Appropriation of Technology
The case of Tata Power Delhi Distribution Ltd.

A case submitted to the
Tata Power Delhi Distribution Limited (TPDDL)

Submitted By

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Acknowledgement

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Appropriation of Technology

The case of Tata Power Delhi Distribution Limited

It was June 16, 2013, it was peak summer when temperature was souring at level of 47degree Celsius. Delhi was facing power cuts. Mr. Praveer Sinha, CEO and Executive Director, Tata Power Delhi Distribution Limited (TPDDL), was wondering how technology could further help in providing reliable power to all whilst mitigating other key challenges of bringing down the Aggregate Technical & Commercial (AT&C) losses further and the company could generate higher revenue with the same power input while providing better satisfaction to the customers. Over the years TPDDL has achieved an unprecedented AT&C Loss reduction from a level of 53% (2002) to 10.78 % (2012-13). TPDDL had been consistently over-achieving the statutory/regulatory targets for AT&C loss reduction. TPDDL has been able to provide uninterrupted supply to its consumers – some of the key indicators signifying radical improvement since takeover being, 140% addition in distribution transformation capacity to meet over 50% increase in peak load (reflecting build-up of sufficient redundancies in the system), 93% reduction in transformer failure rates to reach a system availability of 99.4% uptill FY13. TPDDL has all its Street Light metered and functionality of the same has increase from 40% to 99.93%.It was close to being a benchmark nationally on various parameters but Mr. Sinha was not satisfied. He wanted to achieve international benchmarks in power distribution through appropriation of technology.

Background

Tata Power Delhi Distribution Ltd. (TPDDL) (then known as North Delhi Power Limited), a joint venture between Tata Power Company Limited and Delhi Vidyut Board, was formed on July 1, 2002 as an outcome of Electricity Reforms Process in Delhi. Delhi Vidyut Board (DVB), the former power distributor, was providing power to Delhi Metropolis until June 2002. The performance of power sector in Delhi was continuously deteriorating owing to

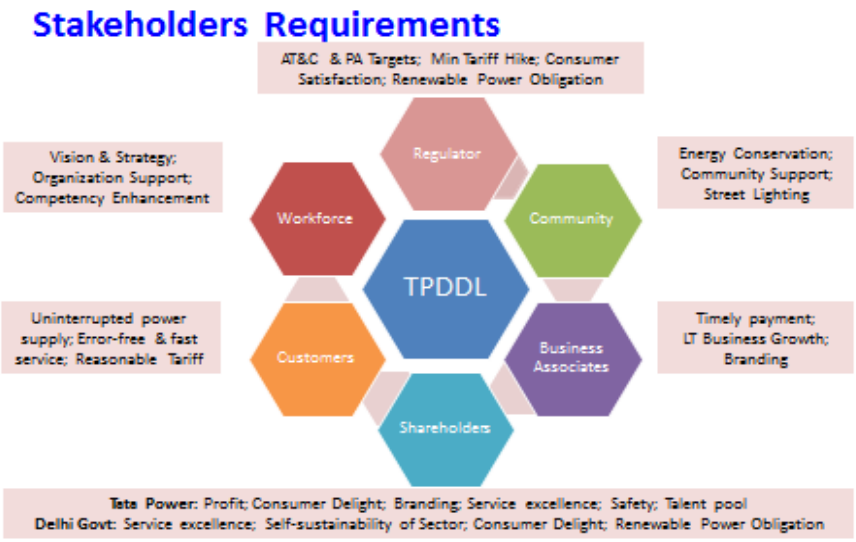
T&D (Transmission and Distribution) losses, inefficient working equipments, dilapidated infrastructure, ever increasing demand andlack of Performance Management System. Delhi Government had enacted the Delhi Electricity Regulations Act of 2000, pursuant to which DVB was disbanded with effect from 1st July 2002. Its distribution operations were taken over by TPDDL and other two distribution companies; BSES Yamuna and BSES Rajdhani. The ownership structure of the newly formed company is given below:

Tata Power Ltd.	49%
Tata Sons.	2%
Delhi Government.	49%

When TPDDL came into existence, AT&C losses were hovering at 53%, distribution network was inadequate and network condition demanded heavy maintenance effort to sustain uninterrupted supply of power. DVB had a weak complaint redressal system where practically no attention was given to consumer service. DVB had a large work force; majority of which was unskilled or untrained. Post turnaround, in the year 2011, NDPL changed its name to TPDDL. TPDDL undertook many technology improvement programmes and adopted appropriate technology efficiently.

By 2012, it was distributing electricity to 13 Lakh customers. The system further needed revamping and augmentation to cater to present and future demands as also meeting the expectations of the stakeholders. The needs of the stakeholders are summarized below.

Key stakeholders and their expectations



Source: TPDDLIT Roadmap

Provisions in the JV

NDPL had many challenges. They, immediately, needed to transform state owned enterprise culture into Tata culture of systems, ethics, governance and performance excellence. Consumers, too, had high expectations from privatization. They wanted uninterrupted quality power at low price. To overcome the dilapidated state of the equipments and the weaknesses in the organization was an uphill task, more so, when NDPL wanted to achieve the world standards. NDPL started with setting stretch goals for itself that, among others, included technology & IT intervention. They knew that behind every intervention, there are people. Thus, employee motivation was the core of all activities. Towards achieving the world standards, the initial goals set were:

a. Reduce AT&C loss to 16 % by the year 2007
b. Improve system reliability comparable with the best utility in India.
c. Improve Consumer service & IT interface comparable with world standards

Besides plucking the low hanging fruits, the CEO, along with his team, decided to take the route of technology intervention in a big way. Over the years NDPL added many new technologies to overcome the challenges of Power distribution in their licensed area.

Challenges for the Joint Venture (NDPL)

The challenges faced by the company were far beyond the provisions provided in the JV agreement. Some of those were:

- Ensuring continuous quality supply of power to 8 lakh consumers who had been suffering frequent breakdowns and blackouts coupled with time consuming restoration of power supply
- Aggregate Technical and Commercial losses (AT&C) were 53% due to technical (transmission) & commercial losses and theft. Commercial losses were due to improper billing, inability to collect bills etc.
- Consumers in unauthorized colonies illegally tapped electricity from the main supply lines.
- The manual billing system had inherent delays. It was difficult to maintain a current and accurate record of consumers leading to difficulty in following consumers who defaulted on their payments.
- Records about consumers and assets were either missing or incomplete.
- Practically nonexistent customer service had created a negative outlook towards DVB.
- The neglected maintenance led to inefficient working equipment. There was delay in restoration of power in case of failures leading to unscheduled load shedding. The primary reason was old, ill maintained equipment and outdated technology.
- Aligning the entire inherited workforce of DVB, which comprised of over 5000 number of employees, with Tata work culture.
- Managing the relationship with the JV partner.

The transformation journey of NDPL*

Targets set by the company (now TPDDL) were interrelated and dependent on each other. One of the biggest reasons for AT&C losses was the electrostatic meters which were inherently slow and prone to tampering. A replacement plan to replace old meters by tamper proof electronic meters was drawn. The first and foremost aim of TPDDL was to provide power to its consumers with minimal load shedding and shorter restoration time to earn consumers confidence. Extensive effort was required in maintenance as there was frequent breakdown due to the old and dilapidated network and grid stations. To improve the maintainability of the network and to meet the demand of current and potential load, a replacement schedule was made to replace old transformers. The new transformers could handle load upto 2000 MW.

*NDPL - *Henceforth the company has been referred as TPDDL*

Bill collection needed clean and updated customer record which was possible only through state of the art IT application and reliable database management. Gaining customer trust was an important factor. The company started various customer-centric initiatives along with extensive use of technology to improve its distribution network. The company decided to invest in world class technology. In this regard, TPDDLengaged the services of KEMA Consultants, a world renowned consultant in Power business. Teams were deputed to bring learning from Baltimore Gas &Energy (BG&E), USA and China Light & Power (CL&P), Hong Kong.

In addition to technology initiatives taken by TPDDL for automation to achieve the target level of losses, it took IT initiatives and integrated it with automation for service reliability while accommodating new customers and load growth every year. These initiatives are described in the following paragraphs:

a. Process Reengineering and automation initiatives

Earlier, there were minimal or no systems and processes in place that resulted in low quality of work. To improve operational efficiency and

productivity, TPDDL introduced relevant Automation and IT initiatives in all the critical areas. With the help of KEMA Consultants of USA, they developed an "Automation Road Map" using state of art technology. "IT roadmap" was developed in-house. The same was discussed with KEMA Consultants, who vetted it.

b. Key technological interventions

The major road blocks that were needed to be overcome to achieve its target were its distribution network, internal processes and customer service. In order to win the confidence of the stakeholders, TPDDL started with tackling fault management and provide uninterrupted power supply. Mobile transformers were put in service for the time being when a failed transformer was under repair.

TPDDL invested in state of the art technologyto ensure reliable power supply. It included automation of substations, improvement of network and technology to detect and repair faults. These resulted in the availability of real time network data to take quick decisions. These initiatives, further, helped to remove person dependency of the network. It was achieved through centralized system where the real time view of entire network was available. Along with these technologies, TPDDL invested in installing a Fiber Optics Network, too, for effective communication. It also developed many IT applications to support its internal processes and customer service. Further, a companywide exercise for "Reengineering" the internal processes was undertaken with participation of the employees.

c. Distribution System Improvement

One of the major challenges that the power company faced and which also had an adverse impact on revenue was power theft. Delhi had a number of unauthorized colonies which had increased over the years with residents migrating from other states and even from neighboring countries. These residents remained unregistered and stole electricity by tapping the bare 220 Volts power distribution lines. According to Mr. Sudarshan K Saini, Head of Commercial, "stopping illegal tapping of electricity and making residents of

unauthorized colonies legal customers of TPDDL became one of our top priorities". Despite the resistance by local political bodies and residents of these colonies, TPDDL decided to go for High Voltage Distribution System (HVDS). Service lines from these transformers provided electricity to only 3-4 houses. Also, the wires were highly insulated which made it almost impossible to steal electricity.

d. Supervisory Control and Data Acquisition (SCADA)

Initially, the communication with the grid station was only over telephone. There was no systematic procedure for operation. In the absence of defined processes, no access to network diagrams and communication among the grid stations and substations, it was difficult to get a clear idea of the loading of the system. The company decided to implement a high end network technology solution, SCADA, to have real time data, monitor and control 35 grid stations from a central location. SCADA system permitted better control over the network, aiding energy distribution management, acquisition and processing of system data and historical data as well as remote management of grid stations and substations. At the same time, grid substation automation work had begun. Access to network data centrally enabled effective load forecasting and thereby enabling load shedding at predefined times. The company focused on making all the network and equipment compatible with SCADA. The SCADA system was implemented in phases to incorporate the immediate need of revamping and also to align with Grid stations automation. To meet any disastrous situation, it created a backup control centre with required functionalities at a different location.

In the SCADA phase two, Distribution Management System (DMS) was introduced. Earlier the distribution was managed at zonal level. Since the zonal engineers did not have any real time network data, it was difficult for them to take any decision regarding shifting of load or partial load to other feeders. With the introduction of DMS, entire 11 KV network of TPDDL could be monitored remotely from SCADA control centre. Although operations were still carried out by zonal people, centralization helped faster fault identification and restoration. Impact of SCADA implementation resulted in reduced losses

owing to better network operation and outage management, besides, faster isolation and restoration of faults leading to customer trust.

SCADA Operations Centre

Devanand, Head of SCADA operations, described that the biggest challenge in deploying SCADA was unmanning of grid substation and their redeployment. Whole SCADA system was implemented by Siemens, a renowned name in the field of automation and energy sector. Siemens provided necessary training to select TPDDL personnel at its head quarter based in Germany. Users were further given training by Siemens for its applications. SCADA system had improved efficiency of TPDDL in terms of human resource management, operations & quality of power and customer satisfaction. Substation grid staff was re-deployed in different departments where there was manpower deficit. Subsequently, the faults during any breakdown were located very fast and thus, restoration was within a few minutes. The average restoration time in sub-transmission system for year 2012-13 was 16 minutes. This had led to enhanced consumer satisfaction in terms of availability and quality of power.

e. Grid automation

The old grid station and dilapidated relay panels had mechanical switches for control that limited the remote operation from a central location. Absence of coordination among different tripping devices added a delay in identifying the faulty section. Mr. Sanjay Banga, Head Systems, pointed out, “as TPDDL was going towards technologically advanced solutions, at the substation level, all 33/66 KV control and relay panels in existing grids were replaced with electronic equipment. This was needed to make relay panels communicable for proposed Supervisory Control and Data Acquisition (SCADA) system”. The Grid Substation Automation System (GSAS) provided integrated monitoring, more information for planning, engineering and protection setting as also improved substation maintenance. As part of this project, remote consoles were setup to monitor grid stations from Ranibag load dispatch centre.

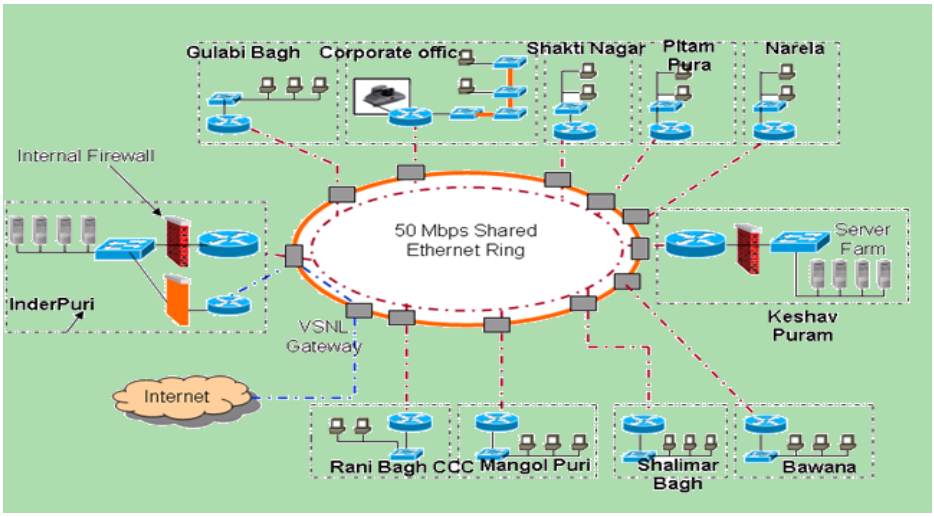
Before After

Outdoor Transformer

f. Communication Network

Reliable and all time availability of communication network was a basic requirement to support all the enterprise systems as well as the communication between Grid stations and SCADA. TPDDL chose to deploy its own private network on already existing Tata Telecom laid fiber, which formed the backbone of communication network in their area. The joint effort of engineering and design of fiber network by TPDDL and Tata Telecom project management group brought down the project cost from 50 Cr to 18 Cr with reduction in project schedule from 3 years to one and half year. The network was high bandwidth and secure that made system availability for

more than 99.8% and removed dependency on third party for communication requirements. The communication network created is depicted below.



Communication Network

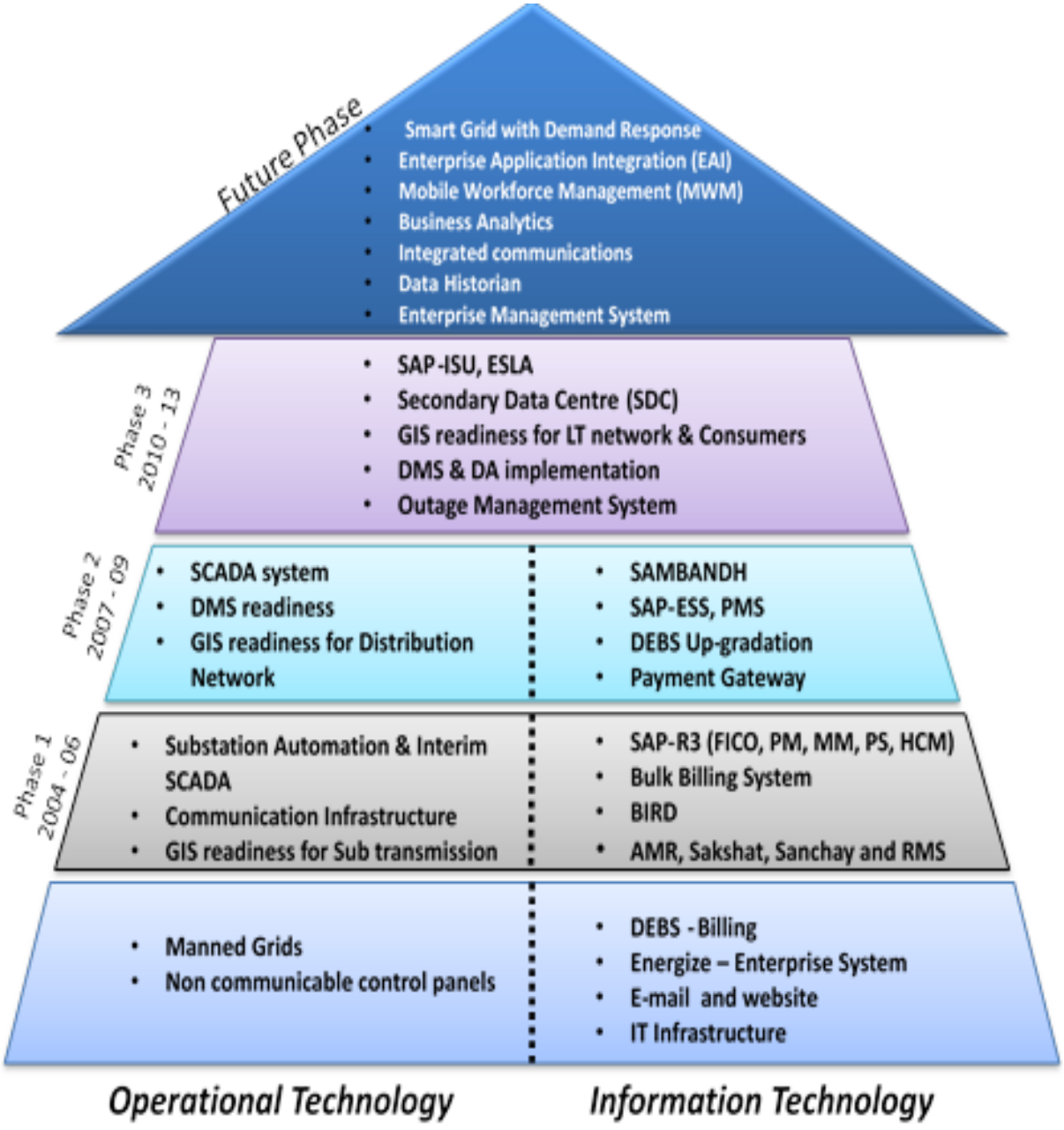
g. Outage Management System (OMS)

To monitor low tension (LT) level outages effectively, OMS was implemented to give a geographical display of electric sub-transmission and distribution network indicating outages, crew and predicted failure points. Also the system could summarize monthly, year-to-date outage statistics and details of outage status via intranet. When the call centre received a call for fault, a system generated SMS was sent to the concerned crew. Once the fault was repaired, the crew informed the call centre. The customer was informed and the call was closed. The integrated technologies, thus, saved time in repairing faults.

Outage Management System

h. Geographical Information System (GIS)

To have a better visibility of the geographical area under its operation, TPDDL implemented GIS. This was required for the central monitoring of the entire TPDDL network. Satellite map of Delhi and the entire network base of North and North West Delhi was plotted on the map showing buildings and roads. The software was integrated with customer database to map all the customer information. GIS software installed was GE's "Small World". The GIS aided SCADA in better monitoring the Outage Management System resulting in faster fault restoration. Additionally, GIS enabled tracking of all the assets from its installation to its retirement through its effective interface with SAP. Also it helped in identifying the dues accurately mapped with each owner.



Key Technology Trends

Compiled by authors with sources from TPDDL

i. Billing and monitoring of electricity consumption

One of the problems that TPDDL faced initially was billing and payment collection. This was due to deficiency in metering, billing and collection processes. Theft from the distribution lines was a major cause of loss. In addition to that, faulty meters gave lower/no reading of the electricity consumed. The meters were electro mechanical which gradually wore out and

gave inaccurate readings and also were easy to tamper with. Since the reading was taken manually, it was also prone to human error resulting in wrong reading and thus, wrong billing. With faulty meters and/or wrong/no reading, consumers were not billed or under billed. Unauthorized colonies like JJ (Jhuggi-Jhopri) clusters were un-metered and therefore, no bills could be raised for them. Non payers and defaulters were in plenty. They were often not traceable since there were no consumer records or the records were not updated

TPDDL at first metered all DT's with AMR enabled meters. This helped in getting accurate Energy Audit data. Further massive meter replacement drives were taken place wherein 99% electromechanical meters were replaced with electronic meters. The electronic meters collected data automatically for consumption, variation and other electrical parameters. These were fed in the system, thus, the data collected was free from human error. In addition to accurate electricity consumption reading, it optimized the billing frequency since the readings were fed directly in the system. These meters also recorded history of the consumer and consumption patterns. TPDDL had 10 Lakh registered consumers at that time.

Consumers who could not pay for the electronic meters were given a choice to pay for these meters in installments. To motivate consumers, TPDDL held meetings with Resident Welfare Associations (RWAs) for awareness regarding electronic meters so that the meter replacement process could be expedited. Convincing residents of unauthorized colonies and JJ cluster was a major challenge since they were using electricity without paying. To include them in the billing process, TPDDL took unique CSR initiative such as skills development program so that they could have a consistent source of income and pay the bill.

As manual recording of consumption required manpower adding to employee expenses, TPDDL decided to go for Automatic Meter Reading (AMR) which required a GSM port to be installed in the electronic meter even though it cost

additional to the company but enabled to take the readings from remotely situated offices. The AMR unit installation started in 2004 with Key Consumer Segment (HT Connections over 100KW) which was generating major revenue. Meter quality and its compatibility with the back end software was an important factor. Procuring meters from different vendors meant that there would be compatibility issues when it came to configuring the meters to communicate with the application software as well as data storage. Despite compatibility issues, it was decided to go with multiple vendors to avoid vendor dependency and to address monopoly issues. The vendors were given common meter specifications. While all vendors provided their own Software versions, TPDDL team developed an in-house AMRDA (Automated Meter Reading and Data Acquisition) system capable of communicating with different meter types. Entire system had been developed and implemented In-house. In the initial phase, the modem installation was done with meter manufacturers only but slowly the in-house team developed competence to take over the installation work. Subsequently AMR was installed on all High Revenue Base consumers (with sanctioned load >10 KW). A dedicated group was created to timely monitor the consumption of these consumers ensuring no revenue leakage on account of these consumers.

TPDDL has implemented integrated CRM software to monitor the entire consumer revenue cycle management. This helped keep consumer record, register requests/ complaints, resolve the request/ complaint and finally close the same.

j. ii) **Automation of customer centric services**

With its focus towards better customer service, TPDDL came out with certain initiatives aimed at transparency and greater customer satisfaction. Different avenues introduced to connect and communicate with the consumerwere:

a) Customer application for new meter connection

In the earlier system, a customer would get a new meter connection only by applying at the centre. In absence of clear internal processes and meter

connection procedure, the customers had to make repeated trip to the centre to follow up the application. Getting a new connection took somewhere around 30 days. Further, there was no mechanism to communicate deficiencies in the document or any other reason on account of which the new connection got rejected or delayed. TPDDL adopted the concept of Field Service Executives (FSE) wherein TPDDL representatives visited the applicant premises within 3 days of new connection request to complete the commercial formalities, collect required documents, and provide site completion status which reduced the entire new connection process cycle time to just a few days. After filing and document processing, the applicant was communicated particulars of demand note i.e. new connection charges applicable based on load and usage category opted by the applicant. For any deficiency observed in documents or any technical constraint observed at the site, a rejection/intimation letter was sent to the applicant. The new meter was installed within 5 days of the payment. This reduced the total time required for providing a new connection to approximately 8 days.

Further, using an Oracle based application, TPDDL integrated GIS with CRM. When a consumer applies for a new connection, a no dues check is required on the premises. Seeking no dues clearance required identification of premises physically and then verification of payment database which used to take long time specially in semi urban areas.

With mapping of entire household units/ buildings on the GIS physical verification has been eliminated thereby ensuring that the connection can be released instantly by verification of the dues on premises through the linkage of GIS and billing database.

Once the consumer applies for new connection, an auto no dues instant connection is initiated. The CRM module reflects information on payment status of each consumer which is updated with concurrent inputs being obtained from the GIS with regard to the concerned premise. Once the request stands clear, demand note is generated by CRM and intimated to customer for payment on the call itself. After payment, the request is automatically forwarded for meter installation.

b) Billing and payment

The company developed its website where customers could retrieve relevant customer information. SUGAM-Billing database of 100% customers was made available through the database which was created for the first time in India. Consumers could view their electricity bill, view consumption graph and print duplicate bills. For consumer convenience, payment avenues were increased. Earlier there were only 20 centers where consumers had to stand in long queues to pay their bill. The centralized billing system allowed consumers to pay their bills through any of the 1100 payment centers, apart from electronic payment.

c) Customer Complaint redressal

In its attempt to connect more with the customer and bring services at customer's doorstep, the company provided the facility of 24X7 call centre. The call centre was connected to the centralized network. The customer was instantly given a complaint number after registering the complaint to enable him to track the complaint. Thereafter, the complaint was routed from the call centre to the nearest service centre.

d) SAP Software for Operational Excellence

TPDDL's journey had been marked with many strategic initiatives. To develop a performance based culture, it needed to assimilate key processes such as finance and accounts, human resource, plant maintenance, inventory management etc. At the time when TPDDL took over, they didn't have any computerized systems, thus, real time data was not available. This resulted in poor and fragmented customer service and affected operations adversely. For quick and effective fault management, it was essential to have fast availability of required material and other resources. The maintenance staff needed to physically check the store for the availability of parts that they needed for repair work. According to Mr. Sanjay Banga, Head Systems, "early on after the JV, we realized that operational efficiency could only be achieved through IT automation. We could either go for customized software developed to fit the needs or go for a commercial software package with a proven record and

reengineer the processes. The management decided to go for SAP implementation and develop processes since there weren't any preexisting clear process for operation". SAP addressed key business requirements of the organization such as inventory management, accounts & payroll and HR processes. The SAP software went live in December 2005 within a record time with business functionalities of finance, HR, plant maintenance, material management and project management.

TPDDL was facing several challenges with its legacy system:

- In legacy system, there were four different call centre numbers for different services (commercial, No supply, Street Light, Ethics & safety)
- "No Supply Call centre" was not integrated to consumer database and thus unable to provide right & efficient services to the consumers.
- System was not flexible enough to convert supervisor desk into an agent desk to handle high call volume.
- System was not supporting email feature for consumers to get information or log complaints automatically.

Computer Telephonic Intelligence/Call Identification (CTI/CLI) feature was not supported in legacy system

Based on the experience a need for re-engineering of the organizational processes was felt to further enhance consumer experience through a world class call centre. Accordingly, various alternatives solutions were evaluated and finally SAP BCM (Business Communication Manager) was implemented in Jan 2013. This globally renowned solution was integrated with other commercial and operational systems.

TPDDL is the first utility in India to implement SAP-BCM giving it an edge over its competitors. This implementation is a major milestone due to its uniqueness, complexity and integration of IT with state of art Operational Technologies like GIS, OMS and commercial SAP modules like SAP-CRM and SAP-CS.

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iii. Asset Management

Over a period of time, TPDDL initiated and implemented various IT applications. The interfaces between each of these IT applications were usually manual and therefore each asset related transaction required several manual updation of databases. Keeping all databases synchronized was a struggle because of the manual interface. During a100% asset verification, massive discrepancy was discovered such as: The main reasons for wrong identification of the Assets were:

- Asset description and quantity appearing in FAR was different from that of the field as those were defined by different user group.
- Some of the assets appearing in FAR were already retired from field physically.
- Asset Physical Location appearing was FAR is different as there is no process of flow of information about the movement of Asset to Finance for necessary Updation in FAR.

These discrepancies triggered to develop an innovative process of synchronization which will interlock GIS ID, Equipment Id & Asset Id to avoid the mismatch in any of the system and hence to have better control on Asset Management, Capital Expenditure Management, Operation & Maintenance Management, Commercial Management, Outage Management System.

To overcome the above challenges, the innovative solution came to integrate all the Assets with GIS ID-Equipment ID– Asset ID through GIS-SAP integration. To integrate processes nad business models TPDDL carried out

- Physical verification of all assets through field survey and assigning of GIS ID through GIS system.
- Capturing of equipment details through physical verification and assigning of Equipment ID by creating / linking Equipment number in SAP (PM Module) system.
- Through equipment details, assigning Asset ID by linking Asset number from Fixed Asset Register in (SAP) system.

For all Assets, GIS ID-Equipment ID-Asset ID is interlocked in all business system using middle ware SBI integrator which integrates GIS-SAP.

The entire organization was integrated in a way that any change in any business system triggers the event in other and restricts the users to carry out any further action unless it is done in other system. This equalization process for binding an asset with physical location identifier i.e. GIS id, technical & maintenance details i.e. SAP id and financial details i.e. FAR id has enabled TPDDL to systematically manage and protect assets through complete asset lifecycle, schedule the timely maintenance of the assets and enabled accurate financial records resulting in enhanced reliability and customer satisfaction.

The benefits reaped from EGIS are not limited to Asset management but made possible to implement Instant new connection to consumers, Consumer indexing for identify high loss area for AT &C loss reduction.

. **iv. Knowledge management**

With substantial investment in technology to improve the dilapidated systems that TPDDL inherited, senior management envisioned training and knowledge management as an important aspect for technology appropriation. Developing, retaining and sharing intellectual capital was done through web enabled portals “Sanchay” and “NDPLoPedia”.

By now, TPDDL had traversed a long journey; the key technology initiatives for power distribution had shown results but Mr. Sinha knew that it was not enough considering the ever increasing demands from stakeholders. He wanted to take TPDDL to next level, setting up global benchmark for AT&C

losses, technology management and customer delight. He was wondering what should be his next steps.

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Appendix 1

Key terms

AMR	Automatic Meter Reading
AT&C	Aggregate Technical and Commercial Loss
DMS	Data Management System
GIS	Geographical information System
GSAS	Grid Substation Automation System
NDPL	North Delhi Power Limited
OMS	Outage Management System
SCADA	Supervisory Control and Data Acquisition
TPDDL	Tata Power Delhi Distribution Limited
WMS	Workflow Management System

Appendix 2

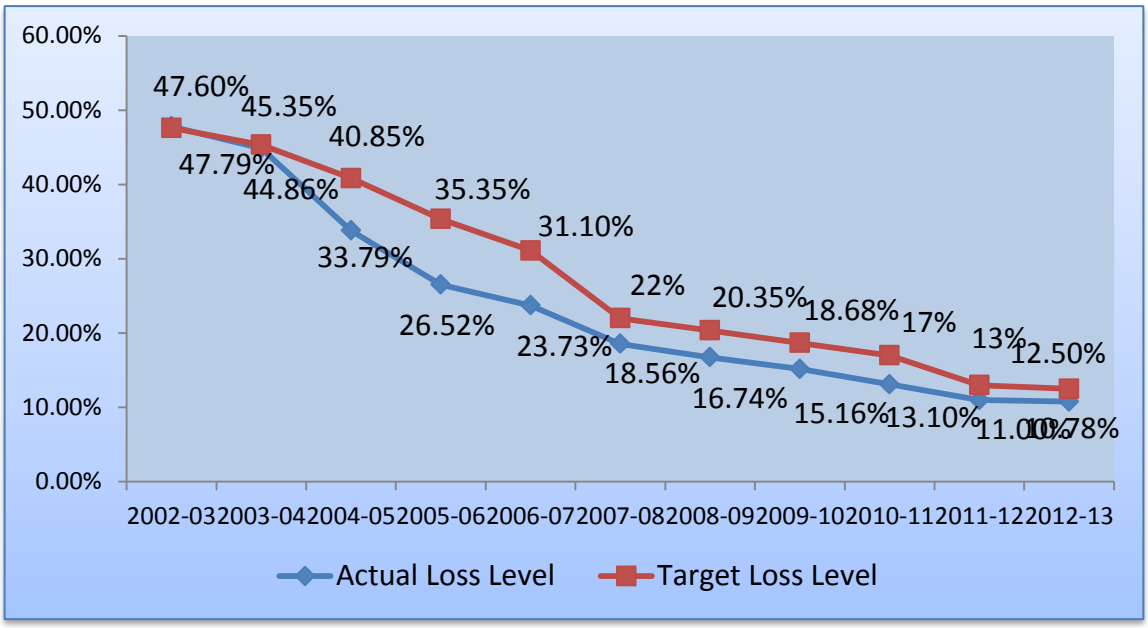
TPDDL Status

Parameters	UoM	July 2002 (on JV)	2007-08	2012-13	% change since 2002
Consumers	Lacs	6.7	9.50	13.50	1914%
Input	MU	5400	5986	7764	44%
AT&C Losses	%	53.1	18.5	11.20	77%
System Reliability – SAI	%	70	70	99.4	42%
Transformer Failure Rate	%	11	1.9	0.79	93%
Peak Load	MW	930	1209	1563	68%
Length of Network	Ckt. Km	6750	10700	13090	93%
Street Light Functionality	%	40	94	99.5	148%
Payment Collection Avenues	Nos.	20	1663	4599	22895%
Consumer Satisfaction	Index	-	76	88	8800%
Parameter	UoM	Jul-02(On JV)		2012-13	% change
Mean Time To Restore Supply	Hrs.	5.2	3.0	1.3	75%
Street Light restoration within 48 hrs.	%	50	50	99.70 (90% completed within 24 hrs)	99%
New Connection Energization Time	Days	51.8	51.8	6	88%
Faulty Meter Replacement	Days	25	15	7	72%

Compiled by authors with sources from TPDDL

Appendix 3

AT & C Loss Reduction Trend



Compiled by authors with sources from TPDDL

Appendix 4

Project details

Project name	Project cost	ProjectStart date	Project completion
GSAS	INR 25 Cr.	Jan 2005	Aug 2008
Communication network	INR 18 Cr.	Jan 2005	Dec 2006
SCADA	INR 11 Cr. (including DMS)	September 2005	Feb 2007 (Phase 1 SCADA)
DMS	Included in SCADA cost	July 2007	March 2010
DA	INR 12 Cr.	Oct 2008	May 2010
AMR	INR 10 Cr.	July 2009	March 2011

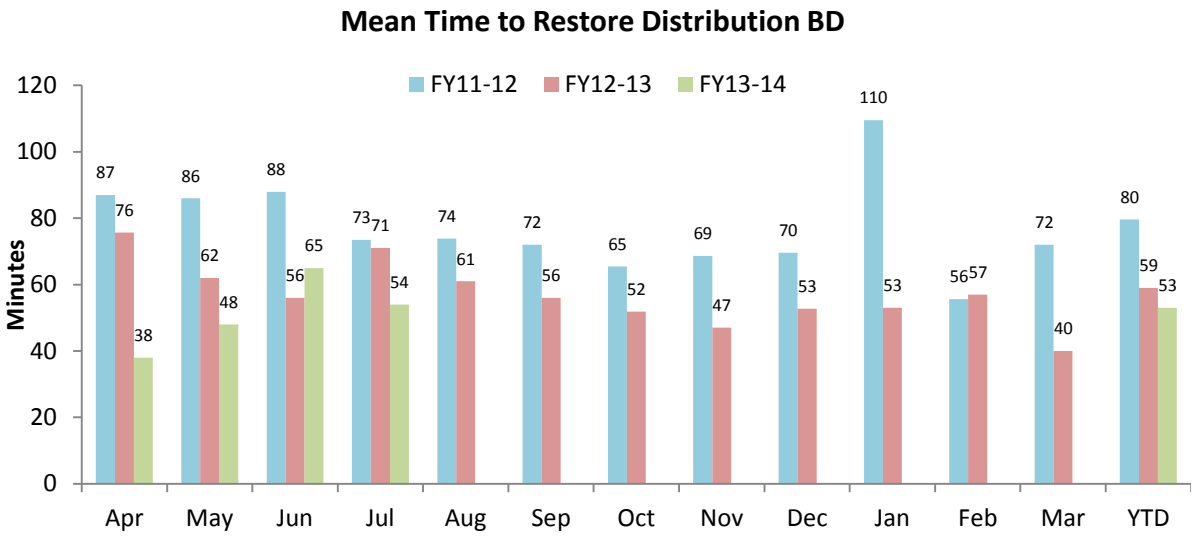
Compiled by authors with sources from TPDDL

*INR : Indian Rupees

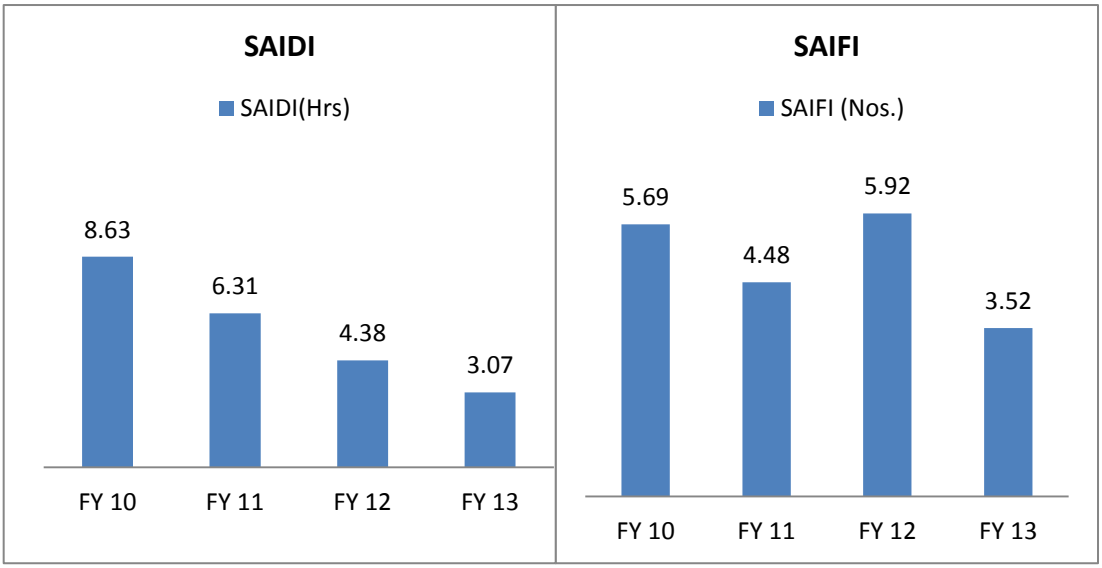
**Cr : Crore (10 million)

Appendix 5

Supply restoration



Compiled by authors with sources from TPDDL



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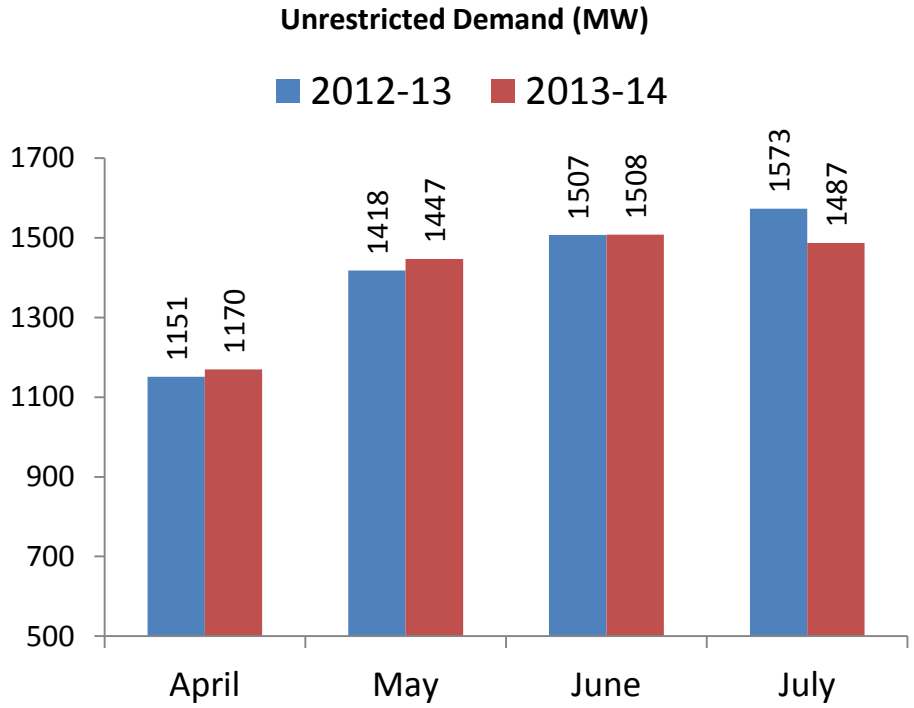
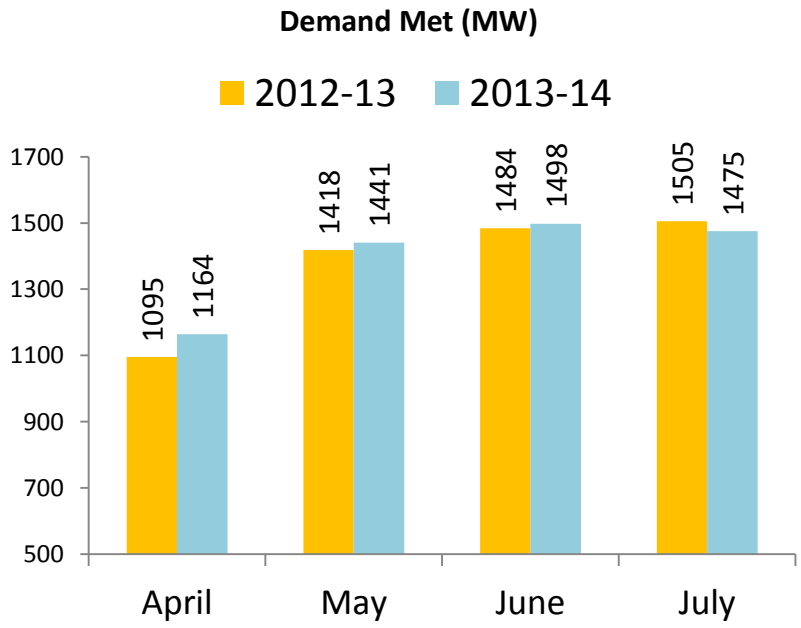
Appendix 6

Peak demand comparison



Compiled by authors with sources from TPDDL



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