TATA POWER-DDL

SMART GRID LAB

Energy Solutions for a Smarter World

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with you Non-Stop

SMART GRID

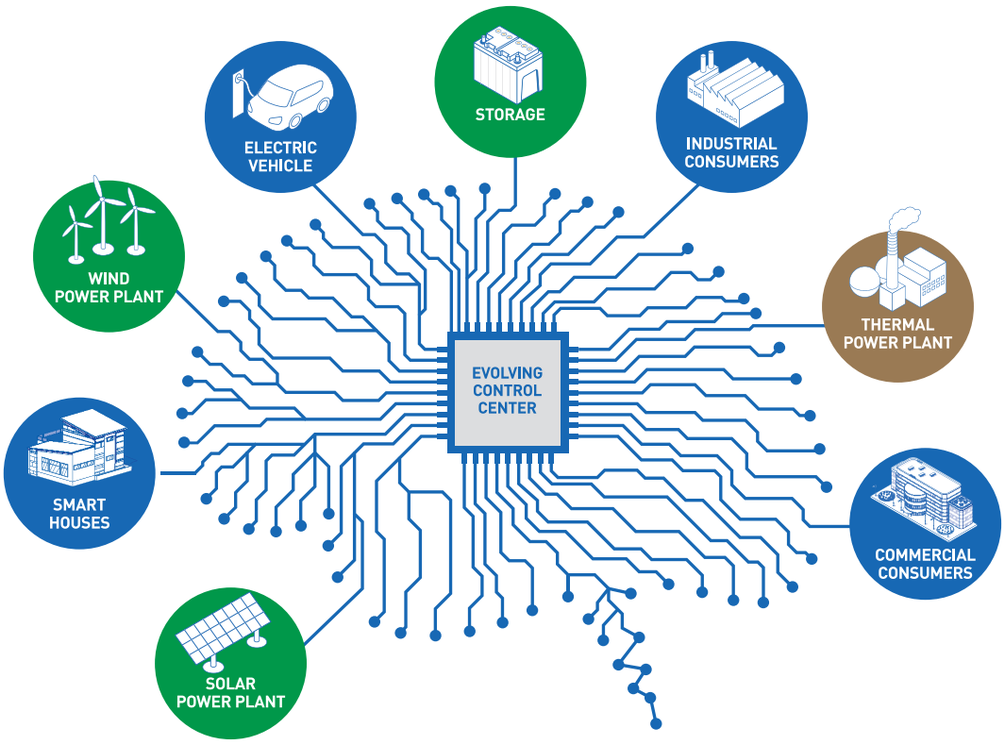
THE INTELLIGENT NETWORK

Smart Grid is quintessentially a platform of robust data networks that enable bidirectional exchange of data for all kinds of power supplies and remote and active monitoring of operation and fault conditions of the electricity network on a real time basis. Smart, self-shaping, fully adaptable networks that connect the energy provider with the customer represent the essence of smart grids.

Tata Power-DDL embarked on this journey in 2002, and has since then, drastically improved response time and enhanced the quality and efficiency of electricity distribution for its 7 million consumers across communities spanning over a space of 510 sq. kms. in North and North West Delhi.

THE SMART GRID ADVANTAGE

- Optimal utilization of assets of power generation, transmission and distribution;
- Enhances the grid stability and reliability;
- Sustainable energy infrastructure;
- Improves the cost efficiency for both the customer and the supplier;
- Capable of handling varying demand and uncertainty of distributed generation.



TATA POWER-DDL SMART GRID LAB

THE ADVANTAGE OF EXPERIENCE

Tata Power-DDL Smart Grid Lab provides a test bed to demonstrate the Smart Grid Technologies and the benefits of convergence of IT and OT technologies for distribution utilities in the Indian context. The focus is on "hands-on" demonstration of various technologies, products and solutions for power distribution utilities and how these technologies help in providing an improved connectivity, efficiency and reliability that is both sustainable and scalable.

THE LAB IS DIVIDED IN TWO AREAS:

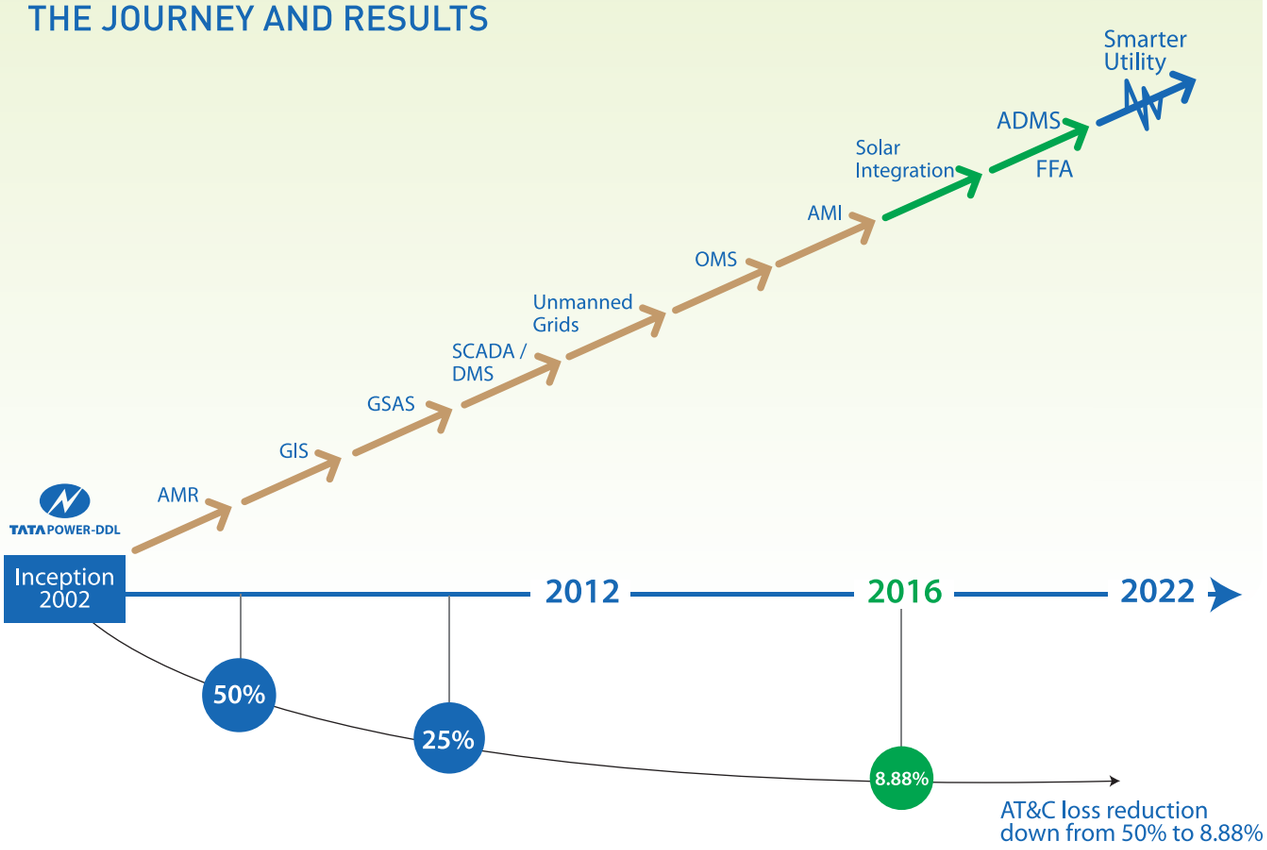
TECHNOLOGY ZONE

Technology Zone provides end-to-end technology solutions that have been commissioned to demonstrate solutions all the way from sub-transmission level (66kV/33kV level) up to the last mile (440V) i.e. Smart Meter to the customer's appliances.

CUSTOMER EXPERIENCE ZONE

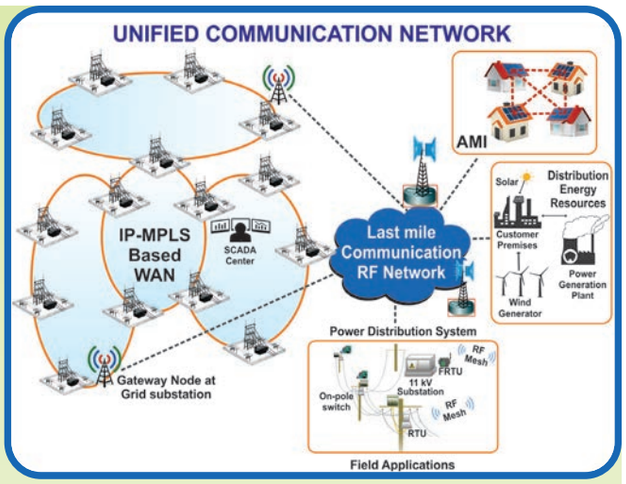
Customer Experience area of Smart Grid Lab was developed to build awareness among students, customers and utility personnel. Various DSM initiatives and energy conservation solutions which have been commissioned are displayed for an easy understanding of foundational principles.

THE JOURNEY AND RESULTS



GIS & NETWORK COMMUNICATION

FOUNDATIONAL TECHNOLOGIES



GEOGRAPHIC INFORMATION SYSTEM (GIS)

The Geographic Information System (GIS) is a representation of an on-field infrastructure on a computer based system. Tata Power-DDL is one of the first utilities in India to implement an enterprise-wide GIS.

To explain this in general terms – all the grid stations, substations, transformers, lines and cables that are part of the Tata Power-DDL distribution electrical network are maintained in the GIS. This information can be viewed as a 'map' by Tata Power-DDL back-office staff. GIS plays a key role for one of the most crucial function of managing outages, where in a matter of minutes, the system will analyze and predict the probable faulty device that has led to an outage. Hence, the location can be reached in minimum possible time for power restoration.

Edison Award by Edison Electric Institute of the United States was conferred on Tata Power-DDL for its operational excellence in the power industry and for utilising and integrating its Geographical Information System (GIS) with other applications for network planning, operations, commercial and asset management.

NETWORK COMMUNICATION

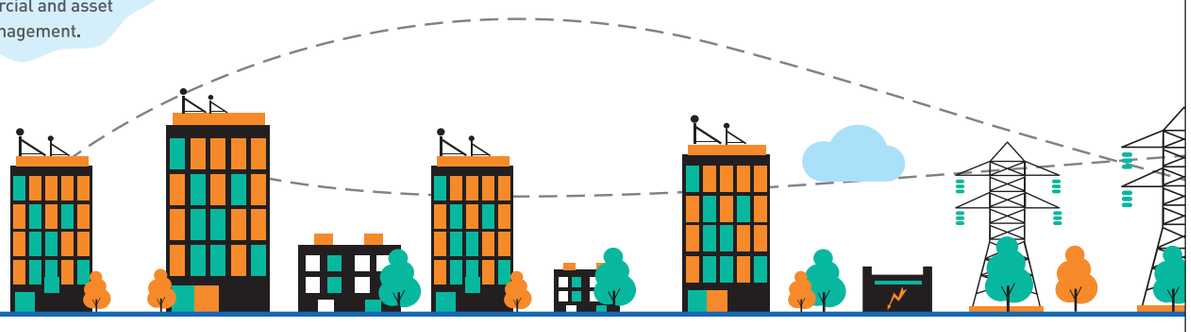
Tata Power-DDL established its Communication Network (in FY 2004-2005) across its areas of operation to support:

- Operational applications like SCADA / Tele-protection / GIS / OMS
- Commercial and billing applications
- Enterprise applications – SAP CRM / SAP BCM / SAP ERP, E-mail, etc.

Tata Power-DDL's upgraded MPLS based Communication Network architecture is a IP / MPLS (multiprotocol label switching), network which is a packet-switched networking technology that provides a good choice for power utilities communication network and supports Smart grid applications such as AMI, DER, EV charging stations, MWM, ADR and Integrated security solutions etc.

KEY BENEFITS ARE:

• Bandwidth Efficiency, Quality of Service, Protection Requirements, Topologies • Plug-and-play Simplicity, Future-proof Investment Protection, IPsec for Access to Smart grid devices • Integration of General Applications like CCTV, Video Conferencing and IP Telephony with IP Services and functionality



DISTRIBUTION NETWORK MANAGEMENT

FOUNDATIONAL TECHNOLOGIES

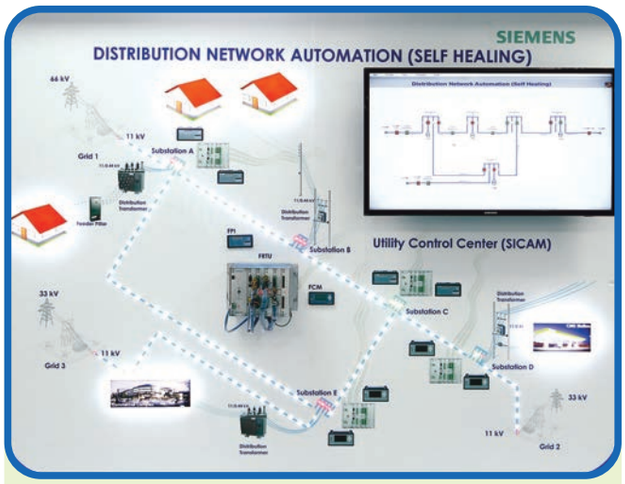
ADVANCED DISTRIBUTION MANAGEMENT SYSTEM (ADMS)

ADMS is an integrated electrical system design and real-time power distribution management system. ADMS unifies SCADA, Advanced Distribution Management Applications & Outage Management System (OMS) functionality in a single modular solution.

The SCADA/ADMS will collect field data on IEC 60870-5-104 from Data Concentrator Units (DCU) / Remote Terminal Units (RTUs) and will interface to existing system like GIS, Customer Care, SAP-Plant Maintenance, Material Management and future technologies like Field Force Automation (FFA), ADR, WFM, Asset Management Systems along with Load Dispatch Center of Other Electric Utilities & State Load Dispatch Center of Delhi over ICCP ICCP/TASE.2.

BENEFITS:

• Quick decision capability on interruption as entire information is available at one location • Reduction in Technical losses • Precise voltage control / Capacitor switching / Tap changing • Monitoring of equipment overloading • Automatic load shedding schemes based on real time data • Historical database for network planning and analysis • Increased safety standards



DISTRIBUTION NETWORK AUTOMATION (SELF-HEALING)

The state-of-the-art control systems for substations requires fast, powerful microprocessor based systems designed to function with flexibility in an environment that has been traditionally designed for a centralized operational system. The tasks of such systems are manifold which guarantee safe and secure operation of the entire system with high availability and shortest repair time

The "self-healing" system is designed to provide a reliable system for acquisition of information and statuses from F-RTU placed at corresponding RMU to communicate the information back to control centre for faster fault location, isolation and system restoration.

BENEFITS:

• Minimal outage time with reduced dispatch expenses through remote control and automation • Quick localization and de-energization of faulty section • Faster restoration will reduce the impact to "life support" systems • Improved customer service • Holistic, customized distribution automation solutions to fit individual needs • Central solution - implemented at the control center solution

ADVANCED METERING INFRASTRUCTURE (AMI)

FOUNDATIONAL TECHNOLOGIES

Advanced Metering Infrastructure (AMI) is an integrated system of smart meters, communications networks, and data management systems that enables two-way communication between utilities and customers. The goal of an AMI is to provide utilities with real-time data about power consumption and allow the customers to make informed choices about energy usage based on the price at the time of use. Customer systems include in-home displays, home area networks, energy management systems, and other customer-side-of-the-meter equipment that enable smart grid functions in residential, commercial, and industrial facilities.

SMART METERS

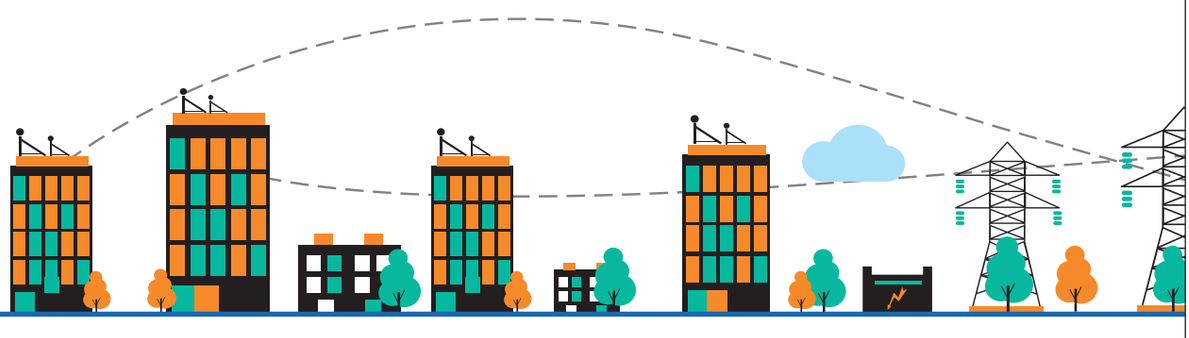
Smart Meter is an AC static watt-hour meter with time of use registers, internal connect & disconnect switches with two way communication capability. It is designed to measure flow of energy, store and communicate the same, along with other parameters defined in this standard. A smart meter as opposed to conventional meters allows for remote access by utility for data, programming and load control.

Smart Meter is a pivotal technology catapulting the evolution of smart grid. With real time 2-way communication, Smart Meters are a critical prerequisite for advanced metering infrastructure as well as for various Smart Grid applications enabling AMI rollout and advanced management of consumer and system requirements.

Bureau of Indian Standards has rolled out the metering standards for the smart meters.

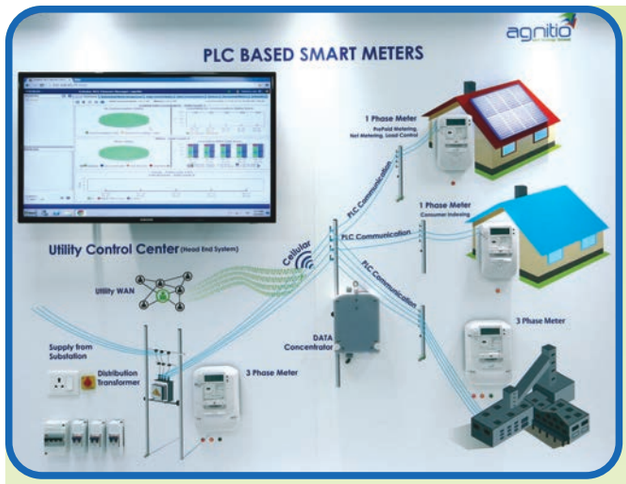
1. IS:16444: 2015, AC Static Direct Connected Watt-hour Smart Meters CLASS 1 AND 2
2. IS 16444 Part 2 : 2016 AC Static Transformer Operated Watt-hour and Var-Hour Smart Meters Class 0.2 S, 0.5 S and 1.0 S – Specification, is under final stages of preparation.
3. IS 15959 : 2011 'Electricity metering - Data exchange for meter reading, tariff and load control — Companion specification' has also been suitably amended and issued for enabling Smart Meter implementation.

IS:16444 metering standards are the first Smart Meter Standards issued anywhere in the globe for the specific purpose of Smart Metering



SMART METER COMMUNICATION TECHNOLOGIES

FOUNDATIONAL TECHNOLOGIES



PLC BASED SMART METERS

Power line networking uses existing electrical wiring, whether in a building or in the utility grid, as network cables, where they also carry data signals. It can also be a means of extending the existing network into new places without adding new wires. PLC can be broadly grouped as narrowband PLC and broadband PLC, also known as low frequency and high frequency respectively.

BENEFITS:

- Low OPEX for meter communication
- Improving Power Quality through online transformer load monitoring
- Automating network topology management by dynamic consumer indexing
- Hundred percent energy auditing and asset management
- PLC will transmit information on issues with network health. This enables utility to keep the network in good health.

CHALLENGES:

- In case of outages, communication is hampered and leads to poor reliability
- No real time power outage notification
- If all consumers connected to a DT are not migrated to AMI meters or there is likely to be distance of more than 100-110 meters between AMI meters, PLC may not be the best solution, Communication testing must be done beforehand

RF-MESH BASED SMART METERS

Each communication module in the RF network is associated to a particular layer and collector in the mesh network. As new communication modules are added to the network, the preferred neighbour defines these characteristics for the newly installed module. The communication modules will dynamically switch to another neighbour in their list, which will route data along a new path. This results in inherent fault tolerance and load balancing as each communication module dynamically routes data to the most available neighbouring device at each message exchange.

BENEFITS:

- Limited OPEX for communication between Meter and DCU
- Transmission is at a higher bandwidth
- No investment of cable and network improvement as transmission not dependent on physical media

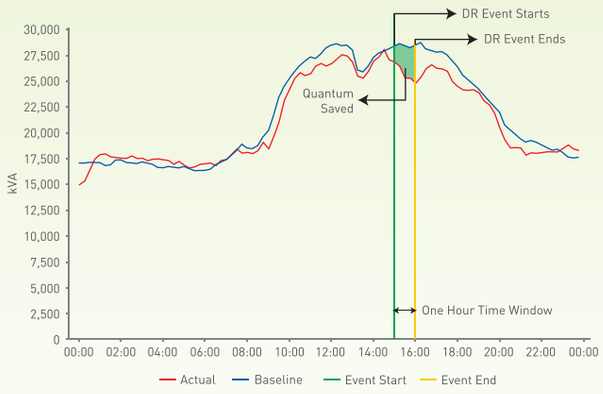
CHALLENGES:

- Higher risk of mesh failure during deployment. It will require redesign and investment in canopy creation at the time of deployment.
- Utility has to develop Telecom Network Management expertise to manage, monitor and maintain the RF mesh network. This will result in additional OPEX cost.
- Interactive design of canopy needs to be engineered to arrive at the final cost of the RF mesh architecture.

AUTOMATED DEMAND RESPONSE (ADR)

DISTRIBUTED ENERGY RESOURCES

Automated Demand Response is a program that responds to the periods of high demand by shifting the consumer load during the periods of high demand to off-peak periods to manage critical peak demand for short durations that reduces grid stress. It provides a dual benefit. It provides energy sourced from a less expensive base load generation as well as optimizes cost required to build additional generation capacity to meet future peak demand.



The participation of the end customers is a response to factors such as:

- Incentive pricing
- New tariff schemes
- Greater awareness and an increased sense of responsibility

The end consumers agree to get involved but their participation may involve either active behavioral changes or passive responses, through the use of automation.

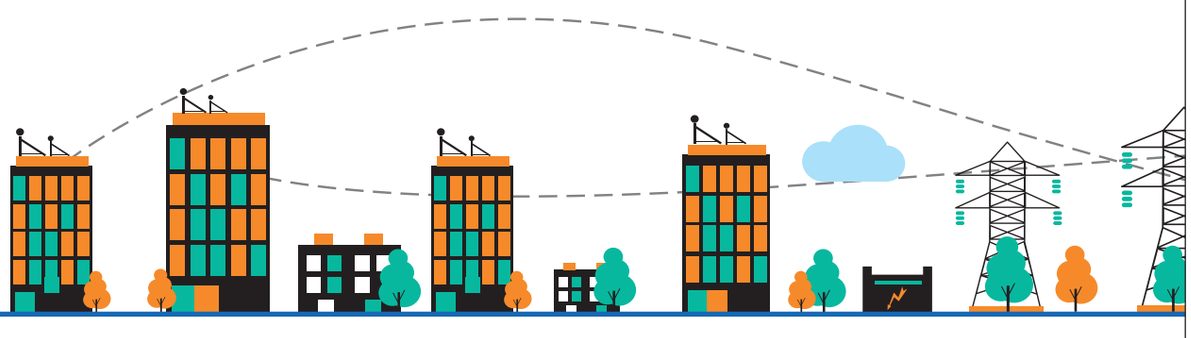
LEVERS FOR A ROBUST ADR PROGRAM:

- Tariffs
- Incentives
- Utility controls
- Awareness and inclined attitude towards energy conservation
- Lucrative DR programs
- Government subsidies to encourage participation

DETAILS OF PILOT PROGRAM:

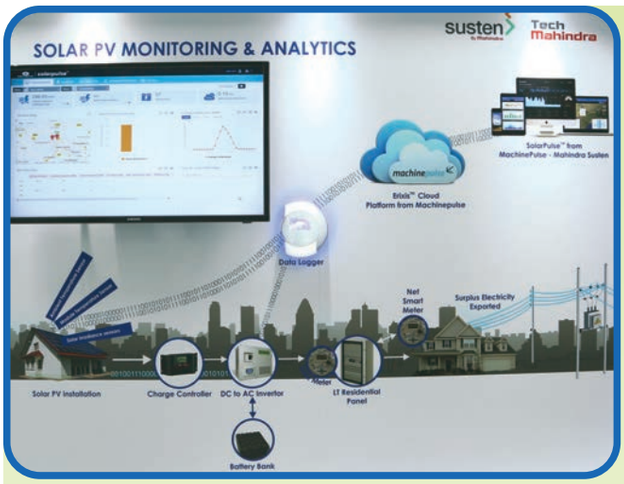
- 161 commercial and industrial consumers were successfully enrolled to participate in a volunteer automated demand response program
- Applicable for consumers with a sanctioned load of 100kW and above
- Expected load reduction of about 34MW envisaged

Tata Power–DDL is one of the first Indian power utilities to launch Auto Demand Response (ADR) project with Smart Meters in India.



SOLAR PV MONITORING & ANALYTICS

DISTRIBUTED ENERGY RESOURCES



As a responsible corporate, Tata Power-DDL is committed to promote the use of renewable energy as well as meet RPO. This involves integrating distributed generation such as rooftop solar into energy planning as well as understanding the variability of solar for accurate forecasting and real time power management.

In 2014, Tata Power-DDL was one of the first utilities to be engaged in a feasibility study to explore adoption of rooftop solar across various consumer segments and understand what regulatory guidance is required to encourage rooftop solar.

Solar analytics help in providing the solar system owners detailed insights into system performance thus allowing them visibility all the way from generation reports to predictive analytics. Due to the inherent variability of solar generation and irradiance, developing historical records are an extremely useful analytical tool when it comes to distributed generation such as rooftop solar. By identifying various agents that contribute to the loss, the analytical tool provides predictive analytics with a strong accuracy.

FEATURES:

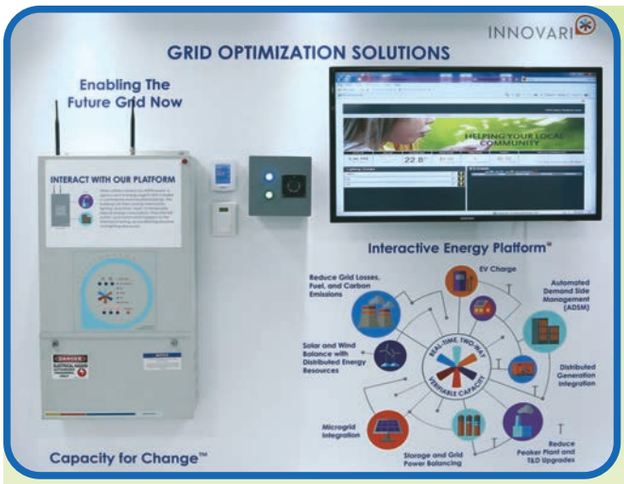
- A web portal for observing live system output
- Accessible to both system owner, installer and other relevant parties
- The web portal also allows live access of energy use at home in dealing with questions / queries like: how much solar power is being consumed vs exported or how much power is being purchased from the grid.
- Asset health check
- Real time generation prediction for solar plants
- Real time inverter characterization during generation hours
- Detailed loss estimation under various scenarios

LOSSES:

• Reflection loss • Soiling loss • Loss due to environmental conditions • MPPT loss • Degradation losses • Quality and mismatch effect

EDGE OF THE GRID SOLUTIONS

DISTRIBUTED ENERGY RESOURCES



With an **Interactive Energy Platform (IEP)**, we can get real time insights, automation and control over all edge-of-the-grid resources such as load from buildings, distributed generation, storage and renewables.

In other words, IEP enables utilities to unlock, store and control demand-side capacity from these resources to optimize system utilization and facilitate the balance of the grid.

Tata Power-DDL is responding to the growing demand on the grid by providing seamless integration of edge-of-the-grid capacity resources to:

a) Improve the utilization of the power grid - the utility can deliver more power with less infrastructure and fewer new power plants

b) Create the platform for cleaner, affordable, and reliable power - to support the growing Indian economy

c) Reduce investments in new infrastructure and generation for future needs

POWER MANAGEMENT & COMMERCIAL SOLUTIONS

POWER PORTFOLIO OPTIMIZATION BY IBM

Power portfolio optimization provisions systems to sustainably balance the distribution-side energy supply and demand safely, reliably and securely. The system operates within three core spheres of operations:

- The physical operation of the distribution network
- A set of expanded roles driven by security and sustainability
- The management of price and participation within a market structure

SMART UTILITY IT SOLUTIONS FOR COMMERCIAL APPLICATIONS

- Establish a near-real-time reporting platform to drive business process improvements and easier decision making
- Develop a reliable and accurate data platform for analytics
- Improve compliance with regulatory requirements
- IT, power management and commercial solutions
- Customize ERP implementation for both customer and operations end
- Financial and management reporting

POWER QUALITY MANAGEMENT BY METRUM

Energy distribution with renewable generation (case in reference, solar) in the mix, demands continuous and reliable monitoring for power quality. Reinforcing our energy management with power quality measurement provides information about the cause for energy losses and required cost effective action.

Metrum Power Quality Solution provides the following benefits:

- Reduced power cuts
- Find the source of the problem
- Control over your grid
- Preventive maintenance
- Decision making support for smarter investments in the grid

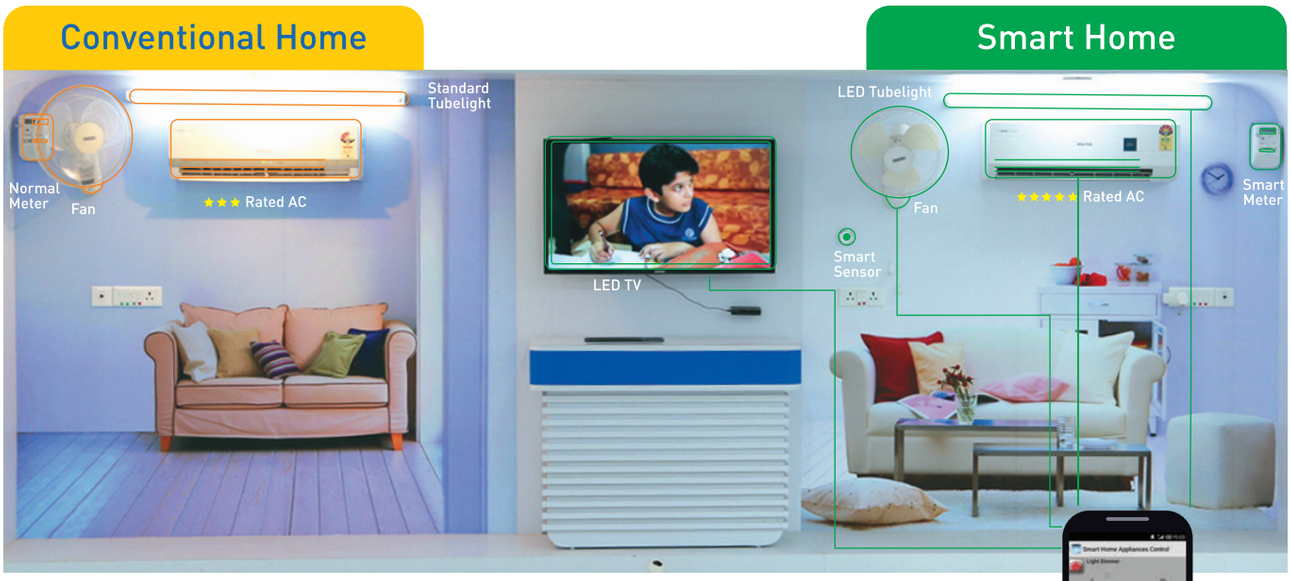
SENSING AND CONTROL TECHNOLOGY BY OMRON

Using Sensor, we contribute towards reduced distribution losses.

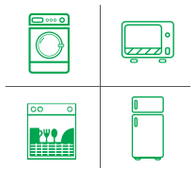
- Light Curtain or Photoelectric Sensor, Fencer can detect human
- Wireless Power Sensor can detect earth leakage
- Tamper detection sensor can detect many kinds of tampering

CONSUMER EXPERIENCE ZONE

AROUND THE HOME



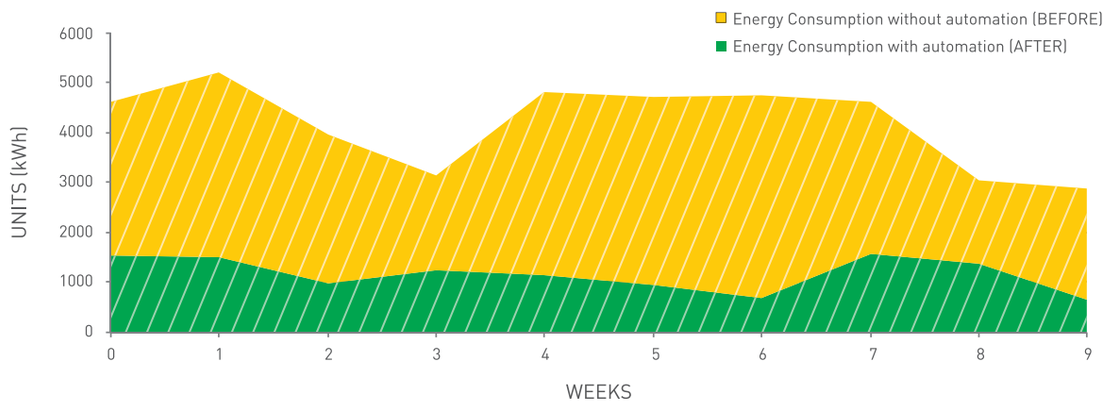
Home automation involves the control and automation of lighting, heating, ventilation, air conditioning (HVAC), appliances, and security. Devices are empowered to communicate over a wireless interface for connectivity, control as well as monitoring remotely.



Some of the key components of home automation system are:

Sensors	To measure or detect parameters such as temperature, humidity, daylight or motion.
Controllers	Controllers such as a computer or a dedicated home automation controller panel can be used.
Actuators	Such as motorized valves, light switches and motors.
Web access	Web Portal / Mobile App for integrated control, analysis and digital information too is available.

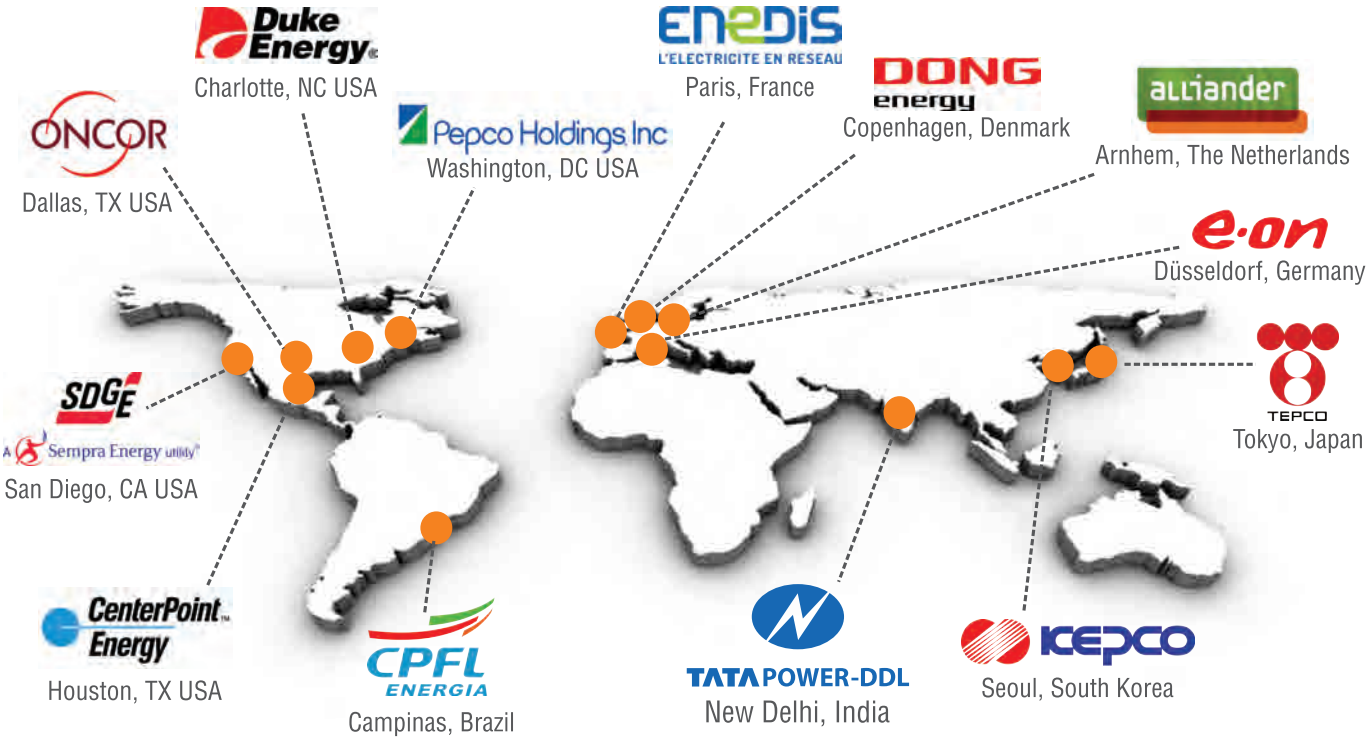
ENERGY SAVINGS IN COMPARISON



Member of Global Intelligent Utility Network Coalition

The Global Intelligent Utility Network Coalition is a strategic relationship created by IBM with leading innovative utilities globally to shape, accelerate and share in the development of the smart grid, covering more than 165 million consumers spanning 6 continents. The Coalition's purpose is to collaborate in the market to enable the rapid creation of solutions, adoption of open industry-based standards and informed policy/regulation which drives the adoption of the Smart Grid. The key benefit of the Coalition is that, it reduces regulatory, financial, market and technology implementation risks for the Coalition members.

GIUNC Global Intelligent Utility Network Coalition



Tata Power Delhi Distribution Limited, as the only utility member from India, is accelerating the development of common standards, technology solutions and processes for intelligent networks.

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