of the program in conserving energy</td></tr>
<tr><td>Annual Energy Savings achieved</td><td colspan="5">Estimated annual energy savings of 0.16 MU achieved.</td></tr>
<tr><td>Current Status</td><td colspan="5">Scheme is amended and converted to LED programme due to availability of LED as a better option.</td></tr>
</table>

	Energy efficient 5 Star Split AC programs
DSM objective	**Strategic conservation** through replacement of old inefficient AC with highly efficient 5 Star Split AC.
Technical specification	5 Star BEE rated Split AC of 1 TR, 1.5 TR & 2 TR
Maximum no. of eligible replacements	Two units per customer
Target customer category	LT Industrial & Commercial customers
Vendor	Carrier India Ltd.
Rebate applicable	Rebate of Rs. 4000 per AC is applicable for "New Purchase" and Rs 6000 per AC for "Exchange Program". Negotiated Cost of 5 Star split AC including taxes, installation charges etc. with buyback is Rs 29,000 for 1 TR, Rs 35,000 for 1.5 TR & Rs 40,000 for 2 TR.
Budget approved	Rs. 105 Lakh approved on 18th March, 2010.

	Energy efficient 5 Star Split AC programs
M&V methodology	• To carry out M and V, stratified sample was selected on random basis from Tata power supply area in Mumbai. These selections included the customers from Chakala, Borivali, Malad, Andheri and Dahisar. The Secure make meters were selected for the measurement of the parameters Cumulative Power, Energy and Running hours. • Prior to installation of the Energy efficient AC, Tata power Engineers along with the electrician of the AC installation agency visited the consumer's premises. The energy meter having capacity of recording 30 minute interval data was placed in series with the Air Conditioners for approximately 1 week. • After replacement, the same meter was put in series with new 5 Star rated Air Conditioner for approximately 1 week. Then the meter data was downloaded and analysis was carried out. These reports proved the savings of 4 to 7 units per day per consumer.

No. of units replaced & Annual Energy Savings achieved

	FY 2013-14	FY 2014-15	Total
No. of AC installation	103	99	202
Rebate paid (Rs. in Lakh)	1.82	4.78	6.6
Annual Energy Savings achieved (in MU)	-	-	0.17

Current Status	The program is extended to Residential customers and rebate of 40% on the MRP is provided on a new purchase of BEE 5 Star rated Split AC of 1 TR & 1.5 TR.

	Energy efficient 5 Star Ceiling fan programme
DSM objective	**Strategic conservation** through replacement of old inefficient ceiling fans with BEE 5 star rated efficient ceiling fans.
Technology comparison	Replacement of old inefficient ceiling fan consuming 75 to 80 W with BEE 5 Star rated ceiling fan consuming 50 to 52 W.
Target customer category	Residential consumers.
Vendor	Havells India Ltd.
Budget approved	Rs. 81.2 Lakh approved for 10,000 ceiling fans.

	Energy efficient 5 Star Ceiling fan programme
No. of units replaced	• A pilot project approved on 18th March, 2010 targeting 2000 consumers. The programme got good response and the customers registered for 2286 fans. Even though the approval was for 2000 fans, all customers were served and quantity of 2286 was installed. TPC has given incentive of Rs. 10.40 Lakh under this scheme to the participants. • TPC submitted its M&V and closure report on 8th July 2011, Based on experience and learning from the pilot, a large scale program was submitted by TPC which was approved on 11th August, 2011. The excess quantity of 286 fans distributed during pilot project was adjusted in large scale program approval. • The 12490 installations were conducted in second phase with rebate of Rs. 74.94 Lakh given to the participants under the programme.

Annual Energy Savings achieved

	FY 2011-12	FY 2012-13	FY 2013-14	FY 2014-15	Total
No. of Installations	1120	5841	4032	1497	12490
Rebate paid (Rs. in Lakh)	6.02	35.74	24.19	8.98	74.94
Annual Energy savings achieved (in MU)	-	-	-	-	0.94

Current Status	Active

	Energy efficient 5 Star rated Refrigerator programs
DSM objective	**Strategic conservation** through replacement of old inefficient Refrigerators with BEE 5 star rated direct cool refrigerators.
Product specifications	• Direct cool refrigerators with maximum capacity of 250 Liters. • A minimum of 2 years warranty and 5 years maintenance period was insisted from the suppliers for 5 star rated direct cool refrigerators.
Target customer category	Residential consumers.
Budget approved	Rs. 2.11 Crore approved on March 2, 2012.
No. of units replaced	• Target was 5000 consumers. The rebate of Rs. 4000/- was offered to the targeted consumers for each 5 star direct cool Refrigerators with a rating up to 250 litres net capacity. • TPC –D has replaced 767 refrigerators with rebate of Rs. 34.51 Lakh given to the participants. • 294 installations in 2013-14 and 473 in 2014-15 happened under this pilot scheme.

	Energy efficient 5 Star rated Refrigerator programs			
Annual Energy Savings achieved		**FY 2013-14**	**FY 2014-15**	**Total**
	No. of installations	294	473	767
	Rebate paid (Rs. in Lakh)	13.23	21.28	34.51
	Annual Energy savings achieved (in MU)	-	-	0.34
Current Status	Active			

	Thermal Energy Storage Programme
DSM objective	Load Shifting.
Target customer category	Commercial and industrial users having central air conditioning systems of rating more than 100 TR.
Rebate/ Incentive mechanism	The program was based on the incentive based model where the fixed capital subsidy of 5000 per TR (assuming the 25 % of the capital cost) was offered by the TPC-D and rest of the amount was to be borne by the consumer. The project expenditure was funded through the LMC (Load management Charge) fund of the TPC-D.
Budget approved	Approved budget was Rs. 59 lakh and the program was launched in May 2010.
Customers enrolled/shown interest	Tata Power enrolled a thermal storage capacity of over 15,000 TRH. 1. M/s. Godrej and Boyce limited, Vikroli, Mumbai. 2. State bank of India, BKC, Mumbai. 3. M/s. M & M, Kandivali (East), Mumbai 4. M/s. Nomura Services, Powai, Mumbai 5. M/s. Neo Pharma Private limited, Santa Cruz(East), Mumbai 6. M/s. Hiranandani Hospitals, Powai, Mumbai 7. M/s. Sahara star, Vile Parle (East), Mumbai 8. Rang sharada, Bandra (West), Mumbai 9. Kohinoor Continental, Andheri (East), Mumbai 10. Uni Design, SEEPZ, Mumbai. 11. M/s. Black & Veatch, Powai, Mumbai 12. M/s. P.N. Writer, Mumbai 13. M/s. Excel Industries, Andheri (East), Mumbai.

<table>
<tr><th></th><th colspan="6">Thermal Energy Storage Programme</th></tr>
<tr><td rowspan="4">Peak load and energy shift achieved</td><td colspan="6">TPC-D was able to shift 1600 KVA load during peak hours and succeeded to achieve 3.78 MU energy shift due to the programs.</td></tr>
<tr><td>TES program</td><td>FY 2011-12</td><td>FY 2012-13</td><td>FY 2013-14</td><td>FY 2014-15</td><td>Total</td></tr>
<tr><td>kWh Shifted</td><td>149803</td><td>2715323</td><td>730242</td><td>180626</td><td>3775994</td></tr>
<tr><td>Incentive paid (in Rs. lakh)</td><td>1.11</td><td>10.24</td><td>1.86</td><td>1.81</td><td>15.02</td></tr>
<tr><td>Current Status</td><td colspan="6">The project is still on.</td></tr>
</table>

<table>
<tr><th></th><th colspan="6">Demand response Programme</th></tr>
<tr><td>DSM objective</td><td colspan="6">Peak Load reduction through changes in temperature settings of AC plants, shifting of work times, staggered switching of lighting supply, shift in pump operations, load curtailment using building management systems and switching on the stand by generation</td></tr>
<tr><td>Target customer category</td><td colspan="6">IT & ITES companies, sewage pumping stations and industrial customers.</td></tr>
<tr><td>Project approval date</td><td colspan="6">13th May, 2011.</td></tr>
<tr><td>Incentive paid</td><td colspan="6">TPC-D paid incentive of Rs. 11.07 Lakh to the participants till date. Program achieved 311422 units load shift during the peak hours.</td></tr>
<tr><td rowspan="3">Load Shifting achieved during Peak time</td><td></td><td>FY 2011-12</td><td>FY 2012-13</td><td>FY 2013-14</td><td>FY 2014-15</td><td>Total</td></tr>
<tr><td>Load shifted (in kWh)</td><td>49877</td><td>20397</td><td>27957</td><td>29610</td><td>311422</td></tr>
<tr><td>Incentive paid (Rs. in Lakh)</td><td>0.66</td><td>7.22</td><td>1.38</td><td>0.88</td><td>11.07</td></tr>
<tr><td>Current Status</td><td colspan="6">The project is still on.</td></tr>
</table>

<table>
<tr><th></th><th>Energy audit Programme</th></tr>
<tr><td>DSM objective</td><td>Identifying energy conservation and energy efficiency measures through conducting energy audit of customer's premises by energy audit firms approved by BEE.</td></tr>
<tr><td>Target customer category</td><td>Commercial and Industrial consumers.</td></tr>
<tr><td>Project approval date</td><td>21st August 2009.</td></tr>
<tr><td>Energy Savings achieved</td><td>TPC-D has completed 77 energy audits and rebate of Rs. 57.10 Lakh is paid to the participants. TPC-D has suggested the various measures to the participants to save the energy estimated to 24435.86 MWh.
<table>
<tr><th></th><th>FY 2011-12</th><th>FY 2012-13</th><th>FY 2013-14</th><th>FY 2014-15</th><th>Total</th></tr>
<tr><td>No. of audits done</td><td>39</td><td>21</td><td>13</td><td>4</td><td>77</td></tr>
<tr><td>Rebate paid (Rs. in Lakh)</td><td>27.25</td><td>19.96</td><td>6.05</td><td>3.84</td><td>57.10</td></tr>
</table></td></tr>
<tr><td>Current Status</td><td>The project is still on.</td></tr>
</table>

	Standard offers Programme
DSM objective	Reduction the morning peak load in Mumbai by supporting energy efficiency initiatives of the consumers and monetizing the energy savings from specific end-uses thus pushing large-scale application.
Project specifications	Under the Standard Offer scheme incentive of Rs. 1 per unit for proven energy saving achieved during 08:00 Hrs to 20:00 Hrs except Sundays and holidays is provided.
Target customer category	Industrial and Commercial
Budget approved	The Commission approved the pilot project in January 2013 with budget of Rs. 42.5 lakh.
M&V methodology	The responsibility of proving the energy saving, providing meters and infrastructure for M&V would be the consumer's. The incentive would be offered for 3 years provided the rolling baseline can be created for each quarter. This will be possible for controls which can be switched off to establish the base line. In case of one time implementation or retrofit project, base line would be developed for a month before implementation and incentive will be calculated based on the same. In such case, the incentive will be paid only for one year as rolling base line is not possible. Tata Power would carry out the M&V with third party M&V professional.
Estimated Energy Savings	The pilot is designed to provide Standard Offer incentive for maximum 3 Million Units (30, 00, 000 KWh/Year) for next 3 years.
Current Status	Recording of actual energy consumption by the consumer has been started. M&V of the project is in progress.

4.3: Reliance Infra: Mumbai distribution

Reliance Infra (R-Infra) also started the DSM cell around 2007. Appliance exchange programmes form the bulk of R-Infra's DSM programme portfolio. The tables below document the project details and the outcome in brief.

<table>
<tr><th></th><th colspan="4">Five star rated ceiling fans Programme</th></tr>
<tr><td>DSM objective</td><td colspan="4">Strategic conservation through replacement of old inefficient ceiling fans with BEE 5 star rated efficient ceiling fans. Creating awareness on the benefits of using energy efficient appliances and also to remove barriers on its purchase.</td></tr>
<tr><td>Technology comparison</td><td colspan="4">Replacement of old inefficient ceiling fan consuming 75 to 80 W with BEE 5 Star rated ceiling fan consuming 50 to 52 W. Maximum of 3 fans per customer was allowed.</td></tr>
<tr><td>Target customer category</td><td colspan="4">Residential consumers having the monthly consumption below 500 units per month.</td></tr>
<tr><td rowspan="4">Vendor</td><td colspan="4">Havells India Ltd. Two fan models were provided. New Purchase was applicable to new and existing customers having no ceiling fans.</td></tr>
<tr><td>5 Star Fan Model</td><td>MRP (Rs./unit)</td><td>Exchange Price (Rs/unit)</td><td>New Purchase Price (Rs./unit)</td></tr>
<tr><td>Velocity 5 Star (Non decorative)</td><td>2240</td><td>1050</td><td>1250</td></tr>
<tr><td>Fusion 5 Star (Decorative)</td><td>2730</td><td>1410</td><td>1610</td></tr>
<tr><td>Budget approved</td><td colspan="4">Rs. 1.34 Crore of budget was approved on 13 April 2012.</td></tr>
<tr><td>No. of units replaced</td><td colspan="4">• In the first phase 5000 ceiling fans were replaced and the replacement of 20000 fans under the second phase of the pilot program was proposed.
• The warranty period from the manufacturer was three years.</td></tr>
<tr><td rowspan="3">Annual Energy Savings achieved</td><td></td><td>FY 2013-14</td><td>FY 2014-15</td><td>Total</td></tr>
<tr><td>No. of Installations</td><td>10400</td><td>1727</td><td>12127</td></tr>
<tr><td>Annual Energy Savings achieved (in MU)</td><td>-</td><td>-</td><td>0.91</td></tr>
<tr><td>Current Status</td><td colspan="4">First phase completed in August 2012 and second phase is in execution.</td></tr>
</table>

<table>
<tr><th></th><th colspan="4">Five Star rated refrigerator programme</th></tr>
<tr><td>DSM objective</td><td colspan="4">Strategic conservation through replacement of old inefficient Refrigerators with BEE 5 star rated direct cool refrigerators and peak load reduction.</td></tr>
<tr><td>Product specifications</td><td colspan="4">• BEE 5 Star rated Refrigerators. Capacity 250 Liters.
• Rebate from the utility were proposed to be given 4500 per refrigerator. Special Rs. 1000 incentive was offered to the consumers willing to switch from double door refrigerator to single door refrigerator.</td></tr>
<tr><td>Target customer category</td><td colspan="4">Residential consumers.</td></tr>
<tr><td>Vendor</td><td colspan="4">Godrej</td></tr>
<tr><td rowspan="3">Annual Energy Savings achieved</td><td>5 Star rated refrigerator program</td><td>FY 2012-13</td><td>FY 2013-14</td><td>Total</td></tr>
<tr><td>No. of Installations</td><td>3073</td><td>636</td><td>3709</td></tr>
<tr><td>Annual Energy Savings in MU</td><td>-</td><td>-</td><td>1.62</td></tr>
<tr><td>Current Status</td><td colspan="4">Project is closed.</td></tr>
</table>

<table>
<tr><th></th><th colspan="4">Five star Split AC Programme</th></tr>
<tr><td>DSM objective</td><td colspan="4">Strategic conservation through replacement of old inefficient window AC with highly efficient 5 Star Split AC.</td></tr>
<tr><td>Technical specification</td><td colspan="4">• 5 Star BEE rated Split AC.
• 1 TR & 1.5 TR capacity.
• Extended warrantee of 1 Year on machine and 4 years on compressor.
• Free standard installation.</td></tr>
<tr><td>Target customer category</td><td colspan="4">Small commercial customers</td></tr>
<tr><td>Vendor</td><td colspan="4">LG</td></tr>
<tr><td rowspan="4">Rebate applicable</td><td colspan="4">Discount of 40% on MRP.</td></tr>
<tr><td>Split AC Model</td><td>Market Price (Rs./ Unit)</td><td>Discounted Price (Rs./ Unit)</td><td>Cost Savings</td></tr>
<tr><td>1 TR</td><td>27000</td><td>16000</td><td>11000</td></tr>
<tr><td>1.5 TR</td><td>33000</td><td>20000</td><td>13000</td></tr>
<tr><td>No. of units replaced and energy savings achieved.</td><td colspan="4">50 units were sold with an estimated savings of 0.07 MU.</td></tr>
<tr><td>Current Status</td><td colspan="4">• The program was discontinued as Star ratings norms were changed by BEE.
• Second phase of five star split AC program with target of 1500 split ACs has been started.
• The program is extended to Industrial customers as well with Godrej as new vendor.
• Savings are estimated to be 3.87 MU.</td></tr>
</table>

	CFL Program
DSM objective	**Strategic conservation** through use of energy efficient CFL bulbs.
Technical specification	15 W CFL
Target customer category	All customer categories
Vendor	Bajaj
Rebate applicable	• Energy Saving CFL worth Rs. 165 at Rs. 63 under scheme. Payment was to be in installments. • If first 9 installments, of Rs. 7 each, are paid in time, last 3 (Rs.19) was waived off.
No. of units replaced and energy savings achieved.	• 2.05 Lakh customers enrolled for the program and 6.17 Lakh CFLs were sold. • Annual energy savings add up to 50 MU
Current Status	The program was launched in FY 2006-07 and is no longer in execution.

	T5 FTL Program
DSM objective	**Strategic conservation** through replacement of old FTLs with highly efficient T5 FTLs
Technical specification	• Power rating: 31 W, Tube (28 W) and ballast (3W) • 2 years extended warranty • Free installation was provided
Target customer category	All Customer category
Vendor	Osram
Rebate applicable	60 % discount on MRP.
No. of units replaced and energy savings achieved.	4000 units were sold and estimated energy savings were 0.15 MU.
Current Status	The program was launched in FY 2011-12 and no longer in execution.

	Capacitor Installation Program
DSM objective	Reduction in maximum power requirement through power factor improvement
Technical specification	• Poly Propylene Capacitor • Extended 5 tears warranty. • Cost inclusive of installation and wiring.
Target customer category	Commercial and Industrial
Vendor	Shreem & Energe Capacitors
Rebate applicable	30 % discount with extended product investment.
No. of units replaced and energy savings achieved.	Total of 2178 kVAR rating of Capacitors installed with estimated savings of 2 MU/annum.
Current Status	Program was launched in FY 2010-11 and is no longer in execution.

	Street Light Conversion Program
DSM objective	**Strategic conservation** through replacement of inefficient HPMV lamps with efficient HPSV lamps
Technical specification	125 W HPMV lamps were replaced with 70 W HPSV lamps.
Target customer category	Municipal
No. of units replaced and energy savings achieved.	36560 lamps were replaced and energy savings achieved were 16.98 MU.
Current Status	The project was launched in FY 2008-09 and is no longer in operation.

	Energy Audit Scheme
DSM objective	Identifying energy conservation and energy efficiency measures through conducting energy audit of customer's premises by energy audit firms approved by BEE.
Target customer category	• Commercial and Industrial consumers. • 75 % of the audit fee reimbursement from R Infra D if the suggested measures were adopted by the consumers
Energy Savings achieved	• Rinfra completed 50 energy audits. • Estimated Savings for Large Consumer: 5.13 MU • Estimated Savings for Small consumer : 3.2 MU
Current Status	The project was launched in FY 2008-09 and is no longer in execution.

4.4: Maharashtra State Electricity Distribution Company Limited (MSEDCL)

MSEDCL has implemented two DSM pilot projects till date one of which was implemented in their own substation and section offices and the other was implemented in agricultural load category. The table below documents the project details and the outcome in brief.

	Five star rating ceiling fan Programme
DSM objective	**Strategic conservation** through replacement of old inefficient ceiling fans (approx. 80 W) with BEE 5 star rated efficient ceiling fans.
Product specification	1200 mm span, BEE 5 Star rated ceiling fans of power rating 55 W.
Target customer category	MSEDCL substations & section offices
Vendor	Orient fans
No. of units replaced and energy savings achieved.	• 5000 fans were allotted out of which 4998 fans were installed. • From M&V analysis of 256 fans, the usage in hrs per fan was measured to be 10.88 hrs. • Energy savings of 0.408 MU was observed after M&V reports.
Current Status	The pilot program is completed.

4.5: Brihanmumbai Electric Supply and Transport (BEST)

BEST submitted a proposal to the Maharashtra Electricity Regulatory Commission (MERC) for carrying out DSM pilot projects. This pilot projects given below were approved which targets mainly the customers from residential and commercial category.

1. Replacement of 25000 old conventional 52 W FTLs with energy efficient 31 W T-5 FTLs: Rebate of Rs. 200/- for residential consumer (maximum 2 FTL per consumer) and rebate of Rs. 150/- for commercial consumer (maximum 5 FTL per consumer).
2. Replacement of 5000 old fans (80 W) with BEE five star rated fan (55 W): Rebate of Rs. 560/- for residential consumer (maximum 1 fan per consumer) and rebate of Rs. 490/- for commercial consumer (maximum 2 fans per consumer).
3. Replacement of 200 old inefficient Window AC with BEE 5 Star rated Split AC: Rebate of Rs. 7000/ TR for Non-government LT-II commercial consumer (300-1000 units /month) (maximum 2 ACs per consumer).
4. Program to install thermal storage of 1000 TR equipment in central air-conditioning system for consumers of LT-II and HT II category consuming 10000 units / month.
5. Replacement of 1000 TR old inefficient chiller consuming 1.2 kW/TR by new efficient screw type chillers consuming 0.8 KW / TR.

Load survey and research is going on for assessing DSM potential and the pilot programmes are yet to be executed.

4.6: Transaction cost of DSM projects implemented

Since utilities in Mumbai have been allowed to recover their DSM project expenditures through ARR, the cost benefits tests such as TRC, RIM and LRIRIM tests as mandated in MERC DSM regulations ensure that the DSM expense filings in ARR do not impact the tariffs adversely. Budgets are approved for DSM projects in accordance with these cost benefit tests. The approved budget ensures a cap on the funding level that can be used to implement the project so that the end consumers are not burdened. Cost and saving analysis can help in understanding the extent up to which the DSM targets are achieved and at what expense.

Since utilities in Mumbai have been allowed to recover their DSM project expenditures through ARR, the cost benefits tests such as TRC, RIM and LRIRIM tests as mandated in MERC DSM regulations ensure that the DSM expense filings in ARR do not impact the tariffs adversely.

Transaction cost of a DSM project can provide an accurate assessment of the cost incurred in generating one unit of energy savings. It can be very handy in comparing the cost of energy savings with cost of actual electricity generation, thus providing a basis to weigh one against the other in true economic sense. DSM implementation is still an outcome of enforced mandates for public utilities and a means for brand marketing for their private counterparts in general. Although some utilities have approached DSM through innovative initiatives like Demand Response and Thermal energy storage, the scale of DSM implementation has not gone beyond pilot projects which have kept the transaction costs of these projects on a higher side as compared to the power procurement cost by the utilities.

It is also difficult to calculate the transaction cost of DSM projects in cases where actual energy savings are actually the estimated values. Moreover, these estimated energy savings have been found to be erroneous in some cases. The actual expenditure on a specific DSM project is also found to be mixed with various other fixed costs and it becomes difficult to separate the one from the other unless a detailed breakup of DSM expenses is available.

Table 4.2 Outlines the DSM expenses by utilities in Mumbai. As per their tariff order submissions, they have claimed these expenses under ARR which is either approved by MERC or adjusted in their LMC (Load management Charge) Fund.

Table 4.2: DSM expenditures as reported by the DISCOMs in Mumbai

Utility	DSM expenses recovered through ARR /LMC fund (in Rs. crore)									
	FY 2007-08	FY 2008-09	FY 2009-10	FY 2010-11	FY 2011-12	FY 2012-13	FY 2013-14	FY 2014-15	FY 2015-16	Total expenditure (in Rs. crore)
Tata Power[1]	1.55 (LMC)	0.53 (LMC)	0.90 (LMC)	0.89 (LMC)	0.91 (LMC)	2.21 (LMC)	4.28 (1.07+3.21 : LMC +ARR)	5.33 (ARR)	5.56 (ARR)	22.16
R-Infra[2]	R-Infra has mentioned the DSM expenses for FY 2008-09 & FY 2009-10 as 42.64 crore & 70.41 crore respectively in its tariff order submission to MERC. They have also stated that these expenses have not been included in the ARR and as they can be adjusted in the LMC fund. It is to be noted that the balance amount in the LMC fund, as per their submission is 7.77 crore. There have been no other submissions regarding DSM expenses for any other years so far.									Insufficient data available in the public domain
MSEDCL[3]	-	-	-	-	-	-	-	1.02 (ARR)	8.44 (ARR)	9.46 (6.79 crore spent on Five star rating ceiling fan Program)
BEST[4] (Projected Expenses)	-	-	-	-	-	-	4.79 (ARR)	5.03 (ARR)	5.28 (ARR)	15.1

Source:

1. *Case No.179 of 2011: MERC Order for TPC-D for ARR of FY 2011-12 and MYT Petition for FY 2012-13 to FY 2015-16.*
2. *Case No.4 of 2015: MERC Mid-Term Review Order for Rinfra-D for FY 2012-13 to FY 2015-16*
3. *Case No. 121 of 2014: MYT Order of MSEDCL for the period from FY 2013-14 to FY 2015-16*
4. *Case No.26 of 2013: MERC Order on BEST Petition for True-up of FY 2010-11and FY 2011-12 and MYT Petition for FY 2012-13 to FY 2015-16.*

Since, the DSM expenses submitted by utilities are not project-wise, it will be difficult to calculate the transaction cost of a specific DSM project which is ideally required so as to come up with benchmark cost for similar DSM projects all over the country. Hence average annual transaction cost for a portfolio of DSM projects undertaken by a utility is calculated due to absence of data in an appropriate and standard form.

$$\text{Average annual transaction cost (in Rs. /KWh)} = \frac{\text{Average annual DSM expenditure}}{\text{Average annual energy savings}}$$

This metric explained above can provide an insight into the amount spent by utilities to achieve one unit of energy savings and can be compared with the average power procurement cost of utilities to identify their level of preference of DSM over traditional energy procurement mechanisms. Although in case of some DSM projects, such as demand response and thermal storage programs, peak load shift is the primary objective/outcome, the metric can be extended to include average annual peak load shift in place of average annual energy savings and henceforth can be weighed against the average peak power procurement cost to choose the most economical strategy.

Table 4.3 shows the utility-wise & program-specific estimated annual energy savings and reported cumulative energy savings and the DSM plan for one of the BEST projects is outlined in Table 4.4.

Table 4.3: Utility-wise & program-specific estimated annual energy savings and reported cumulative energy savings

Implementing agency	DSM program name	Technology	Starting year of project	Completion year of project/ current status	Operating days/Year	Operating Hrs/day	Savings (in kW)	Estimated annual energy savings per installation (in kWh)	Total Installations till date	Annual Energy savings (in MU)	Reported cumulative energy savings till date (in MU)
Tata Power	Energy efficient Lighting program	FTL	Nov-09	Over and extended to LED program	300	6	0.021	37.8	4353	0.16	0.44
	Energy efficient 5 Star Split AC program	AC	Mar-10	Active	180	8	0.6	864	202	0.17	0.42
	Energy efficient 5 Star Ceiling fan program	Ceiling Fan	Mar-10	Active	300	10	0.025	75	12490	0.94	1.45
	Energy efficient 5 Star rated Refrigerator program	Refrigerator	Mar-12	Active	365	24	0.05	438	767	0.34	0.01
	Thermal Energy Storage Program	TES	Mar-10	Active	Not Applicable (NA)	NA	NA	NA	15000 TR capacity was enrolled	NA	3.78 MU of energy shift
	Demand response Program	DR	May-11	Active	NA	NA	NA	NA	21 DR events of 2 hrs each	NA	0.31 MU of energy shift
	Energy audit Program	Auditing	Aug-09	Active	NA	NA	NA	NA	77 audits	NA	24.46
	Standard offers Program	SOP	Jan-13	Active	NA	NA	NA	NA	NA	NA	Data not available

Implementing agency	DSM program name	Technology	Starting year of project	Completion year of project/ current status	Operating days/Year	Operating Hrs/day	Savings (in kW)	Estimated annual energy savings per installation (in kWh)	Total Installations till date	Annual Energy savings (in MU)	Reported cumulative energy savings till date (in MU)
R-Infra	Five star rated ceiling fans Programme	Ceiling Fan	Apr-12	First phase over. Second phase in execution	300	10	0.025	75	12127	0.91	1.01
	Five Star rated Refrigerator Program	Refrigerator	Mar- 12	Over	365	24	0.05	438	3709	1.62	0.57
	Five star Split AC Program	AC	2012	Active	180	8	0.6	864	1550	1.49	3.94
	CFL Program	CFL	2006	Over	300	6	0.045	81	617436	50.01	38
	T5 FTL Program	FTL	2011	Over	300	6	0.021	37.8	3939	0.15	0.15
	Capacitor Installation Program	Power factor improvement	2010	Over	NA	NA	NA	NA	2178 kVAR rating of Capacitors installed	NA	2
	Street Light Conversion Program	Street lighting (HPSV)	2008	Over	350	8	0.055	154	36560	5.63	16.98
	Energy audit Scheme	Auditing	2008	Over	NA	NA	NA	NA	50 audits	NA	8.33
MSEDCL	Five star rating ceiling fan Program	Ceiling Fan	2014	Over	300	10	0.025	75	4998	0.37	0.41

Table 4.4: Cost and saving analysis of one of the proposed DSM projects by BEST

Name of the programme	Parameters	Quantity	Details of programme	Fiscal Year			
				2012-13	2013-14	2014-15	2015-16
Replacement of 10000 no's of T-5 FTLS to replace old conventional 52 watt FTLS for the residential consumer having consumption up to 100 units per month.	No. of replacement	10000	Saving of units in MU	0.49	0.49	0.49	0.49
	No of hours	6	Reduction of MD in kW	6.30	6.30	6.30	6.30
	Cost in Rs./ Unit	525	Cost of technology in Rs.	5512500.00	5788125.00	6077531.25	6381407.81
	% Utility rebate	40%	Utility rebate in Rs.	2205000.00	2315250.00	2431012.50	2552563.13
	% Admin cost	2 %	Administration cost in Rs.	110250.00	115762.50	121550.63	127628.16
	% M &V cost	1 %	M &V cost in Rs.	55125.00	57881.25	60775.31	63814.08
	Diversity to peak	3 %	Total estimated programme expenditure in Rs.				
	Life of technology	2		2370375.00	2488893.75	2613338.44	2744005.36

Source: Detailed DSM Plan of other proposed DSM projects is available on their website.
Website link: http://dsm.bestundertaking.com/program.asp

Table 4.5: Utility-wise calculation of average transaction cost for portfolio of DSM projects

Utility Name	Average estimated annual energy savings (in MU)	Average annual DSM expenditure (in Rs. crore)	Average transaction cost for portfolio of DSM projects (in Rs./kWh)
Tata Power (TPC-D)	5.214	2.46	4.72
Reliance Infra (R-Infra)	-	-	Data insufficient
MSEDCL	0.37	3.395	91.75
BEST	8.6	5.03	-

Table 4.5 depicts the average transaction cost for a portfolio of DSM projects of two utilities in Mumbai. The average transaction cost for Tata power is calculated to be Rs. 4.72/kWh and is quite comparable to their average power procurement cost. On the other hand, the average power procurement cost for MSEDCL is quite high at Rs. 91.75/kWh. This clearly shows that the overall transaction cost can be lowered if large number of DSM projects, even if they are pilot in nature, is attempted. Similar observation can be made for pilot vs. large scale program where the huge fixed costs in DSM expenses can be leveled out if the scale of DSM program implementation becomes large.

4.7: Conclusion

The DISCOM's in Mumbai have been successful in implementing a significant number of DSM pilots under the regulations mandated by MERC. The total expenditure on DSM activities and consequently the estimated savings are just a fraction of the total expenditure on the power purchase cost and the total sales.

It was found that the reporting of the DSM project cost and savings is quite inadequate and at times faulty. Tata power has been consistent in reporting its expenses on DSM and the achieved savings but due to lack of any template for reporting, the information is not at one place thus making it difficult for other utilities and peers for review. The idea of reporting the project cost and outcomes in a standard format will not only bring clarity among the utilities about the direction of their efforts but can also act as learning tool for other utilities to replicate similar projects. This will also encourage transparency among utilities in conducting their operations regarding DSM and lead to improvement in their brand.

The project team would like to extend their sincere thanks to following people who helped us in conducting the survey and documenting this report in present form:

Honorable Member, MERC

Honorable Secretary, MERC

Mr. R. Ambedkar, Director, MERC

Mr. S. Khadilkar, Tata Power

Mr. Pramod Deo, Rinfra

Mr. S. Rokade Deputy Director, MERC

Staff of distribution companies in Mumbai

5.0: Agriculture DSM projects in India

Project location: India

5.1: Introduction

As of October 2015, Agriculture Sector contributes 17% to the Gross Domestic Product (GDP) that is equivalent to 24, 28,000 Crore and at the same time engages 49% of total work force of the country. This sharp difference in percentage share in GDP and employment contribute towards lower per capita income in agriculture sector. Worldwide, agriculture is a highly capital intensive and low income generating sector. As for the European Union, various concessions provided in terms of subsidy account for 40% of EU's budget; similarly, in United States, agricultural subsidy account for 24% of total cost incurred, although agriculture sector only engage 10% and 2% of their total population respectively. In India agriculture directly contributes to the livelihood of at least half of the total population. Various subsidies are provided to farmers for fertilizers, seed, irrigation setup and power to keep the production cost in check.

Agricultural subsidy provided in the power sector is for irrigation purposes. State governments provide low tariff or free electricity to farmers for use of electric pumps for irrigation. As illustrated in Figure 5.1 and Figure 5.2, the purchase rate for electricity and tariff rates charged to agricultural loads differ drastically. Few states such as Punjab and Tamil Nadu provide free electricity for agriculture. This low cost of electricity has motivated farmers to utilize more and more groundwater for irrigation purposes. Current statistics suggest that groundwater is used for 67% of India's net sown area. Indian farmers have shifted from monsoonal rain and gravity flow irrigation towards groundwater irrigation using mechanical and electric pumps. The use of electric pumps has increased considerably after independence. In 1947, it accounted for 2.99% of total electricity consumption whereas now in 2015, it nearly accounts for 18.45% of total consumption. This unprecedented growth in share of irrigation is credited to very large population engaged in farming, relatively cheaper or free electricity provided to farmers and the reliability of groundwater over monsoonal rain and gravitational flow-based irrigation.

As of October 2015, Agriculture Sector contributes 17% to the Gross Domestic Product (GDP) that is equivalent to 24, 28,000 Crore and at the same time engages 49% of total work force of the country.

In most parts of India, farmers have to pay a fixed charge based on the power rating of the pump installed. There is no provision for metering on agricultural customers. In some part of the country, regular billing is considered at highly subsidized tariff rates. As of year 2015, approximately 19 million irrigation pumps are employed across the country with an annual addition of around 0.5 million new irrigation pump sets. Together, they consume 131.96 billion kWh annually. Majority of these pump sets have poor efficiency of 20-30% as compared to the efficiency of 40-50% of improved star-rated irrigation pumps. Thus, there exists a huge potential for energy savings through replacement of inefficient old pumps. Voltage and power quality at feeder, choice of foot valve, suction pipes and delivery pipes, height of pump and water level are other factors which influence the overall efficiency of irrigation process. Also factors such as irrigation techniques, choice of crops, method of water recharge influence the water requirement in the farm and thus influence the consumption of electricity. Hence, there is a huge untapped potential to save energy and improve efficiency. This process of management in electricity use at the load/customer end is known as Demand Side Management (DSM).

Various DSM techniques are practised worldwide for variety of load types. Practices to improve efficiency and reduce energy consumptions at load end dates back to 1980s. As discussed before, the agricultural loads consume 18-19% of net electric consumption with an average efficiency of 20-30%. On the other hand efficient pumps and supporting structure can improve efficiency up to 45-50%. Thus a huge DR potential of 40% is untapped and can be realized in this sector. That is greater than 7% of net consumption of the whole country. Thus serious efforts and attention is required towards agricultural demand side management.

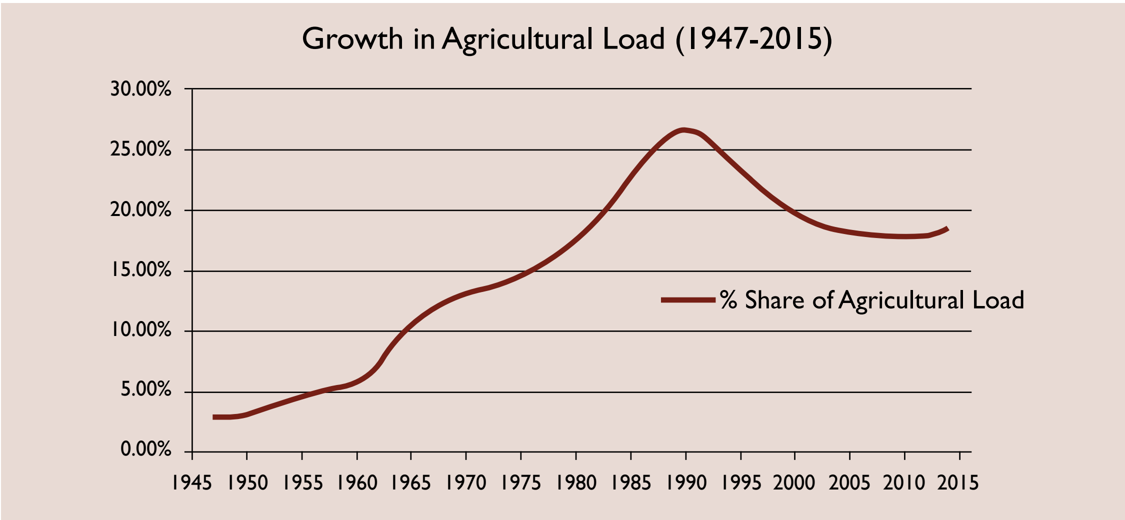


Figure 5.1: *Growth in share of Agricultural load (1947-2015)*

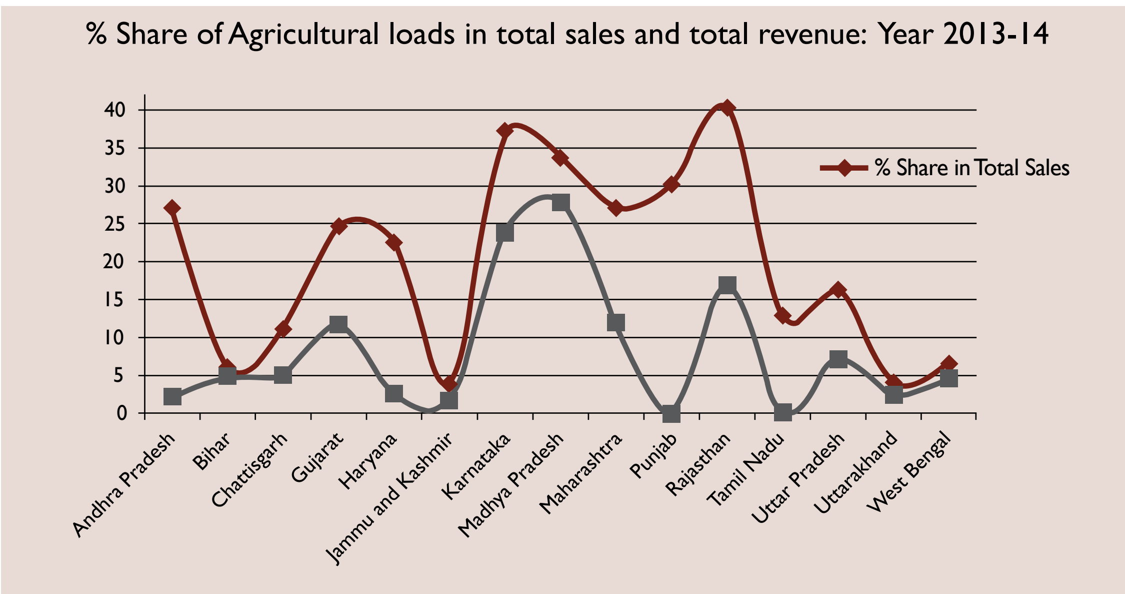


Figure 5.2: *Agricultural load sales and revenue for year 2013-14*

This report draws a picture of the Agricultural Demand Side Management (AgDSM) scenario in Indian context. It provides a comprehensive study of efforts made in this domain so far, thus providing an outlook for future endeavor in AgDSM in India.

5.2: Technology Assessment

Electric pumps provide most of the pumping needs India. 67% of net sown land is irrigated using groundwater, which in turn carried out using diesel pumps or electric pumps. As of year 2015, there are nearly 20 million electric pump sets operational in the Indian Territory and there is an addition of 0.5 million pumps annually. This section provides an overview of technological aspects involved in AgDSM projects regarding pump sets, pumping technique, grid supply etc.

5.2.1: Pump Sets and Periphery

Multiple local, regional, national and overseas players are involved in pump manufacturing and distribution. Annually around 12 lakh pump-sets are manufactured in India, mostly by domestic vendors. There is complete demand supply equilibrium in pump market. As of year 2014, estimated market size for pumps in India was around 12,000 crore. Agricultural consumer constitutes 35% of total pump market and rest 65% account for domestic and industrial application. Figure 1.5.3 shows the number of energized pump sets for various states in the country. The unorganized sector in pump manufacturing occupies 48% of total market share. However, these capital share is around 35%. This unorganized sector includes local assemblers and manufacturers, unregistered companies and non-standardized pump sets. These non-standardized pumps are very cheap in comparison to BEE star-rated pump sets. Farmers prefer to buy these unrated pump sets owing to the cost difference between star-rated pump and unrated pumps. Other than that, the capacity to withstand voltage fluctuation, frequent power interrupts and scope of local and fast repairing of unrated pumps favors the choice of unrated pump sets.

Multiple local, regional, national and overseas players are involved in pump manufacturing and distribution. Annually around 12 lakh pump-sets are manufactured in India, mostly by domestic vendors.

Recently, the Bureau of Energy Efficiency (BEE) has designed a mechanism of star rating for efficiency of pumps. Non-standardized pump sets are generally over-rated and consume excessive power in the same capacity. The average efficiency of these pumps is around 20-30% as compare to BEE-star rated pump sets which is nearly 35-50%. These over-rated pump sets need frequent repairing and rewinding of the motor that decreases their efficiency. This leads to overloading at grid, poor power quality, voltage fluctuation and power cuts. This vicious cycle thus causes more motor burnouts and inefficient irrigation.

Monoblock and submersible pumps have a major presence in the irrigation sector. Monoblock pump-sets have all rotating parts connected to a common shaft. Monoblock pump are very useful in higher water table regions where the suction height is low. However in most parts of India as the water table is reducing drastically, monoblock pump are being replaced by submersible pumps. Submersible pump have its components submerged in water that is to be pumped out. These pump sets have a market share of 72% and they are gradually replacing monoblock pumps in the Indian subcontinent.

Figure 5.4 shows the % share of pump-sets based on rating. 5 hp pumps with a market share of 36% have the largest share in terms of motor rating. Apart from this, 7.5 hp (24%), 3 hp (19%) and 10 hp (11%) pumps are also required by farmers depending upon water level and desired water output. ISI standardized pump sets have a market share of 71% as compared to non-ISI marked pump sets which hold a 29% share. Recent inclusion of BEE star rating for pump sets have a share of only 6% in total pump sets installed. Farmers are more accustomed with ISI rating and BEE star rating being a relatively novel concept is not too popular among farmers.

As the report [9] illustrates, from the farmer's point of view, low voltage capacity, available warranty/guarantee, price and water output are the factors that influence the selection of a particular pump set. From a retail point of view, price is the most important factor to determine choice of pump sets among farmers. Other than that, standards and low voltage capacity is also valued by farmers.

The choice of periphery elements for a pump-set greatly influences the overall efficiency of irrigation system. Periphery elements involve foot-valve, suction pipe, delivery piping etc. As per report [5], replacement of suction pipe and foot-valve alone improves efficiency by 10-14%. Hence choice of periphery components and technique of installation should be consciously considered for efficiency improvement. Factors such as water head, height of pump, suction height, delivery length, pipe diameters greatly influence efficiency. In various DSM projects, GI (Galvanized Iron) pipes were replaced with RPVC (Rigid Polyvinyl Chloride) piping to improve efficiency.

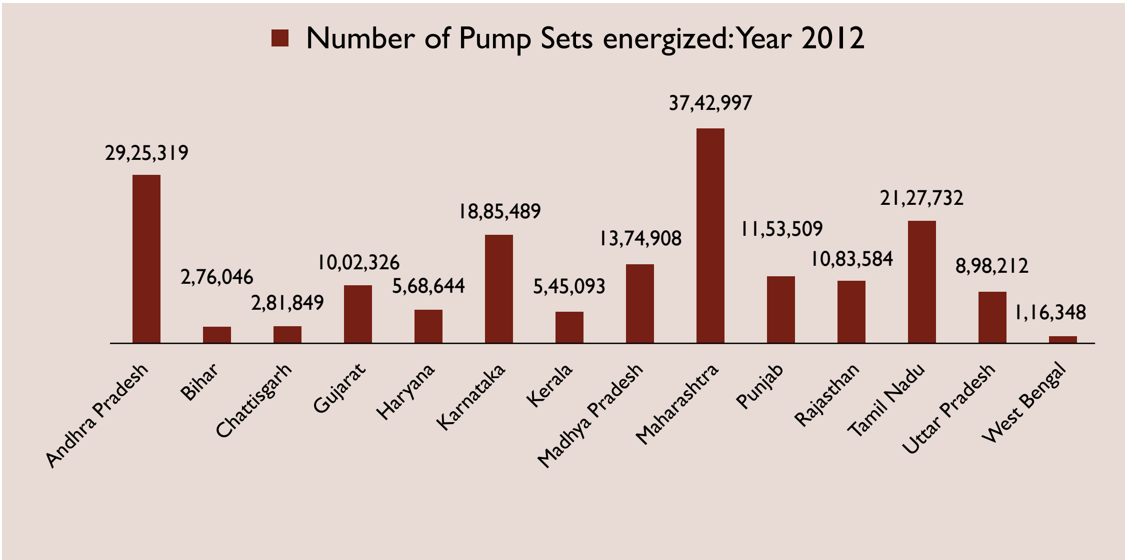


Figure 5.3: *State wise number of Pump sets energized in Year 2012*

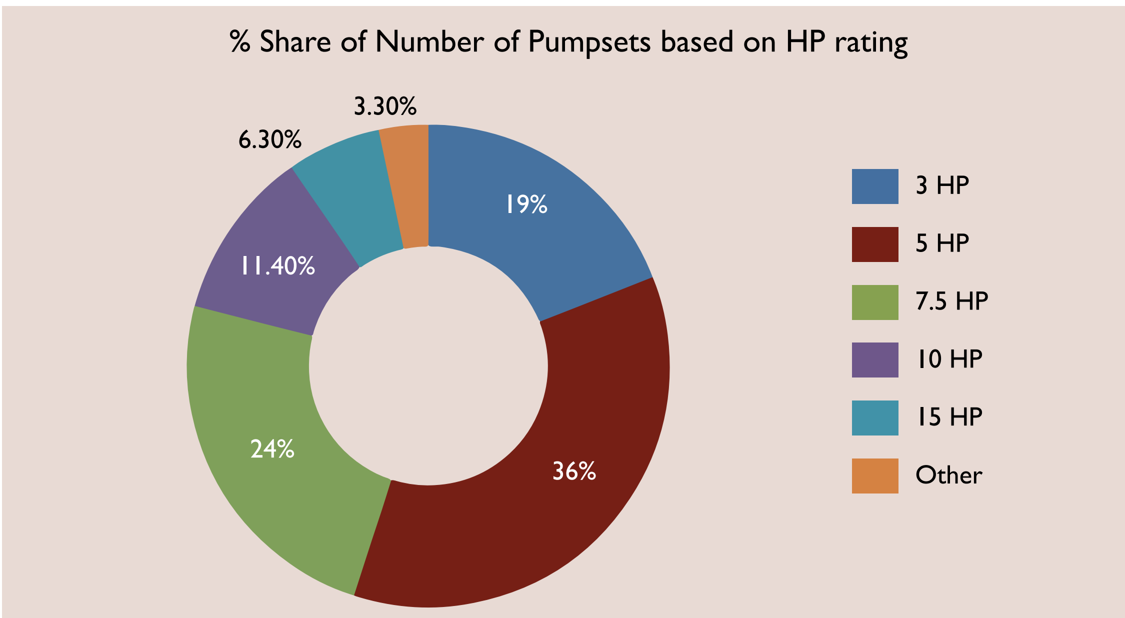


Figure 5.4: *% Share of Number of Pump sets based on HP rating*

5.2.2: Voltage Profile

For an agricultural pump which has an induction motor, voltage profile and power quality is an important aspect. Due to the reactive nature of load, feeder suffers with low power factor and voltage fluctuation. Due to large distance of loads from distribution transformer (DT), voltage down is observed which in turn leads to poor performance of pumps and overloading of feeder. Different practices such as installation of DT at the load point, installation of capacitor bank at feeder and pump sets, segregation of agricultural feeder from domestic and commercial loads are carried out. Few states (Gujarat and Punjab) have carried out complete segregation of agricultural feeder to ensure quality power for agricultural loads for certain period of time. This feeder segregation also helps in load scheduling for agricultural customers as the agricultural loads are supplied power in off peak hours of industrial and commercial load. Feeder segregation also helps to maintain the power consumption pattern of agricultural customers as agricultural loads are unmetered. Reactive power imbalance at feeder side drastically affects the voltage level. These voltage disturbances further lead to poor performance of pumps and further to over loading of feeder. This voltage fluctuation is the biggest cause of motor burnouts and feeder failure. In order to maintain the power quality at feeder, capacitor bank installation is carried out. As part of DSM initiative in Karnataka, capacitor bank installation at feeder alone helped in improving efficiency and reduction in total consumption. Motor burnouts also reduced in that region. Installation of capacitor set at the pump set is also carried out for protection of pump set from frequent power cuts and voltage fluctuation.

As a matter of fact, efficient pump sets have poor capacity to withstand severe voltage fluctuations. As in the Doddaballapur Project, efficient pump installation was carried out without feeder improvement and it was observed that motor burnouts were more frequent and overall the project was not economically viable. Inefficient unrated pumps are sturdy in terms of their capacity to withstand voltage fluctuation. Also repairing of such pump sets is possible locally. This is one of the major reasons behind farmers preferring unrated inefficient pumps. Voltage profile and power quality at feeder are the few important factors while looking into DSM scenario for agricultural loads. Any holistic approach must take care of this issue while addressing the problem of AgDSM.

5.2.3: Irrigation Practices

Irrigation accounts for consumption of 80% of total water consumption in country. Efficient use of water, better irrigation practices (drip irrigation) and smart selection of crops greatly affects the water consumption and energy required for the same. Multiple such programs and initiatives have started all over India which directly impact the energy scenario.

5.3: Stakeholders involved in AgDSM projects

Various entities influence the power scenario in the agricultural sector. In a hierarchical structure from central and state govt. to farmers many stakeholders are involved as shown in Figure 5.5. In the context of AgDSM, the roles and objectives of different stakeholders need to be understood clearly. The overall objective of DSM at large is to shift/reduce the load demand from peak hour and in turn postpone the need for capacity enhancement. Therefore, in agricultural sector, the main objective of DSM is to reduce the electricity demand for irrigation by various means at the consumer end. 49% of the nation's workforce is engaged in agriculture and around 60% of population is dependent on agriculture for their livelihood. The dynamics involved in this agricultural sector are very peculiar. As the agricultural sector constitutes a major chunk of the population, the government has to address and prioritize their concerns. Moreover, as this sector constitutes lower strata of economy, it is unable to adopt novel innovations and fast changing technology.

ESSL, a joint venture of multiple PSUs under Ministry of Power was formed in year 2010 with energy efficiency as its principal agenda for smooth and efficient processing of projects involving multiple agencies. EESL act as a monitoring, funding and consulting agency for various state and central government projects. Government is the most significant stakeholder in AgDSM as it can benefit the most from the energy saving that accrues due to the savings in huge subsidy it provides for agricultural loads.

Farmers are the end-users in this scenario. The cost of electricity paid by farmers is very low or by and large free. The power consumption is, in general, unmetered and farmers have to pay a fixed amount based on the HP rating of the pump. Farmers are not motivated to reduce their electricity consumption and to procure star rated efficient water pumps. The initial cost of star rated pumps is around twice the cost of locally manufactured pumps. Thus, small and marginal farmers prefer locally made inefficient pumps to save money as against relatively expensive

Different practices such as installation of DT at the load point, installation of capacitor bank at feeder and pump sets, segregation of agricultural feeder from domestic and commercial loads are carried out.

energy efficient pumps. Along with this, flood irrigation is practised by a majority of Indian farmers, leading to multiplying effect on power consumption in the inefficient pump sets. Table 5.1 illustrates the roles of various stakeholders involved in AgDSM, with the expectations and associated logjams.

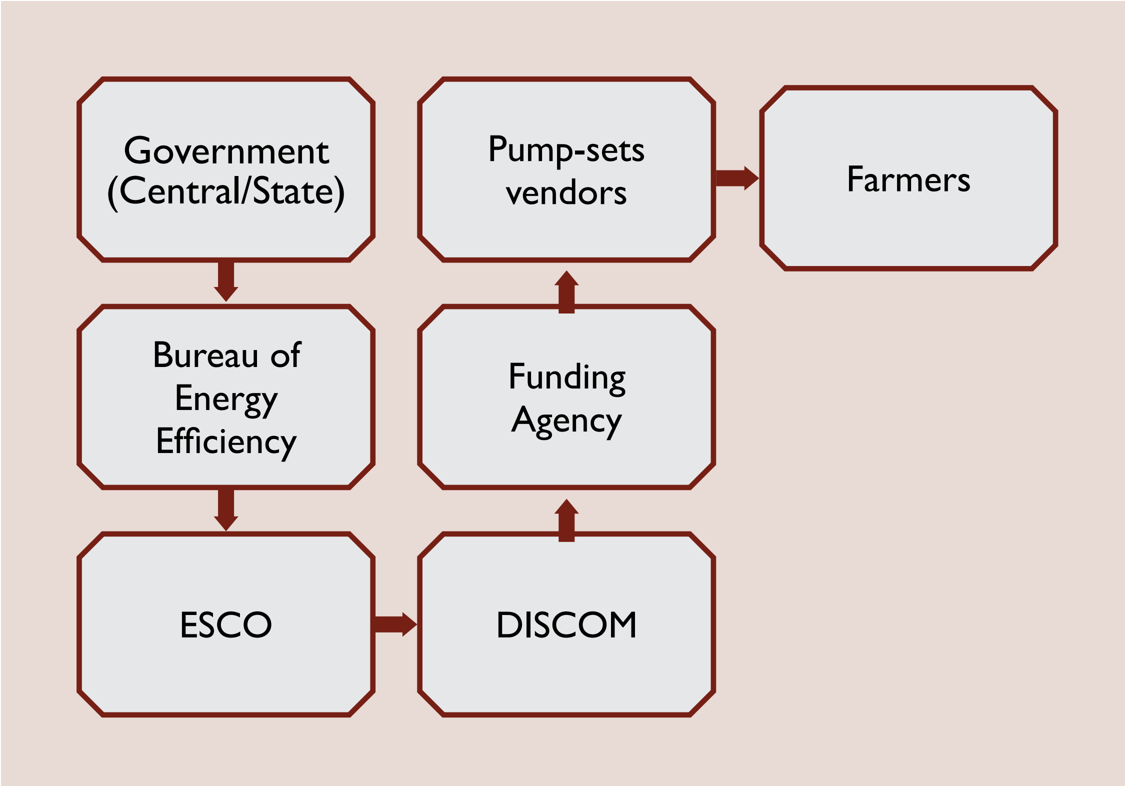


Figure 5.5: *Stakeholders involved in AgDSM*

Table 5.1: Roles of stakeholders involved in AgDSM

Stakeholder	Roles	Expectations	Logjam
State/Center Government	Policy design regarding agricultural electricity tariff, provision of subsidy and fund allocation.	Take holistic decision for the benefit of farmers, DISCOMs, and energy Scenario.	Politically motivated decisions often delay the implementation of policies and projects.
Bureau of Energy Efficiency	Independent govt. agency for standardization of appliances (viz. Pump, Suction Pipe etc.)	Quick approval and investigation for pump set manufacturers. Strict policies for standardization of pump sets.	Slow process for approval of star rated pumps. Voluntary schemes often fail to get attention from regional pump manufacturer.
EESL (ESCO)	A separate body which acts as an ESCO, created under Ministry of Power, with collaboration of multiple PSUs involved in Power Sector. EESL is assigned for smooth and fast process of energy efficiency projects country wide.	Provide assistance to DISCOM for technical and monetary aspects. Also act as a resource center. Encourage other private ESCO to participate in AgDSM Market.	Scalability of the work is a challenge for EESL.

Table 5.1: Roles of stakeholders involved in AgDSM

Stakeholder	Roles	Expectations	Logjam
DISCOM	For agricultural loads, state electricity board act as a DISCOM. They are assigned with the task of distribution, monitoring, billing of power.	Provide reliable and sufficient electricity with voltage stability and maintaining power quality.	Poor power quality and low voltage for agricultural consumer. Poor maintenance of agricultural loads and DTs, Lack of metering for agricultural loads.
Pump Manufacturer	Local, Regional, National and Overseas players are involved in Pump manufacturing. Organized pump manufacturers occupy only 52% of market share. 48% of market share is captured by local/regional manufacturers.	Follow BEE standard for efficient star rated pump. Build farmer awareness for efficient pumps and their benefits.	Lack of motivation for R&D investment. Low cost unrated pump capture 48% of India's agriculture pump market. Higher Voltage compatibility of unrated pump is also a key determining factor.
Funding Agency	Provide Initial capital required for Pump replacement and other AgDSM projects.	Provide financial aid to highly capital intensive projects.	Private players are disinclined due to slow rate of return. Energy efficiency market is still untapped in India.
Farmers	End user in the entire chain. Consumer of electricity.	Efficient use of electricity and irrigation practices. Awareness for market and technological changes.	Lack of motivation for energy efficient pump set due to availability of power at low/ Zero tariffs. Initial cost difference in Pump sets is the deciding factor.

5.4: Business Model for DSM

In order to implement Demand Side Management program, there are various financial models implemented for smooth passage of DSM project. Specific to AgDSM, following are the three types of DSM Models implemented in India. The categorization is based upon method of funding and pay back. DISCOM model, ESCO model and Hybrid Model are discussed briefly in the following section.

In DISCOM Model the agency involved in distribution and billing of electricity, takes the financial burden of installation of new pump sets. These DISCOMs enact such schemes with the tariff collected from its customers or funds received from the state. DISCOMs bear the burden of subsidy for agricultural load and try to achieve break even for their investment in new pump set by cost reduction achieved from decrease in electricity consumption. A third party is commissioned for Installation, R&M (Repair and Maintenance) of the newly installed pump sets. These private contractors are paid by the DISCOM, from the subsidy reduction achieved by energy saving. State DISCOMs further increase its revenue by selling the saved energy to commercial, industrial and domestic loads which have a higher tariff rate than agricultural loads.

However in many states, DISCOMs are running under loss and lack the capital required for one time investment in new pump sets. Thus, a third party is needed for capital support. This third party, in general, should take the responsibility for installation, R&M and monitoring of energy use. In Indian scenario, a separate government agency or private company acts as the ESCO. In most of the pilot projects in India, EESL (Energy Efficiency Services Limited) and BEE (Bureau of Energy Efficiency) played the role of third party, for investment, installation and R&M operation of new pump sets. The ESCOs receive their revenue as peran agreement with DISCOM and are paid in regular installments for the contracted period. The payment involves the capital cost of new pump set with annual interest and annual R&M cost.

Another working model involves both the ESCOs and DISCOMs. In this Hybrid Model, the funding agency instead of getting direct payment receive a percentage share in annual energy saving. The Solapur pilot project in Maharashtra is one such project in India in which hybrid Model was adopted. EESL was the funding ESCO which was entitled with 85% share in energy saving achieved in the project for a period of 5 years.

5.5: Timeline of AgDSM Projects in India

5.5.1: Early Projects (1980-2000)

In the early 90s, Rural Electrification Corporation Limited (REC) has sponsored various pump rectification projects in Gujarat, Tamil Nadu, Madhya Pradesh, Karnataka, Haryana and Andhra Pradesh. More than 20,000 pump sets were covered across these six states, post project evaluation was carried out for selected pump sets. Energy saving of pump sets was recorded between 20-30%. These projects consist of suction and delivery piping replacement, foot valve replacement and pump set rectification. Gujarat Electricity Board carried out component replacement and pilot projects of pump replacement with the available advanced monoblock pump sets. A similar project of pump replacement was also cited under the Ministry of Energy (MoE) which was later renamed as Ministry of Power for 500 pump sets.

Table 5.2: Project Summary for Year 1980-2000 (reference)

Sr. No.	Project	Activities	Achievements
1	Gujarat Electricity Board Project: Year 1978-1985	Carried out partial Component Replacement of 1108 Pump Sets.	Energy Saving of 21.7% is achieved in first year of installation
2	GEB Project in Sabarmati, Baroda and Mehsana region of Gujarat: Year 1980	10HP Pumps were replaced with 5HP Monoblock Pump with equal discharge	Energy Saving in the range of 24% to 69% is achieved
3	Tamil Nadu Electricity Board (TNEB) and Rural Electrification Corporation Limited (REC) project: Year 1980	GI suction and delivery pipe replaced with RPVC pipe in region of Madurai, Periyar, Tiruvannamalai and Vellore.	Energy Saving of 10-30% is recorded. On 500 case studied, an average of 19% energy saving is achieved.
4	GEB and REC Project in Gujarat: Year 1985-86	3100 old foot valve replaced with Sujala Foot valve	Efficiency of Pump is improved up to 48%
5	Pump Rectification in Madhya Pradesh under MPEB-REC Project: 1985	Pump Set rectification is carried out for 3125 pump sets	Average efficiency is improved from 23.08% to 32.94%
6	REC Project for Component Replacement in Karnataka: Mid 1980s	Suction and Delivery Pipes in 3125 Pump sets were replaced from GI to RPVC.	An average improvement in power factor from 0.6 to 0.85 is achieved, with an efficiency improvement from 23.5% to 36.1%

Table 5.2: Project Summary for Year 1980-2000 (reference)

Sr. No.	Project	Activities	Achievements
7	REC- APSEB Project: Year 1985-86	Suction and Delivery pipes were replaced for 2500 Pump sets in Chittoor region of Andhra Pradesh	Energy Saving of around 26.17% is achieved
8	REC-HSEB Project in Haryana: year 1985-86	Component replacement for 3757 Pump set is carried out	Average Decrease in consumption up to 24% is achieved
9	Ministry of Energy (MoE) and Institute of Co-operative Management (ICM) Project in Gujarat: year 1989-1993	500 old irrigation pump sets were replaced with advanced monoblock pumps.	Overall efficiency improved from 20.8% to 44%, with reduction in connected load from 4062KW to 2216KW.
10	Pump Retrofitting Project in Maharashtra undertook by MEDA: Year 1989-94	In 17 blocks pump retrofitting is carried out with Piping and Foot Valve replacement for 350-400 pump sets annually.	No results were recorded. However MEDA recommended a large scale (1 lakh) pump sets retrofitting program based on this project.

A majority of these pilot projects were test runs in order to evaluate the energy, economic and technical aspects involved in pump rectification. However no large scale implementation or policy drafting was carried out further. Table 5.2 enlist the details of the projects carried out in the period of 1980-2000 with the focus on activities involved and achievements recorded in these projects.

In the annual reports of Ministry of Power from 1991 to 1998 and also in five-year plan, few projects, as shown in Table 5.3, were mentioned. Possibly these projects overlap with the above mentioned projects. These reports did not provide any post project evaluation or achievements. These projects were also concentrated in state of Tamil Nadu, Gujarat, Andhra Pradesh, Haryana and Punjab. Table 5.3 shows the summary of Ag-DSM projects implemented in Year 1980 to 2000.

Table 5.3: Project Reported in MoP Annual Report (1991-1998) and 9th Five-year plan (reference)

Sr. No.	Project	Activities
1	Tamil Nadu: Year 1991-92	10,000 Pump sets were reported to be rectified.
2	Punjab: Year 1992-98	Pilot Project of partial rectification is carried out for 1350 Pump sets.
3	Haryana: Year 1997-98	Energy efficiency program for 800 Agricultural Pump sets was carried out.
4	Gujarat: Year 1997-98	For 5000 pump sets in Gujarat rectification program was carried out.
5	Andhra Pradesh: Year 1996-99	Pump rectification program for 1000 pump sets were carried out. Also in year 1998-99foot valve replacement for 20,000 pump sets was reported.

5.5.2: Projects from 2000 to 2010

In the last decade, various AgDSM projects were introduced in the states of Haryana, Karnataka, Andhra Pradesh, Madhya Pradesh and Gujarat. New ratings were introduced by BEE for efficiency of pump sets complementary with ISI standard ratings. The new star ratings were optional and only large scale organized manufacturers adopted these rating voluntarily.

One of the projects in Andhra Pradesh, carried out replacement of three phase pump sets with high voltage single phase pump sets. Separate single phase supply was erected for these pump sets. Efficiency and power quality were improved. In Doddaballapur subdivision of Karnataka WENEXA conducted a project in which old pumps were replaced with BEE star rated pump sets without any improvement in feeder power quality. These pump sets suffer from frequent burnouts. The post project analysis highlighted that it is not economically viable to carry out pump replacement without feeder power quality improvement. In same Doddaballapur region Capacitor banks were installed at feeder which report significant reduction in losses with a payback period of 14 months. Table 5.4 shows the summary of Ag-DSM projects implemented in Year 2000 to 2010.

Table 5.4: Project Summary for Year 2000-2010 (reference)

<table>
<tr><th>Sr. No.</th><th>Project</th><th>Activities</th><th>Achievements</th></tr>
<tr><td>1</td><td>Nalgonda- Andhra Pradesh Single phase HVDS Project: Year 2000</td><td>Here a detailed study of 1000 sample pump set was carried out for efficiency. HVDS supply for 1641 Single phase pumps was installed.</td><td>Average improvement in efficiency from 26% to 37% is reported. Project was reported to close prematurely due to disagreement between involved parties.</td></tr>
<tr><td>2</td><td>Karimnagar- Chittoor DSM Project in Andhra Pradesh: Year 1998-2000</td><td colspan="2">This project reported in world bank report, for 5800 pump-sets spread across 8 feeders. It includes upgrading distribution network from low voltage to high voltage. Replacement of 3 phase pumps with single phase motor and replacement of piping components.
No activities on completion or post project study are recorded.</td></tr>
<tr><td>3</td><td>Madhya Pradesh (Kirloskar/Econoler/CIDA) project: Year 2004</td><td>Here pump replacement for 50 pump sets were carried out. Most pumps of 5 HP were replaced with 3 HP Kirloskar Pump with equal discharge.</td><td>The energy saving of 33.8% to 43% was recorded with an estimated payback period of 27 months. The proposal for large scale implementation was drafted for 6.25 lakh pump sets.</td></tr>
<tr><td>4</td><td>Gujarat- GEDA Project: Year 2007-2009</td><td>6000 submersible pumps were replaced with 5 HP BEE-Star rated pumps. Along with replacement of GI piping with RPVC piping.</td><td>Project was funded by state government (67%), farmers bear the remaining 33% cost. This project received an overwhelming response and farmers outside the policy bound used this scheme.</td></tr>
<tr><td>5</td><td>HAREDA Scheme – Haryana: Year 2006 Onwards</td><td>Under HAREDA scheme, farmers are provided with 50% of the cost difference between ISI and non-ISI pump sets.</td><td>This scheme since its inception in 2006 has been used for 14,668 new pump sets till 2008-09. Scheme is still in operation but no further data is recorded.</td></tr>
<tr><td>6</td><td>Karnataka (WENEXA) Pilot project in Doddaballapur: Year 2006-2008</td><td>A Pilot project is conducted for 15 old pumps to replace with BEE star rated pumps without improvement in distribution network and power quality.</td><td>Though power saving is achieved initially but more frequent burnouts of pumps in recorded. It was economically not viable as the maintenance cost increased.</td></tr>
<tr><td>7</td><td>Karnataka BESCOM Capacitor Installation in Doddaballapur: Year 2008</td><td>In the same subdivision capacitor installation is carried out for 19 agriculture feeders where installation of 600 KVAR capacitor bank on 11 KV feeders is carried out.</td><td>Pre and post study of feeder is carried out. A payback period of 14 months is estimated in terms of reduction in losses on the feeder.</td></tr>
</table>

5.5.3: Projects Post 2010

After the formation of Energy Efficiency Services Limited (EESL) DSM projects on large scale have been executed and are planned for future implementation. EESL was founded in December 2009 as a joint venture of NTPC Ltd., REC, PGCIL and PFC under the Ministry of Power. EESL acts as an ESCO company for various state and private utilities, it provides financial, consultancy and implementation requirements for DSM programs. All major project reported post 2010, have EESL as a key partner. EESL operates in a hybrid model and provides upfront investment for project implementation. So far EESL has assisted 30 DISCOMs across the country. Table 1.5.5 shows the summary of Ag-DSM projects implemented post 2010.

Table 5.5: Summary of Ag-DSM projects implemented post 2010

Sr. No.	Project	Activities	Achievements
1	EESL -MSEDCL Project in Solapur, Maharashtra: Year 2010-11	In Mangalwedha Subdivision 3530 old pump sets were replaced with star rated pump sets.	Energy saving of 5MU is achieved with 35% reduction in net consumption. Payback period of 4 years is estimated.
2	EESL - BESCOM Doddaballapur Project: Year 2011	277 Old pump sets are replaced with BEE star rated pumps.	35% improvement in efficiency is achieved. 5.75 million Units are saved in a period of April 2011 to December 2014.
3	EESL -CESC Mysore Project: Year 2015	In Mandya District of Karnataka replacement of 1337 old pump with star rated pump sets.	37% energy saving is estimated, that is equivalent to 5.6 Million Unit/ Annum. The cost of 5.06 Cr will be recovered from the energy saving achieved.
4	EESL - HESCOM Project: Year 2013- Onwards	Under EESL, study of 11,013 pumps has been completed. In Nippani and Byadagi Subdivision replacement of 590 pump set is in progress.	This project is estimated with minimum 30% energy saving. The first phase already started in 2013.
5	EESL - APEPDCL Rajanagaram Project: Year 2015- Onwards	Complete DPR is prepared for 2496 pump sets. A budget of 20.05 Cr is allocated by EESL.	The Project started in June 2015, a payback period of 5 year is estimated in Hybrid model.
6	EESL - BESCOM Pavagada Project: Year 2015- Onwards	An ambitious project of 100,000 pump set replacement in six Talukas of six different districts of Karnataka is planned in phased manner. In first phase DPR for 10,673 pumps is prepared for Pavagada subdivision by EESL in 2014	As of June 2015, due to disagreement between EESL and BESCOM regarding Baseline measurement and pump operating hours; EESL declined to prepare DPRs for remaining 5 Talukas. For now, this project is at hold.
7	EESL -JVVNL Jaipur Project :Year 2011-2014	Pump replacement for 1966 pump sets was conducted in chomu division of Jaipur.	No post projects were reported, but energy saving of 15% is predicted.

The first EESL project was in 2010, implemented in Solapur region of Maharashtra, where replacement of 3530 old pump sets was carried out with BEE star rated pump sets. This project has a payback period of 4 years in terms of energy savings and reduction in subsidy achieved by state utility. In 2015, EESL in coordination with BESCOM utility had planned an ambitious project of one lakh pump replacement. A Detailed Project Report (DPR) for 10,673 pump sets was prepared at the first stage of project. However due to certain disagreement between BESCOM and EESL regarding baseline measurement, EESL has withdrawn further support to this project.

5.6: Solar Pump Installation

India has a huge potential to utilize the solar energy as a sustained and reliable source of energy. In particular for irrigation purposes solar pump offers an alternative to diesel pump and off grid irrigation.

India currently has around 7 million diesel pumps employed for irrigation purpose. As of January 2014, it is estimated that in India over 12000-13000 solar pump sets are installed. 70% of which are concentrated in state of Rajasthan, Haryana, Punjab and Bihar. MNRE under central government provides 30% subsidy on solar installation, State Government provides additional subsidy from 40-60% thus consumer bears the 15-40% of the actual cost of solar pumps.

CREDA Chhattisgarh has installed 664 off grid solar pumps for irrigation with a capacity of 1.51 MW in year 2012-13. In the Financial Year 2014-15, the central government has approved a budget of 400 Cr. specifically for solar pumps. Annual target of 100,000 solar pump installations is set for next 5 years of which 50% are for irrigation purposes. This solar pump installation is carried out sparsely in different states and remote areas. As a part of central government scheme, state of Maharashtra has adopted a project of installation of 7540 solar irrigation pump sets in year 2015-16.

5.7: Capacitor Installation

The Indian power sector has grown phenomenally in the past two decades. However it still has an annual power deficit of 8%, and power quality has been a major issue. Specifically the agricultural sector suffers from frequent power cuts, low power factor and high voltage fluctuations. These frequent interruptions, power cuts and voltage fluctuation lead to motor burnout and pump failure. Capacitor banks are connected at the feeder for mitigating power fluctuation and maintaining the power factor. Few of the projects have also implemented capacitor addition on the pump sets. Capacitor installation at feeder is an efficient DSM practice given the present condition of power quality. An overview of the projects suggests that capacitor addition at feeder has a payback period of around 14 months. Also if pump replacement is supplemented with capacitor addition at feeder; it also addresses the issue of voltage withstand capability of new efficient irrigation pumps.

5.8: Feeder Segregation

States of Gujarat, Karnataka and Haryana have carried out segregation of agricultural feeders from domestic and industrial loads. This feeder segregation is also under way in state of Maharashtra, Rajasthan and Andhra Pradesh. It helps to maintain power quality for specified load and also prevents overloading of network. Feeder segregation also helps in load scheduling as irrigation pumps can be fed in night when commercial and industrial demand is low. Feeder segregation is carried out at 11KV level.

5.9: Conclusion

Agriculture DSM projected implemented across in the country have yielded satisfactory results. So far, AgDSM projects implemented across the country have yielded satisfactory results. Various projects indicate that even small component replacements such as a foot valve results in considerable change in overall efficiency. Therefore, there is a need to look at all the elements which influence the overall efficiency.

It is observed that energy efficient star rated pumps have poor voltage fluctuation withstand capability. Therefore improvement of voltage profile and power quality at feeder should go hand in hand with pump replacement. The Doddaballapur project highlights that pump replacement without improving the power quality is not economically viable. Moreover, improvement in voltage stability alone can improve the efficiency considerably. Hence feeder segregation and capacitor installation at pump-set location are such practices that can be considered along with pump replacement. In one of the projects, Distribution Transformers (DTs) were installed at each pumping site. This ensured that the power transfer is carried out at HV over the long distance and also at the voltage level thus ensuring that power quality is maintained at pump site. DT installation is a costly process with higher upfront cost and maintenance cost but it can regulate the power supply and metering can be enabled at pumping site.

Long term productivity and sustenance of DSM programs involves active consumer participation at all stages. Hence, a mechanism needs to be evolved in which farmers have a monetary participation and liabilities in the AgDSM programs without putting much additional burden on marginal farmers. In one of the projects in Gujarat, farmers contributed 33% of the cost of new pump, while 66% of the expenses were paid by state utility. Various other farmers outside the policy-bound also used this scheme and farmers ensured that there is regular maintenance of pump-sets.

Long term benefits of DSM project can be guaranteed if saturation model is followed. Various pilot projects in different states assert the need of a centralized scheme/policy for AgDSM implementation. In saturation model, particular block/area is saturated with various necessary modifications and regular monitoring is carried out. Saturation model eases the implementation and monitoring process over a long period.

There is an addition of around 5 lakh pump sets annually, hence schemes for procurement of new BEE star rated pump will help in reducing the future demand. As successfully demonstrated in Haryana, where state government partially funded the difference in amount between the cost of unrated and rated pump, to encourage farmers to buy efficient pump sets.

Trained local pump mechanics and repairman will be needed to repair rated energy efficient pump sets. As efficient and timely repair services are not easily available, farmers prefer locally manufactured pump sets. The training can be facilitated by pump manufacturer or state body for local pump mechanics. An investment on further research and innovation in pump technology is also necessary from manufacturing side, in order to make more efficient and robust irrigation systems.

Solar pump installation is carried out at various locations in Rajasthan, Gujarat and Chhattisgarh. Although, it has a huge upfront and maintenance cost, it is cost-effective for remote and sparsely located load points. However solar integration at segregated feeder end can provide added advantage. Small solar plants of 1-2 MW capacity are more cost effective and reliable than individual solar pump sets. Solar integration for agricultural loads also helps to cater to peak hour load as peak hours are in day time when the solar plant is in operation.

Thus, various AgDSM practices can go hand in hand in order to ensure sustained long term effect while ensuring active participation and responsibility of all the stakeholders. Also large scale implementation and policy level execution will lead to substantial energy saving, capacity building and environmental benefits.

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Annexure: Questionnaire for sample survey

A list of questions were identified to assess the outcomes of the case studies presented in this report from the perspective of implementing agencies and participating customers. This questionnaire was then used for conducting the sample surveys during the visit of project site.

Appliance Exchange schemes:

Implementing agency's Perspective:

1. What is the disposal mechanism adopted for old refrigerators collected through appliance exchange schemes? How is their resale avoided?
2. What are the challenges related to consumer's preferences about size (Capacity) and variety (single/double door, frost-free/direct cool) of equipment under appliance exchange schemes? How have been these challenges addressed?
3. What are the issues faced post installation /delivery of equipment? Who handles them? Utility or dealer?
4. Has there been a market study conducted to know the impact of such schemes on the sale EE equipment covered under the scheme?
5. Are the savings verified or considered guaranteed given the huge potential (energy consumption by refrigerators constitute the base load) that exists?
6. Are the dealers paid upfront by the utility for the equipment? What is the payment recovery mechanism adopted?
7. What are the learning points for future implementation of such schemes? How can these used to improve the future design and implementation of similar programs?
8. Were any awareness sessions conducted to educate the customers about the life cycle costing of the EE equipment? What has been their response during such sessions?
9. What were the criteria used to qualify the equipment to be replaced under the scheme? Energy consumption level/life of equipment?
10. Did the program require the customers to have the electricity bill in their name? What percentage of participants of the program were tenants? Does the issue of spilt incentives arise during the program? How is it handled?

Participating consumer's perspective:

1. How did you come to know about the appliance exchange scheme? Electricity bills/internet/ pamphlets/newspaper?

2. Were you happy with the old equipment? In what way the experience with the replaced unit changed in context of aesthetics, size, amount of electricity bill, neighbor's response, etc.
3. What are the things that you like to be added to the scheme? Variety, size, aesthetics, discount level, payment mechanism.
4. How do you find this scheme different from the offers you get in the market? Does this scheme have similar payment mechanism (EMI's)?
5. Would you buy the equipment if no discount is provided?
6. What would be your response if your neighbor enquires about the new equipment? Would you tell them about the scheme?
7. Are you aware about the star rating of the equipment? If yes, does it help you assess the quality of the product received during the scheme?
8. Would you prefer a costly EE equipment or affordable second hand equipment?
9. In the absence of the scheme, how much time you would have taken to replace the old equipment? What would have been the reason for replacement? Increase in income, higher capacity requirement, increasing electricity bill, lucrative offer in market, etc.

DELP Scheme (EESL)

Participating consumer's perspective:

1. Is there any change in the electricity bills post installation of LED bulbs? What amount approximately?
2. Was there any other change regarding brightness, aesthetics of LED bulbs as compared to ICLs?
3. Are there still any ICL in your home? Would you be willing to replace all the ICLs with LED bulbs under the scheme?
4. Were there any complaints (failure) regarding the LED bulbs installed? How did you handle it?
5. How did you come to know about the DELP scheme? Electricity bills/internet/pamphlets/newspaper.

Implementing agency's Perspective:

1. What was the percentage of participants that cleared their arrears to be eligible for the DELP scheme? Can tenants who are residing in rented houses participate in this scheme?
2. How many domestic households were covered during the scheme?
3. Which of the following challenges were faced during the scheme implementation?
   a) Baselining of energy use
   b) Promotion of the scheme
   c) Installation
   d) Cost recovery
   e) Logistics challenges during distribution
4. What were the mechanisms adopted to prevent the resale of distributed LED bulbs and reuse of ICLs?
5. How are the energy savings achieved due to the scheme verified?
6. How were samples used for M&V selected?
7. What were the regulatory challenges faced during finalizing the contract with public utilities?

Thermal Storage Programs

Implementing agency's Perspective:

1. What are the target customers for thermal storage programs? What are the criteria required to qualify as a participant in such programs?
2. How can the Star rating program of buildings by BEE be used to encourage participation in thermal storage programs?
3. Are new constructions covered in such programs? What are the regulatory measures required to tap the potential of thermal storage in new constructions?
4. What are different thermal -storage technologies (Ice Storage/chilled water storage) considered for the project? Do these technologies cover all kind of chillers (Air-cooled/water cooled) installed at customer's facilities?
5. Who bears the cost of technological up gradation in the existing system? Is there any rough estimation available on the cost incurred vs. installed capacity for such programs?
6. What are the different incentive mechanisms in place to rope in large designated consumers to participate in such programs?
7. How effective have been such programs in bringing down peak demand? Have the customers been able to recover their capital investment? What have been their response/complaints?
8. Has the possibility of including the participants of thermal storage programs into DR programs been investigated? To what extent such inclusions will lead to further energy savings?
9. What is the M&V methodology adopted to verify the savings? What is the average savings to installed capacity ratio for thermal storage programs implemented?
10. What is the comparison of challenges faced in retrofitting vs. new installation in case of thermal storage programs? Which seems easier to implement?
11. What have been the learning points from the already implemented thermal storage programs? How can these be used to improve the future design and implementation of similar programs?

Participating consumer's perspective:

1. What motivated you to enrol for the thermal storage program? Was it a self-driven initiative or an obligation to the utility?
2. What are the kinds of cooling need in your facility? Air-conditioning/refrigeration.
3. What kind of modifications was done to the existing setup under the program? Did you have to curtail/stop the operation? What was the period of curtailment, if any?
4. How did you come to know about the program? Were you approached by the utility?
5. Were any energy audits conducted during the programs? Who paid for the audits? What was the amount of energy savings potential communicated to you after the energy audits?
6. Was the cost of the installations during the program paid entirely by you? Have you been able to recover the cost?
7. Was any survey/audit conducted post installation to verify the normal operation of units and energy consumption level?
8. What changes do you notice post installation in context of variation in operation and output of AC /refrigeration units, energy bill, etc.?
9. Have there been any complaints by occupants in the facility due to the modifications to the existing installation?
10. What has been the response of engineer/operator responsible of the installed system? Do they think they require additional training or there has been increase in their workload?
11. What has been the nature of support from the top management in your facility regarding thermal storage programs?
12. Are you aware about the star rating program of buildings by BEE?