Introduction to Smart Grid

Unit 1

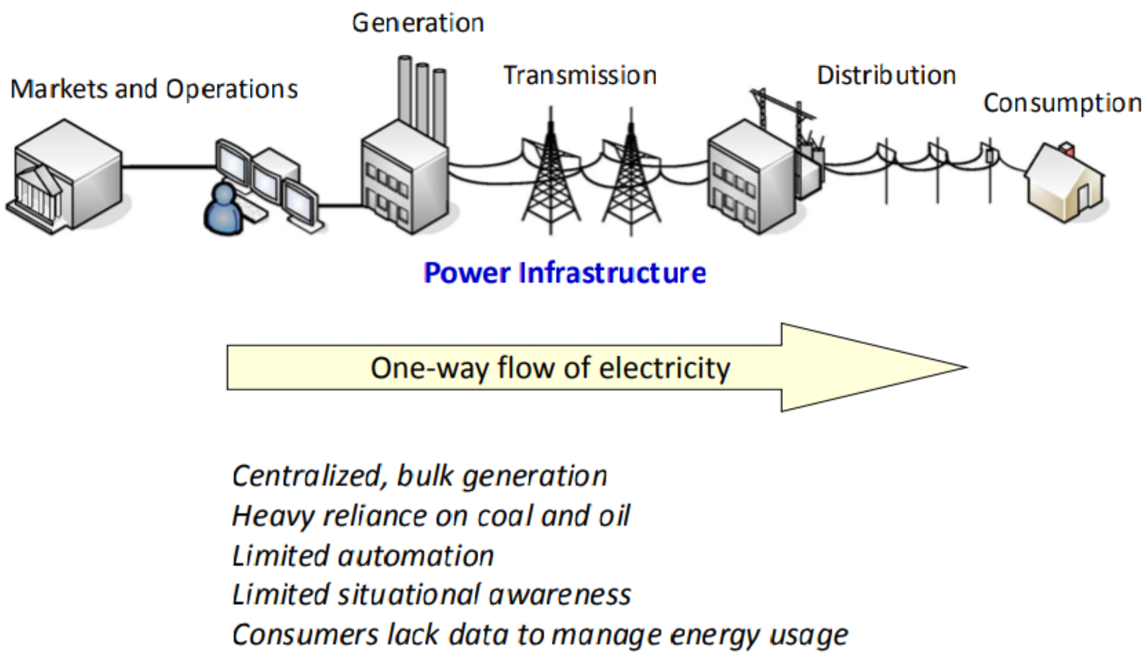
What is electrical grid?

Electric grid is network of synchronized power providers and Consumers that are connected by transmission and distribution lines and operated by one or more control centres.

1.1 Evolution of Electric Grid in India

1. In India, firstly, Electric Grid was developed at state level, after that grid management started on regional basis from 1960's
2. Regional grid are namely Northern, Eastern, Western, North Eastern, and Southern grids
3. Regional grid interconnection started in 1991.
4. In 1991, North Eastern and Eastern grid were interconnected
5. Western and ER-NER were interconnected in March 2003.
6. After that Northern grid was interconnected to WR- ER-NER in the year 2006.
7. In the year 2013 finally, Southern Grid was interconnected to NR-WR-ER-NER thereby achieving One Nation- One Grid -One frequency

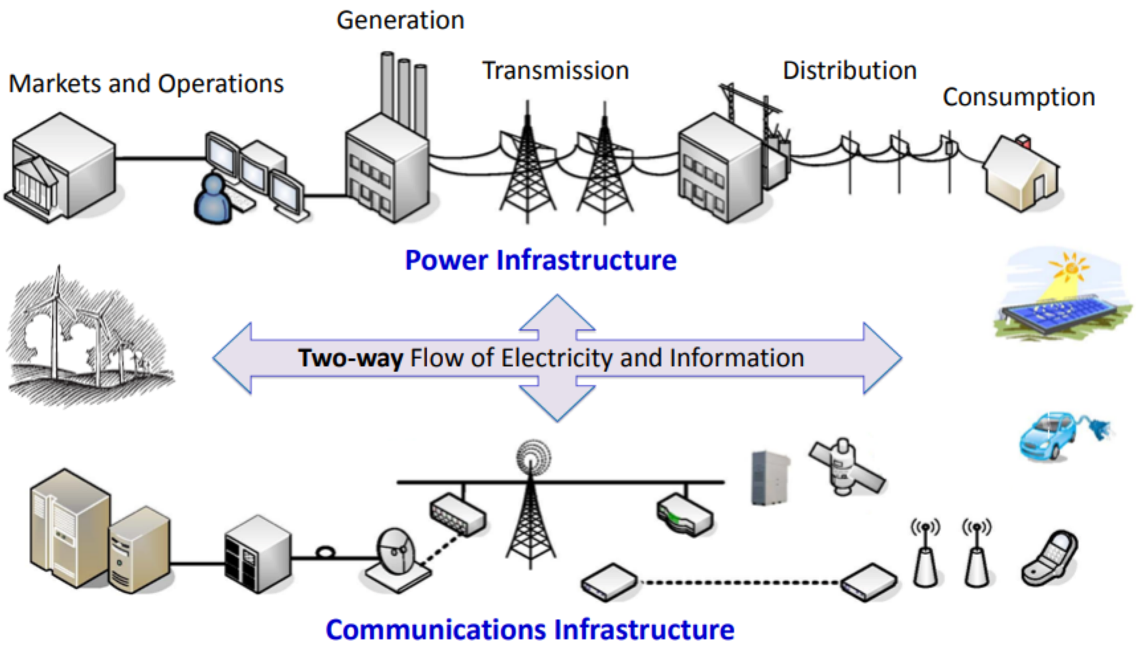
Traditional Electric Grid



1.2 Concept of Smart Grid

In short we can define smart grid as electrical grid with communication intelligence technologies.

Smart Grid



1.3 Smart Grid - Definitions

As per European Technology Platform -
Smart Grid is an electricity network that can intelligently integrate the actions of all users connected to it – generators, consumers and those that do both-in order to efficiently deliver sustainable, economic and secure security supplies.
As per U.S. Department of Energy -
A smart gird uses digital technology to improve reliability, security and efficiency (both energy and economic) of the electrical system from large generation, through the delivery systems to electricity consumers and a growing number of distributed generation and storage resources.
As per IEC -
Smart Grid is a developing network of transmission lines, equipment, controls and new technologies working together to respond immediately to our 21st century demand for electricity.

As per IEEE –

Smart Grid a revolutionary undertaking-entailing new communications and control capabilities, energy sources, generation models and adherence to cross jurisdictional regulatory structures.

In General

Smart grid is an advanced digital two-way power flow power system capable of self-healing, adaptive, resilient and sustainable with foresight for prediction under different uncertainties. It is equipped for interoperability with present and future standards of components, devices and systems that are cyber-secured against malicious attack.

1.4 Need of Smart Grid

A smart grid distribution system, whose objective is to develop a power grid more efficient and reliable, improving safety and quality of supply in accordance with the requirements of the digital age.

- Higher Penetration of renewable resources or distributed generation
- Extensive and effective communication overlay from generation to consumers
- Use of advanced sensors and high speed control
- Higher operating efficiency.
- Greater resiliency against attacks and natural disasters
- Automated metering and rapid power restoration
- Provided greater customer participation

Presently the Indian Electricity System faces a number of challenges which can overcome by smart grid:

- Shortage of power
- Power Theft
- Poor access to electricity in Rural areas
- Huge losses in the Grid
- Inefficient Power Consumption
- Poor reliability

Smart Grid drivers?

- **Increasing demand:** Information and communications technology, Measurement and control Demand response, Advanced metering infrastructure (AMI)
- **High Aggregate Technical &Non-Technical, Losses:**18%-62%
- **Ageing Assets:** Transformers, Feeders etc.,

- **Grid to carry more power:** Need for, Reliability and greater Security
- **Billing and collections:** Profitability of distribution companies
- **Energy mix:** Need for Renewable Energy [Hydro Power, Solar Thermal Energy, Wind, Biomass, Biogas] to reduce carbon footprint
- **Deliver sustainable energy:** Voltage & VAR control, Resource planning, analysis, and forecasting tools, Fault Detection, Identification, and Restoration (FDIR)
- **Increased efficiency:** Direct load control, Distributed energy resources, Distributed energy resources integration, Energy storage, Advanced metering infrastructure (AMI)
- **Empower consumers:** Consumer education and awareness, Residential consumer energy management, Information and communications technology
- **Improve reliability:** System wide monitoring, Measurement and control, Distributed energy resources, Distributed energy resources integration, Energy storage, Advanced metering infrastructure (AMI)

1.5 Functions of Smart Grid

Function	Definition
Fault Current Limiting	Fault current limiting can be achieved through sensors, communications, information processing, and actuators that allow the utility to use a higher degree of network coordination to reconfigure the system to prevent fault currents from exceeding damaging levels. Fault current limiting can also be achieved through the implementation of special stand alone devices known as Fault Current Limiters (FCLs) which act to automatically limit high through currents that occur during faults.
Wide Area Monitoring Visualization, & Control	Wide area monitoring and visualization requires time synchronized sensors, communications, and information processing that make it possible for the condition of the bulk power system to be observed and understood in real-time so that protective, preventative, or corrective action can be taken.
Dynamic Capability Rating	Dynamic capability rating can be achieved through real-time determination of an element’s (e.g., line, transformer etc.) ability to carry load based on electrical and environmental conditions.

Power Flow Control	Flow control requires techniques that are applied at transmission and distribution levels to influence the path that power (real & reactive) travels. This functionality is enabled by tools such as flexible AC transmission systems (FACTS), phase angle regulating transformers (PARs), series capacitors, and very low impedance superconductors.
Adaptive Protection	Adaptive protection uses adjustable protective relay settings (e.g., current, voltage, feeders, and equipment) that can change in real time based on signals from local sensors or a central control system. This is particularly useful for feeder transfers and two-way power flow issues associated with high DER penetration.
Automated Feeder and Line Switching	Automated feeder and line switching is realized through automatic isolation and reconfiguration of faulted segments of distribution feeders or transmission lines via sensors, controls, switches, and communications systems. These devices can operate autonomously in response to local events or in response to signals from a central control system.
Automated Islanding &Reconnection	Automated islanding and reconnection is achieved by automated separation and subsequent reconnection (autonomous synchronization) of an independently operated portion of the T&D system (i.e., microgrid) from the interconnected electric grid. A microgrid is an integrated energy system consisting of interconnected loads and distributed energy resources which, as an integrated system, can operate in parallel with the grid or as an island.
Automated Voltage and VAR Control	Automated voltage and VAR control requires coordinated operation of reactive power resources such as capacitor banks, voltage regulators, transformer load-tap changers, and distributed generation (DG) with sensors, controls, and communications systems. These devices could operate autonomously in response to local events or in response to signals from a central control system.
Diagnosis & Notification of Equipment Condition	Diagnosis and notification of equipment condition is defined as on-line monitoring and analysis of equipment, its performance, and operating environment in order to detect abnormal conditions (e.g., high number of equipment operations, temperature, or vibration). Asset managers and operations personnel can then be automatically notified to respond to conditions that increase the probability of equipment failure.
Enhanced Fault	Enhanced fault protection requires higher precision and greater discrimination of fault location and type with coordinated measurement among multiple devices. For distribution applications, these systems will detect and isolate faults without full-power re-closing, reducing the frequency of through-fault currents. Using high resolution sensors and fault signatures, these systems can better detect high

Protection	impedance faults. For transmission applications, these systems will employ high speed communications between multiple elements (e.g., stations) to protect entire regions, rather than just single elements. They will also use the latest digital techniques to advance beyond conventional impedance relaying of transmission lines.
Real-time Load Measurement and Management	This function provides real-time measurement of customer consumption and management of load through Advanced Metering Infrastructure (AMI) systems (smart meters, two-way communications) and embedded appliance controllers that help customers make informed energy use decisions via real-time price signals, time-of-use (TOU) rates, and service options.
Real-time Load Transfer	Real-time load transfer is achieved through real-time feeder reconfiguration and optimization to relieve load on equipment, improve asset utilization, improve distribution system efficiency, and enhance system performance.
Customer Electricity Use Optimization	Customer electricity use optimization is possible if customers are provided with information to make educated decisions about their electricity use. Customers could be able to optimize toward multiple goals such as cost, reliability, convenience, and environmental impact.

Opportunities of Smart Grid

- Upgrading and expanding infrastructure to improve interconnectivity and communications.
- Build up smart tools and technologies to exploit DR, demand load control and energy efficiency.
- Promote smart grid investment and inform regulatory frameworks
- Build up infrastructure to guarantee cyber security and resilience.
- Regulations in communication, price and cyber security

Local Opportunities of Smart Grid

• Integrated Communications

– Data acquisition, protection and control and allowing consumers to interact

– Connect components in real-time for control and data exchange

– Scope for improvement – Substation Automation, DR, Feeder automation, SCADA, EMSs, wireless mesh networks and other technologies, power-line carrier communications and fiber optics.

• Sensing and measurement

– Support acquiring data for healthy and integrity of grid

– Support faster and more accurate response

• Advanced Components

• Advanced Control Methods

• Improved interfaces and decision support

Regional and National Opportunities of Smart Grid

• Provide high quality power

• Accommodate all generation and energy storage options

• Motivate consumers to actively participate in grid operations.

• Be self-healing

• Resist attack.

Global Opportunities of Smart Grid

• Run the gird more efficiently

• Enable higher penetration of intermittent power generation sources

• Enable electricity market to flourish

Barrier of Smart Grid

Seven barriers are holding back the implementation of smart grids; none of which are insurmountable, as described in the next section. The paramount issue is a regulatory framework that is out of sync with today's industry needs and society's broader environmental objectives.

In the following section, the current challenges that are holding back investments in smart grids will be examined, before looking, in Section 3, at potential actions that could be taken to address them and accelerate the adoption of smart grid technologies. There are a number of factors that, in combination, are acting as a brake on smart grid investment, most of which are institutional and relate to the regulatory and policy frameworks that have evolved to support the existing power delivery system. Seven areas have been identified that will need to be addressed before smart grids become more widely adopted:

1.**Policy and regulation** In many cases, utilities do not get as far as a business case for the smart grid as there are regulatory and policy barriers in place that either create reverse incentives or fail to create sufficient positive incentives for private sector investment.

2. Business case Where policy-makers and utility executives are aware of the role that smart grids can play, they are often unable to make the business case for smart grid investments. With in the business case, two factors operate: first, the capital and operating costs are too high, as suppliers have not been able to achieve scale economies in production and delivery risk is priced in; and second, only those benefits that are economically tangible are factored in, while other ancillary and non-financial benefits are not included (e.g. the carbon benefits) or are aligned to the appropriate value-chain players.

3.**Technology maturity and delivery risk** A smart grid brings together a number of technologies (communications, power electronics, software, etc.) at different stages of the technology maturity lifecycle. In some cases, these technologies have significant technology risks associated with them because de facto or agreed standards have note merged. In addition, there are only a handful of examples of large- scale implementation of more than 50,000 premises and therefore there continues to be significant delivery risk priced in to the estimates.

4.**Lack of awareness** Consumers and policy-makers are becoming increasingly aware of the challenges posed by climate change and the role of greenhouse gas emissions in creating the problem. In some cases, they are aware of the role of renewable generation and energy efficiency in combating climate change. It is much less common that they are also aware of the way that power is delivered to the home and the role of smart grids in enabling a low-carbon future.

5.**Access to affordable capital** Utility companies are generally adept at tapping the capitalmarkets; however, where delivery risks are high and economic frameworks are variable, therelative cost of capital may be higher than normal, which acts as a deterrent to investment.Stable frameworks and optimum allocation of risk between the customer, the utility andgovernment will be the key to accessing the cheapest capital possible. In the case ofmunicipalities and cooperatives, this challenge may become amplified as the ability tomanage delivery risk is reduced.

6.**Skills and knowledge** In the longer term, a shortfall is expected in critical skills that will be required to architect and build smart grids. As experienced power system engineers approach retirement, companies will need to transition the pool of engineering skills to include power electronics, communications and data management and mining. System operators will need to manage networks at different levels of transition and learn to operate using advanced visualization and decision support.

7. **Cybersecurity and data privacy** Digital communication networks and more granular and frequent information on consumption patterns raise concerns in some quarters of cyber-insecurity and potential for misuse of private data. These issues are not unique to smart grids but are cause for concern on what is a critical network infrastructure.

Of the seven barriers outlined above, the first three pose the most significant hurdles, but, if addressed, will go a long way towards creating an environment that will encourage investment in smart grids. None of these barriers is insurmountable; however, it is important to understand the root cause of the issues before developing strategies to break them down.

Difference between Conventional and Smart Grid

Characteristics	Conventional grid	Smart grid
Active participation consumer	Consumers are uninformed and theydo not participate	Consumers are involved ,informedand participate actively
Provision of power quality for thedivision of economy	Response to power quality issues arelow	Rapid resolution of power qualityissues with priority
Accommodation of all generation	Many obstacles exist for integrationof DERs	Many DERs with plug-and-play option can be integrated at any time
Optimization of assets	Little incorporation of operational data with asset management – business process silos	Greatly expanded data acquisition of grid parameters ;focus on prevention, minimizing impact to consumers
New products, service and markets	Limited and poorly integrated wholesale markets ; limited opportunities for consumers	Mature and well integrated wholesale markets ; growth of new electricity markets for consumers
Resiliency against cyber attack and natural disasters	Vulnerable to malicious acts of terror and natural disasters ; slow response	Resilient to cyber attack and natural disasters ; rapid restoration capabilities
Anticipating responses to system disturbances(self-healing)	Responds to prevent further damage; Focus on protecting assets following a fault	Automatically detects and responds to problems ; focus on prevention ; minimizing impact to consumers
Topology	Mainly radial	Network
Restoration	Manual	Decentralized control

Reliability	Based on static ,offline models and simulations	Proactive , real-time predictions , more actual system data
Power flow control	Limited	More extensive
Generation	Centralized	Centralized and distributed . Substantial RES and energy storage
Operation and maintenance	Manual and dispatching	Distributed monitoring , diagnostics and predictive
Interaction with energy users	Limited to large energy users	Extensive two-way communications
System communications	Limited to power companies	Expanded and real-time
Reaction time	Slow reaction time	Extremely quick reaction time

What is Resiliency in Smart Grid?

Resiliency is a feature of the smart grid, and it may be defined as under-

*The ability of the smart grid to resist failure and rapidly recover from breakdown or fault occurred is referred to as **resiliency** of the smart grid.*

At present due to increasing power demand, the reliability of the electric grid system is decreasing day by day. Consequently, our typical power systems becoming prone to outages and blackouts. Hence, in order to avoid such losses and to increase the reliability of the power system, the idea of the smart grid is being used.

Smart grids work on digital platforms for fast and reliable sensing, communication, control, and protection of the entire transmission and distribution system. A resilient electric grid is a more reliable grid.

Working of a Resilient Smart Grid

A resilient smart grid follows three basic steps in its working mechanism after receiving any kind of disruptive fault to the system. These three steps are as follows:

- The resilient grid gives the ability to prevent initial failure or reduce its magnitude.
- The resilient grid provides a high degree to which the system can absorb the impact of the initial failure of the system.
- A resilient grid provides the ability to the system to be easily repaired.

Based on these three working guidelines, electric grids involve various technologies such as electric vehicles, distributed generation, etc.

What is Self-Healing in Smart Grid?

The property of a smart grid that enables a power system to know that it is not operating correctly and without human intervention, the system makes necessary adjustments to restore itself to normal operating conditions is referred to as the self-healing property of the smart grid.

The self-healing property of the smart grid is almost similar to the self-healing action of cells and tissues in a human body on receiving any injury.

Smart grid uses sensors and smart meters for receiving data to make decisions. It regularly monitors the working status of the system. When any fault is detected in the system, the system automatically tries to reduce it or remove the faulty part. Then, it performs a maintenance job to check overall operation along with the removal of the fault to zero level.

This complete process of pre-fault, during-fault, and post-fault is performed automatically by the system itself without any human intervention. For this reason, it is known as the self-healing or automatic troubleshooting facility of the smart grid.

Working Steps of Self-Healing of Smart Grid

The following are the basic working steps of self-healing in a smart grid:

- Self-healing smart grid uses real-time security monitoring and reaction mechanism that allows the system to constantly check itself automatically to an optimal state.
- A self-healing smart grid has functionality that enables the system to automatically look for problem areas that can cause large disturbances in the system.
- Self-healing in a smart grid provides rapid isolation that allows the system to isolate those parts of the system that experience failure from the rest of the system. It is essential to avoid a further loss to the existing working system.

Therefore, a smart grid system uses sensors, embedded systems, and digital communication which enables the modern grid to become observable, controllable, automated, and fully integrated.

International policies in Smart Grid

Smart grids policies For USA

The Energy Policy Act of 2005 is the first federal law that specifically promotes the development of smart meters. It directs utility regulators to consider time-based pricing and other forms of demand response for their states. Utilities are required to provide each customer a time-based rate schedule and a time-based meter upon customer request. The 2007 Energy Independence and Security Act (EISA) lays out a national policy for the Smart Grid in the U.S.

– The Act assigned NIST the primary responsibility to coordinate development of standards for the Smart Grid

– NIST is also supporting future FERC and State PUC rulemaking to adopt Smart Grid standards

• Key Federal policy recommendations:

– Enable cost-effective smart grid investments

– Unlock innovation

– Empower and inform consumers

– Secure the grid

The National Institute of Standards and Technology (NIST), a major standards developing federal agency, is directed to develop a smart-grid interoperability framework that provides protocols and standards for smart-grid technologies. EISA established a federal smart-grid investment matching grant program to reimburse 20% of qualifying smart-grid investments.

The next important legislative effort is the American Recovery and Reinvestment Act of 2009. It accelerates the development of smart□grid technologies by appropriating $4.5 billion for electricity delivery and energy reliability modernization efforts. Utilities and other investors can apply stimulus grants to pay up to 50% of the qualifying smart-grid investments. To date, the Smart Grid

Investment Grant authorized under this Act has 99 recipients, with a total public investment of $3.5 billion

Smart grids policies For UK

To modernize and reduce the carbon footprint of electric grids, one major initiative of the United Kingdom is to encourage energy efficiency through smart-meter deployment.

The British government expects full penetration of smart meters by 2020, with a total financial investment of £8.6 billion ($13.5 billion) and total benefits of £14.6 billion ($22.9 billion) over the next 20 years

Puducherry Smart Grid Pilot Project (Case Study)(I. S. Jha, S. Sen and R. Kumar, "Smart grid development in India — A case study," *2014 Eighteenth National Power Systems Conference (NPSC)*, Guwahati, India, 2014, pp. 1-6, doi: 10.1109/NPSC.2014.7103866.)

POWERGRID has taken a pioneering initiative to develop Smart Grid Pilot Project at Puducherry through open collaboration jointly with Electricity Department, Govt. of Puducherry for demonstration of technology efficacy, provide input for standardization and interoperability framework of various technologies, policy advocacy and regulatory framework for tariff design & net metering, electric vehicle deployment with charging through renewables etc.

Under this project various Smart Grid attributes have already been implemented and are being scaled up in a progressive manner. Presently, more than 1600 smart meters at consumer premises along with Data Concentrator Units (DCU) & Meter Data Management System (MDMS) have been integrated at one common platform at Smart Grid Control Centre at Puducherry.

Real time monitoring of energy consumption pattern, various alarms associated with it, etc. have been made possible with AMI system installed at Puducherry.

Meters with various communication technologies have been deployed including narrow band & broad band PLC, RF-2.4GHz, RF-865 MHz & GPRS. Smart Grid Control Centre at Puducherry is the first of its kind in the country has been establish

hed under this project. Real time Distribution Transformer (DT) wise energy audit is also possible, an example of monthly audit of a given DT is shown at Fig 1.

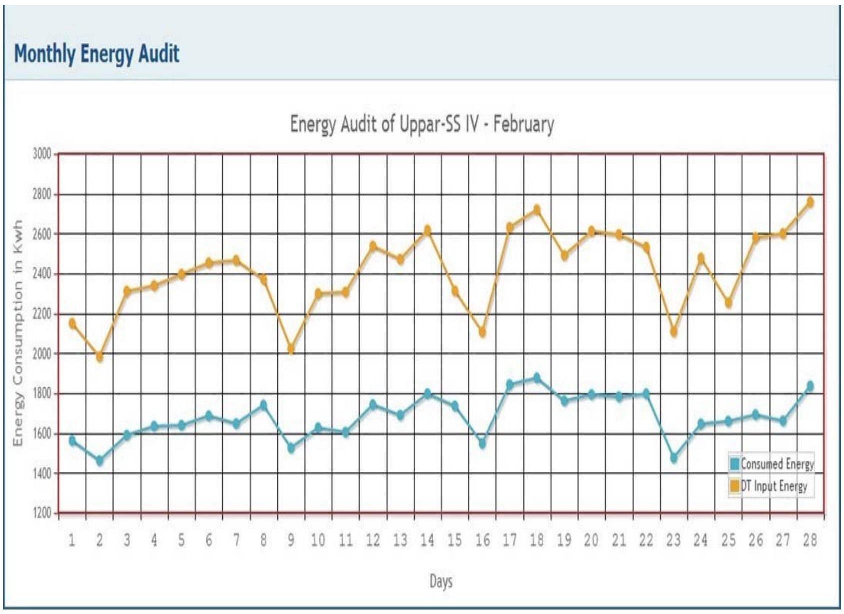


Fig 1: Real Time DT wise Energy Audit

To bring down outage duration and ensure reliable supply to consumers, Outage Management System (OMS) having Distribution Transformer Monitoring Unit (DTMU) and Fault Passage Indicators (FPI) have also been installed integrated with Smart Grid Control Center. DTMU monitors various parameters of distribution transformers (DT) like oil level, oil temperature, load current, voltage, harmonics, palm temperature etc. on real time. Daily average Loading and temperature profile monitored through a DTMU installed at Puducherry FPI facilitates in quick detection and identification of faulty network.

Outage information is being sent to control center through GPRS communication at regular interval.

In order to ensure quality supply to consumers 140 kVAR Automatic Power Factor Corrector (APFC) in steps of (50+50+20+10+10) as part of Power Quality Management (PQM) has been integrated. In addition IGBT based 150 kVAR active filters for harmonic suppression; reactive power compensation and smooth voltage control have also been deployed.

A demonstration model of demand response has also been set up at Puducherry. It would facilitate customer to receive utility signals and to respond for demand management. In addition, efficient street light automation system has been implemented for 126 nos. of street light which has resulted into reduction of energy consumptions for street lighting by about 57%.

Renewable integration is one of the major thrust areas of Smart Grid implementation. With rooftop solar generation, every consumer has become a "Prosumer" (a term commonly used for energy producer and consumer). For integration of distributed generation in the form of roof top solar & integration into grid, net metering has been implemented in the premises of two different types of consumers' i.e. residential consumer and academic Institute in the Puducherry Project area. Besides getting clean and reliable supply of power, these consumers with rooftop solar are saving significantly on monthly electricity bill.

Environmental friendly Electric vehicle having charging facility through Solar PV has been deployed at Puducherry under this pilot project.

To facilitate in consumer participation, Smart Home Energy Management system has been demonstrated at Puducherry. Functionality like Smart security, Micro grid controllers etc. have also been demonstrated under this project.

PED, the electricity utility in the project area has been immensely benefited from the success of Smart Grid Pilot. Some of the tangible benefits reported by PED on implementation of initial phase of Smart Grid pilot Project in their area are as summarized below:

1. Improved metering and collection efficiency: Metering efficiency increased by 14 % in the project area. This resulted in corresponding increase in billing efficiency.

2. Improved Billing Cycle: Remote meter reading AMI has enabled simultaneous collection of meter reading for a large consumer base. Therefore, now working on modification of billing cycle that would improve collection and cash flows.

3. AMI has facilitated utility in detection of abnormal consumer behaviour in real time. Examples of few such cases are explained below:

•In one of the case utility observed very high consumption by a consumer. On investigation it was found that there was additional lighting and other loads during a family function.

•Detecting meter tampering in real time: On investigation it was observed that consumer was trying to bypass the meter for using welding machine.

•Several cases of consumer shifting the meter within his premises due to some construction work were detected. Consumers were advised to inform the utility for carrying out such activities.

•In another case damaged wiring at consumer premises was also detected. Consumer was advised to rectify the wiring.

- Case of meter recording more than actual consumption due to faulty meter was reported. Faulty meters were replaced.
- Cases of bypassing meter were also reported.

4. AMI also helped utility in detecting unbalance in power thereby reducing the overall efficiency of system. Facilitated utility in planning mitigating measures.

5. AMI also helped utility in detecting variation in voltage at consumer end as
This pilot would help in Indigenization of technology and evolve a suitable commercial mechanism. The project also aims at preparing groundwork for policy advocacy, regulations, standards, and evolution of a commercial mechanism among other things.

This Puducherry Smart Grid Pilot Project has not only been found to be very useful in understanding the evolving Smart Grid technology but also act as a proof of concept in India. Experts from distribution utilities across the country, regulators and policy makers, etc. are regularly witnessing various smart grid attributes like, AMI, OMS, PLM, net metering, smart street lighting, demand response etc. implemented under Puducherry Smart Grid Pilot Project. Various functionalities implemented under this smart grid project can serve as a reference for other utilities planning to implement it in their system.

The smart grid shall bring efficiency and sustainability in power sector, meeting the growing electricity demand with reliability, resilience, stability and best of the quality while reducing the electricity bill of a consumer. It also enables consumer participation in energy management.

Clean Development Mechanism Opportunities

Clean Development Mechanism or CDM is one mechanism that allows an industrialized nation listed in Annex I of the United Nations Framework Convention on Climate Change (UNFCCC) to buy emission reductions which arises from sustainable development projects that are in non-Annex I (developing) nations. The carbon credits that are generated by a CDM project are termed in CERs, expressed in tones of CO2 equivalent (tCO2e).
Under the Kyoto Protocol's Clean Development Mechanism (CDM), an additional finance for the projects that reduce greenhouse gas emission could possibly help to accelerate wind and solar power development across the world.

CDM and Carbon Credits:

Carbon credits are a tradable permit scheme. They provide a way to reduce green house gas emissions by giving them a monetary value. A credit gives the owner the right to emit one tonne of carbon dioxide. Carbon credits are generated as the result of an additional carbon project. A can be an emissions allowance which is allocated or auctioned by the administrators of a cap-and-trade program or an offset of Greenhouse Gas equivalent carbon dioxide emissions. An offset generated by a carbon project under Clean Development Mechanism (CDM) or Joint Implementation (JI) is limited in value by the fact that regulated entities are limited as to what percentage of compliance can be accomplished via these flexible mechanisms. International treaties such as the Kyoto Protocol set quotas on the amount of greenhouse gases countries can produce. Countries, in turn, set quotas on the emissions of businesses. The concept of carbon credits came into existence as a result of increasing awareness of the need for pollution control. Carbon credits are certificates awarded to countries that are successful in reducing emissions of greenhouse gases. For trading purposes, one credit is considered equivalent to one tonne of CO2 emissions.

Various sectors which comes under CDM project

1) Green Buildings

2) Plug in Hybrid Electric Vehicles

3) SF6 based Gas Insulated Substations

4) Renewable Energy Sources like Solar, Wind, Biogas