Dissertation
Smart Grid Implementation In - India, South Korea, Japan & Netherlands

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CERTIFICATE

This is to certify that **Ms. Lopamudra Gautam**, a student of **University of Petroleum & Energy Studies, Dehradun**, Pursuing **MBA (Power Management),** has successfully completed her Dissertation.

As part of her curriculum, the project report entitled, **"Smart Grid Implementation In – India, South Korea, Japan & Netherlands"**, and Submitted by the student to the undersigned is an authentic record of her original work, which she has carried out under my supervision and guidance.

I wish her all the best.

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Lastly, I thank almighty, my parents, brother, sisters and friends for their constant encouragement without which this assignment would not be possible.

Thank you.

DECLARATION

I hereby declare that the project, entitled **"Smart Grid Implementation In – India, South Korea , Japan & Netherlands"** in partial fulfillment of the requirements for the award of the Degree of MBA in Power Management is a record of original research work done by me during the period of 2013-2015 under the supervision and guidance of **Dr. Anil Kumar** and co-guidance of **Mr. Avishek Ghosal**, and it has not formed the basis for the award of any Degree / Diploma / Associate ship / Fellowship or other similar title to any candidate in any university.

Place:

Date: **Signature of the Candidate**

Executive Summary

A well-developed grid is one prime necessity of the electrical sector. In the 20th century, the electrical grid has been said to be the greatest engineering achievement. The grid in today's circumstances faces several challenges like that of sustainability, reliability and energy security. The developed nations have already implied the Smart approach to the electrical grid and the developing nations are still expanding their grids.

A smart grid is a power network which collaborates the different producers and consumers needs and operation to distribute energy in an effective, sustainable and reliable manner. The "grid" means the power grid which has the network of transmission and distribution lines along with the transformers and the substations which can bring the electricity from the point of generation to the consumer end. The grid is called smart because of the use of digital technology which actually gives a two way communication between the power utility and the consumer.

The Smart grid basically has the capacity to enhance the power reliability and supply. Also it gives customers the tools to augment the power usage and also enhances system performance. It helps in system sustainability and also distribute energy effectively. Smart Grid is a new grid with two way communication with two way power flow and meets customer feedback and distributed generation and also peer to peer interaction. Smart Grid meets an overall new form of methodology for generation of energy, delivery and use.

Implementation of Smart Grid is of ardent necessity in India. With a population of 1.2 billion and about one-third of this population living without access to energy, there is an immediate need for an efficient and effective affordable electric infrastructure which is reliable. With the rapid growth in energy demand and increase in per capita consumption, all the sectors like industry, residential, commercial, transport and agricultural needs electricity. There is a need for smart grid in the whole of the country.

The government and the regional utilities have implemented around 14 smart grid pilot projects in India. Also there is the launch of ISGF and ISGTF for implementation and planning of smart grid in the country. Despite all these endeavours, India still lags in the process to become one of the successful model in the world in smart grid technology.

There are various challenges regarding the fundamental infrastructure, policy and regulatory framework, customer and industry awareness, lack of technology etc. India has to meet all the mentioned challenges in order to come at par with the global market and technology. The shortcoming of the electrical network like the significant line loss, theft of electricity, irregular grid operations has to be overcome to avoid an unstable network. For all these and also low carbon emission technology, smart grid is fruitful. There is also need for the education of the among utilities, generation, transmission and distribution network and government leaders about the positive of smart grid. India must invest in systematic way on smart grid and the stakeholders should go for capacity building. Investment should be made on ADMS (Advance Distribution Management System) and AMI (Advance Metering Infrastructure) in India. Demand Side Management is necessitates at the moment.

The Smart Grid has the different barriers and challenges that are holding back the implementation of smart grid in Global as well as in Indian platform. The main barrier in India, is that of the regulatory issues and the fact that they are out of sync with the industry and society's broader perspective of modernisation with implementation of technology.

In this Report, there is the analysis of the barriers and challenges in the implementation of smart grid in India and thereby to find out solutions to solving the barriers and define a roadmap to implement Smart Grid in India.

Also to have a global perspective on smart grid implementation in South Korea, (JEJU island Smart Grid Model), Japan (Yokohama Smart Community Model) and Netherlands (Amsterdam-Nieuw West Smart Grid Project) and analyse the successful model of Smart Grid Implementation of these three countries. The opportunities and Challenges for all the three models are studied and how these models can help implement smart grid in India are defined.

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List of Abbreviation

AC	Alternating Current
ACM	Authority for Consumer and Market
ADMS	Advance Distribution Management System
AMI	Advance Metering Infrastructure
AMI-I	Advance Metering Infrastructure-Industry
AMI-R	Advance Metering Infrastructure-Residential
AMR	Automated Meter Reading
APX	Amsterdam Power Exchange
ASC	Amsterdam Smart City
AT&C	Aggregate Technical and Commercial Loss
BEMS	Building Energy Management System
CEA	Central Electricity Authority
CPRI	Central Power Research Institute
DC	Direct Current
DER	Distribution Energy Resources
DG	Diesel Generator
DMS	Distribution Management System
DR	Demand Response
DSM	Demand Side Management
EV	Electric Vehicle
FEMS	Factory Energy Management System
GDP	Gross Domestic Product
GHG	Green House Gas
GIS	Geographic Information System
GOI	Government of India
GPS	Global Positioning System
GWH	Giga Watt Hour

HEMS	Housing Energy Management System
HT	High Tension
HTLS	High Temperature Low Sag
ICT	Information and Communication Technology
ISGF	India Smart Grid Forum
ISGTF	India Smart Grid Task Forum
IT	Information Technology
JEPX	Japan Electric Power Exchange
JNNSM	Jawaharlal Nehru National Solar Mission
KOREC	Korean Electricity Commission
kV	Kilo Volt
kWh	Kilo Watt Hour
LT	Low Tension
METI	Ministry of Economic Trade and Industry
MOP	Ministry of Power
MU	Million Units
MW	Million Watt
OMS	Outage Management System
PFC	Power Finance Corporation
PGCIL	Power Grid Corporation of India Limited
PLM	Peak Load Management
PMU	Phasor Measurement Unit
PQM	Power Quality Management
RAPDRP	Restructured Accelerated Power Development Reforms Program
RE	Renewable Energy
RGGVY	Rajiv Gandhi Gramin Vidyutikaran Yojna
RTU	Remote Terminal Unit
SCADA	Supervisory Control & Data Acquisition
SGTF	Smart Grid Task Force
SOA	Service Oriented Architecture

SRS	System Requirement Specification
TOD	Time of Day
TA	Tariff Analysis
TR	Tariff Regulation
TRIEA-EA	Third Party Independent Evaluation Agencies for Energy Auditor
T&D	Transmission and Distribution
UI	Unscheduled Interchange
UNFCCC	United Nations Framework Convention for Climatic Change
YSC	Yokohama Smart Community
YSCP	Yokohama Smart City Project

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1. Introduction to Smart Grid

i. Definition, Basics and Features

A Smart Grid can be defined as an system of interconnection of various parameters information, communication, technologies and control systems which is use as a medium of interaction between the different parts of the power sector which are the generation, transmission, distribution and consumer in a manner which has the interconnected systems and the business processes for controlling and coordination. The main thought behind Smart Grid is to make an infrastructure of the grid more efficient, reliant, robust in nature by the use of modern technology, automation and intelligence which encourages active supply and demand side management, involving pioneering practices, regulatory and policy framework. There should be provision for providing incentives schemes for the implementation of smart grid in generation, transmission and distribution networks.

There is a kind of emergency in India which demands for the urgent implementation of smart grid at the national level. This has come from the key challenges that the industry is imposing in the system. Although, India functions on the 3rd largest transmission and distribution network in the world, still it faces various challenges on the electricity sector. 40% of the rural population in India survives without access to electricity. There are various key issues like the shortfall in supply, losses in the system, theft, Poor peak load and outage management system in India, unreliability of India's DISCOM, poor quality of power and bad grid infrastructure. The smart grid implementation can cut out these key issues and modernize the power sector and bring Indian technology in transmission and distribution network at par with the global platform.

The function or feature of a Smart Grid is to increase in the connectivity, automation and coordination between the suppliers, consumers and networks which either implement long distance transmission or distribution or for short distances.

- Transmission networks move electricity in bulk over medium to long distances, are managed dynamically, and generally function from 345kV to 800kV over AC and DC lines.

- Local networks conventionally transfer power in unidirectional , and "distributing" the Bulk power to consumers and businesses via lines operating at 132kV and lower.

The technology is modifying because of the move towards renewable technology generating sources. Modernization is necessary for real time management of power flow and also energy consumption efficiency. In US and Europe, mostly modern technology is implemented but still faces challenges to handle intermittent nature of alternative electricity generation and bulk energy transmission.

HISTORY

Based on Nikola Tesla's design published in 1888, the alternating current power grid evolved in 1896. Many of the design and decision that are implemented today were made around 120 years ago. Some features of the old power grid like that of, centralize unidirectional transmission use today, demand motivated control along with the distribution network were thought process of the 19th century.

Over a time span of 50 years, the electrical network have not kept pace with the modernized changes in the environment. There have occurred lot of changes in the modern grid. Smart Grid technologies have emerged from the use of electronic control and metering from the earlier days. In 1980, Automatic meter reading was use for monitoring loads from large scale consumers which gave rise to AMI (Advance Metering Infrastructure) of the 1990s. These technology can store how electricity was use at different time of the day. Smart Meters are aa great boom to the industry, which can store data and communications that helps in monitoring the data at actual time and also make use of the demand response known devices and smart sockets.

There are generally 4 factors which contributed for modernization of power scenario of today.

- Enhancing the efficiency, reliability and safety of power grid network.
- Decentralized Power Generation Mode
- Power Consumption Flexibility- Choice of supply
- Increase in GDP by enforcing green energy generation techniques and innovation in technological use. There is an emerging technology of Smart Grid is a boom of the power industry.

ii. Smart Grid Implementation in Generation, Transmission and Distribution

POWER GENERATION –

The Power Generation In India has gained due to the entry of private players into the generation sector post the Electricity Act 2003. The extent of capacity added every year has amplified in comparison to previous year planning data. With the advent of new and advanced technologies, competence of thermal power plants has improved and emission has reduced considerably. Requirements related to operational proficiency, scheduling and dispatch of power are operated in an automated way and are implemented in generation techniques. The new plants have IT implemented technologies and are upgrading gradually. Renewable energy technology are gaining grounds and several policies and regulations have formed to increase the renewable generation capacity over the time. National level plans like JNNSM have been launched and individual state policies have formed to enhance renewable generation. Averaging the yearly addition of RE it comes around 3000MW installed capacity every year. Smart grid is a driver for promoting green energy and it also helps in decarbonisation. Smart Grid has the capability to reduce the irregularity factor in generation from RE due to sun and wind unavailability in certain time of the day only. Smart RE control centers systems are focused upon and monitored by help of smart grid. These centers can monitor the DR of the system and can predict the requirement laid down according to the requirements laid down by Electricity Grid Code. Also these centers of Smart RE can help in Renewable Integration techniques which is of vogue now. With the unavailable and shortage in fuel supply, RE can go a long way in meeting the country's requirement.

POWER TRANSMISSION –

The Power Grid Corporation of India(PGCIL), has installed newer and advanced technologies like Phasor Measurement Units (PMU) on a pilot basis on several grounds in various selected locations of India. PMU are installed for Wide Area Monitoring System and plans to install it in many other locations on a national basis. The Indian Transmission network I moving towards higher voltage regions or levels of 1200 kV and it requires higher level of automation and grid intelligence structure. There are various other technological development in the made in the transmission sector. Increasing the capacity of transmission corridor by use of VAR compensator and also lines are re wired using HTLS (High Temperature Low Sag. Monitoring this type of a system is going to need a strong control system which is robust in nature and a strong communication system. Due to the disturbance in July 2012, Power system operation is also under assessment and there will be policy reform which will give more system control to the load dispatch Centers. Unscheduled Interchange (UI) mechanism intended to dishearten Dis Coms and Gen Cos from differing from published schedules. The UI mechanism is expected to be substituted by an ancillary services in the market. Power exchanges will be managing this and bring more liberal power markets and therefore giving superior transparency on costs and prices of services. Ancillary Services market has become a vogue in the power market and there are discussions from time to time on these matters.

POWER DISTRIBUTION –

At the present scenario, the electricity distribution sector is in a bad status and has high network components which are incurring huge losses in the system. There is huge network as well as financial loss in the system. There is an immediate need in the system to bring about technologies and new ideas to fill the gap and reduce the loss in the system. India has around 27% of AT&C losses in the system and it is huge. The Restructured Accelerated Power Development Program (R - A PDR P) (s e e : http://www.apdrp.gov.in/) introduced by the GOI is an initiative aiming to reduce the network losses to 15%. Part A includes Information Technology implementation, SCADA (Supervisory Control & Data Acquisition)/ DMS (Distribution Management System) in electrical distribution system. Consumer Indexing, Asset Mapping, GIS(Geographical Information System) of the entire distribution network. Automated Meter Reading (AMR) on distribution transformer and feeders. Establishment of IT enabled customer services. Part B includes System Strengthening, Improvement and Augmentation of Distribution Systems Capacity. Renovation and Modernization of 11 kV level and below, Load bifurcation and balancing, HVDS(11 kV), Installation of Capacitor Bank and Mobile Service Centre, Strengthening at 33 kV and 66 kV line.

The R-APDRP is still under operation and accomplishment is expected during the 12th Five Year Plan. This initiative will provide a strong base for upbringing of smart grid in India in the distribution sector. In this sector smart grid will bring DR programs, EV introduction nd implementation in India, integration of distributed energy sources in a way which will balance the local supply of the Dis coms and reduce outages. Also Smart Grid implementation will bring about Advance Metering Infrastructure (AMI) and Advance Distribution Management System (ADMS) into the network. These will manage the Peak Load management (PLM), Power Quality management (PQM), and Outage Management Functionalities of distribution system. It will reduces losses and thefts too. It will help develop green buildings, smrt communities and smart city projects in India.

iii. An overview of R-APDRP

The Indian Power Ministry of government of India has introduced or launched Restructured Accelerated Power Development and Reforms Program on July, 2008 which is a central sector scheme.

The main focus of the scheme is to have performances on the following areas:

- AT&C loss reduction.
- Establishment of the reliable and automated sustainable systems for collection of base line data.
- Adoption of information technology in the areas of energy accounting, consumer care.
- Strengthening of Distribution network of State Power Utilities.
- IT to improve consumer service and quality of supply.
- The scheme also envisage establishment of supervisory control & data acquisition system/ distribution management system in large towns, capacity building, incentive scheme for distribution personnel.

Objective of R-APDRP: Mainly it was implemented in two parts

- Part A-

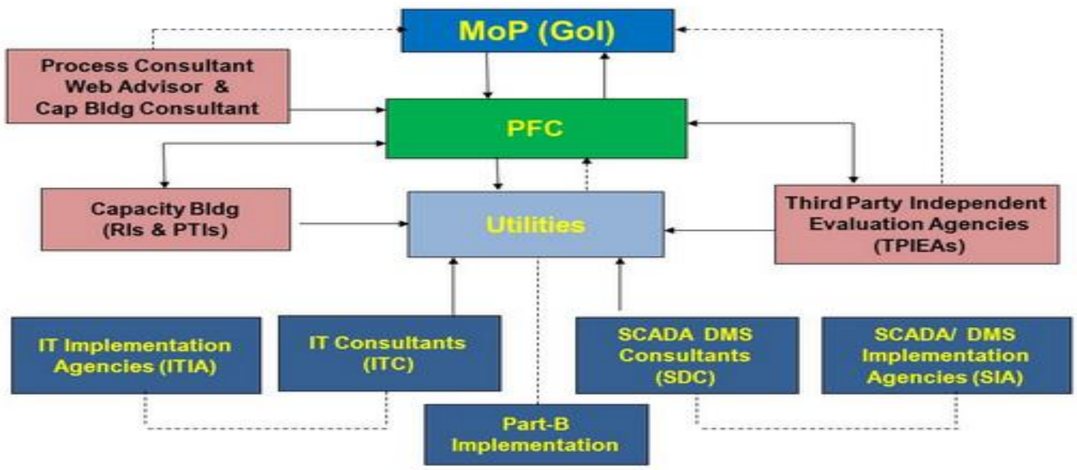
  Information Technology implementation, SCADA (Supervisory Control & Data Acquisition)/ DMS (Distribution Management System) in electrical distribution system.

Consumer Indexing, Asset Mapping, GIS(Geographical Information System) of the entire distribution network. Automated Meter Reading (AMR) on distribution transformer and feeders. Establishment of IT enabled customer services.

- Part B- System Strengthening, Improvement and Augmentation of Distribution Systems Capacity. Renovation and Modernization of 11 kV level and below, Load bifurcation and balancing, HVDS(11 kV), Installation of Capacitor Bank and Mobile Service Centre, Strengthening at 33 kV and 66 kV line.

The Power finance corporation (PFC) is the nodal agency appointed by the Government of India. PFC is supported an advised by various agencies or consultants on the running of the program. Third Party Independent Evaluation Agencies for Energy Accounting (TPIEA-EA) under R-APDRP have been appointed to establish/verify AT&C losses including annual verification of AT&C losses of the project areas and state power utilities/distribution companies to achieve the programme objective of AT&C loss reduction in the specified project areas/ state. Funding is done by GOI(Government of India) , PFC/ REC(FI). Process Consultant has been appointed for developing Model Bid Document for the R-APDRP Programme to help various Power Utilities in the Country in establishing IT enabled infrastructure under Part A of the Restructured APDRP. The process consultant will prepare the SRS(System Requirement Specification and convert it into a biddable document. IT consultants will be appointed to assist the utilities for program management during implementation phase. It implementation agencies assist utilities to implement IT related schemes in the defined areas and supply, install and commission necessary infrastructure containing hardware, software and network. TPIEA will be appointed by the nodal agencies as an independent third party which establishes the initial base line data and also annual project verification for losses, assessment of conversion of loan into grants and period reports to nodal agencies.

Figure 1: Block Diagram of R-APDRP (Source : Indian Power Sector.com)



iv. Benefits and Characteristics of Smart Grid

Smart Grid **benefits** can be categorized into 5 types:

- Power reliability and power quality – The smart grid has the functionality of reliability and improved quality of power in the cleaner form and it drives green power. It has self-healing facility with automatic control and condition based maintenance.
- Safety and cyber security benefits – Smart grid can monitor itself and it can detect suspicious behavior and has safe operation benefits. Higher Cyber security systems are present in smart grid applicable to all type of systems.
- Energy efficiency benefits – Smart Grid gives operational efficiency and produce good quality power. It can reduce losses, reduce peak demand, can make end-user use decrease instead of new generation in power system operations. It helps in greenhouse gas decreasing and other harmful gases as it bring electric vehicle and reduce use of Gasoline based vehicles.
- Direct financial benefits – Here operation cost are reduced in the system.It has customer feedback or price choosing options as it's a two way communication. Entrepreneurs are encouraged to use smart grid in power sector business.

Stakeholder Benefits

The benefits from the Smart Grid can be categorized by the four primary stakeholder groups:

- Consumers - It has customer feedback or price choosing options as it's a two way communication. Entrepreneurs are encouraged to use smart grid in power sector business. Consumers can poise their energy consumption with the real time supply of energy available in the system. Operation cost are reduced in the system. There are incentives that are available along with the smart grid policies for the customers' variable pricing options. . This infrastructure take advantage of lower- priced energy in off-peak hours, but also it curtail consumption of higher-priced energy in peak situations.
- Utilities - Utilities can definitely supply more stable and reliable power using smart grid due to the intervention of IT and also the communication and other systems available.
- Manufacturers – These are the group of stakeholders who will produce the equipment and services required to implement the smart grid. The more they produce, the more can be implemented in the grid and also the businesses of smart grid technology can grow only in the presence of more equipment and services.
- Society – Society can benefit as an stakeholder as there are better quality power and also because of PLM, PQM, OMS and PHEV system available in the smart grid. These gives a thrust to the development of the society as a whole.

The other stakeholders also benefit from the Smart Grid functionalities and also Regulators will gain from the transparency in the system and stable grid operations. Vendors and integrators will benefit from the market conditions and product sale and smart grid components and systems of the network. The task of the stakeholders are inter related.

The **characteristics** (or the behaviors) of the Smart Grid are:

- Enable Active Participation by Consumers – The smart Grid is a thing for the customers. It has a two way communication network which demand for the active participation of the customers. In smart Grid the customers has the choice of pricing for variable pricing pattern and also incentives are present. The customer is the one who drives the market and the products and enhances the smart grid operation.

- Accommodate All Generation and Storage Options - The Smart Grid has all the options for generation and storage. It has provisions for the large, centralized power plants as well as for the Distributed Energy Resources (DER). The smart grid has options for all generation techniques and as storage facility grows, they will integrate with the larger smart grid network. DER has aggregators with arrays for generation network or a farmer with some solar or wind options for distributed generation.
- Enable New Products, Services, and Markets – The smart grid is the major driver for the market and services. With the advent of new technology comes new product in the market. Smart Grid provides a cost benefit business to the customers which creates opportunities for the market forces. Innovative product drives the market and the 3rd party vendors get opportunities to enter the market with many choices and options. With the existing grid infrastructure, there is lot of scope for the market penetration of smart grid.
- Provide Power Quality for the Digital Economy – Smart Technology provides reliable and stable power for consumption with less outages The power is clean and there are no disturbances in the network. There is lot of global competition with demand for smart technology to drive the digital technology.
- Optimize Asset Utilization and Operate Efficiently – Smart Grid applies latest technology and integrate assets to maximize operational efficiency and decrease in cost. Self-healing and good routine maintenance make smart grid operations viable with less human intervention.
- Anticipate and Respond to System Disturbances (Self-heal) – The smart grid has the capability to detect or identify the problems or disturbances and has the capacity to correct them. It has engineering techniques that is capable of isolating the problem and analyzing the situation and no human intervention. It has quick restoration and react to losses quickly.
- Operate Resiliently to Attack and Natural Disaster – The system has resistance against both physical (transformer, poles, lines) and cyber (communication, software) related structure. There are sensors against any kind of problem and they indicate in case of an emergency situation. There are cameras, switches, intelligent systems operating which gives indication against any threats. The system is self-healing and resilient to natural disasters. Monitoring and Self-testing are integral part.

v. Comparison between Existing and Smart Grid

Table 1: Comparison between Existing Grid and Smart Grid

EXISTING GRID	SMART GRID
Mostly Electromechanical	Digital in Nature
One Way Communication	Two Way Communication
Mostly Centralized Generation	Distributed Generation
Sensors are not widely used	Sensors are widely used
Lack of Monitoring- only manual	Digital Self-Monitoring
Failures and Blackouts	Adaptive and Intelligent
Lack of Control	Robust Control Technology
Less Energy Efficient	Energy Efficient
Usually not possible to integrate Renewable energy	Possible to integrate large Scale Renewable Energy
Customers have less scope to modify uses	Customers can check uses and modify

vi. Smart Grid Technologies

Smart Grid technology can be grouped into five key areas:

- Integrated communications – In some cases data is collected via modern method and not by network connection. Integrated communications are up to date technologies and are apt for development of substation, automation, SCADA implementation, GIS and other IT tools and also for energy management systems, wireless mesh networks. It has fiber optics and power line carriers. It gives for real-time control, information and data exchange for reliability of system, asset utilization, and security of assets and network.
- Sensing and measurement – The technologies here includes advance microprocessor Smart Meters, Meter Reading Equipment, Dynamic Line Rating system, Temperature sensors, RTTR systems, Electromagnetic signal measurement/analysis, and Digital protective relays. Main Duties are to have grid stability and manage congestion, monitor the network, Theft preventing system, Control systems.

- Advanced components – Technologies are flexible alternating current transmission system devices, high voltage direct current, first and second generation superconducting wire, composite conductor system , cables. These technologies are use in innovative technologies like superconductivity, tolerance of faults, power electronics application on network parameters, supervise characteristics of grids.
- Advanced control – Technology for advance control are : distributed intelligent agents (control systems), analytical tools (software algorithms and high-speed computers), and operational applications (SCADA, substation automation, demand response). It uses artificial intelligence techniques, VSMC software is used for sensitivity analysis and Linear control program is deployed too. It is used in diagnosis of grid disruptions and outages.
- Improved interfaces and decision support – Smart Grid provides improved information and decision support for the network operators. It reduces complexities in the system and also operates grid with increased number of variables. Technologies improves the visual formats and techniques and decrease large data into easily managed numbers. It makes the grid perform in a effective and efficient manner because of the presence of the tools to operate.

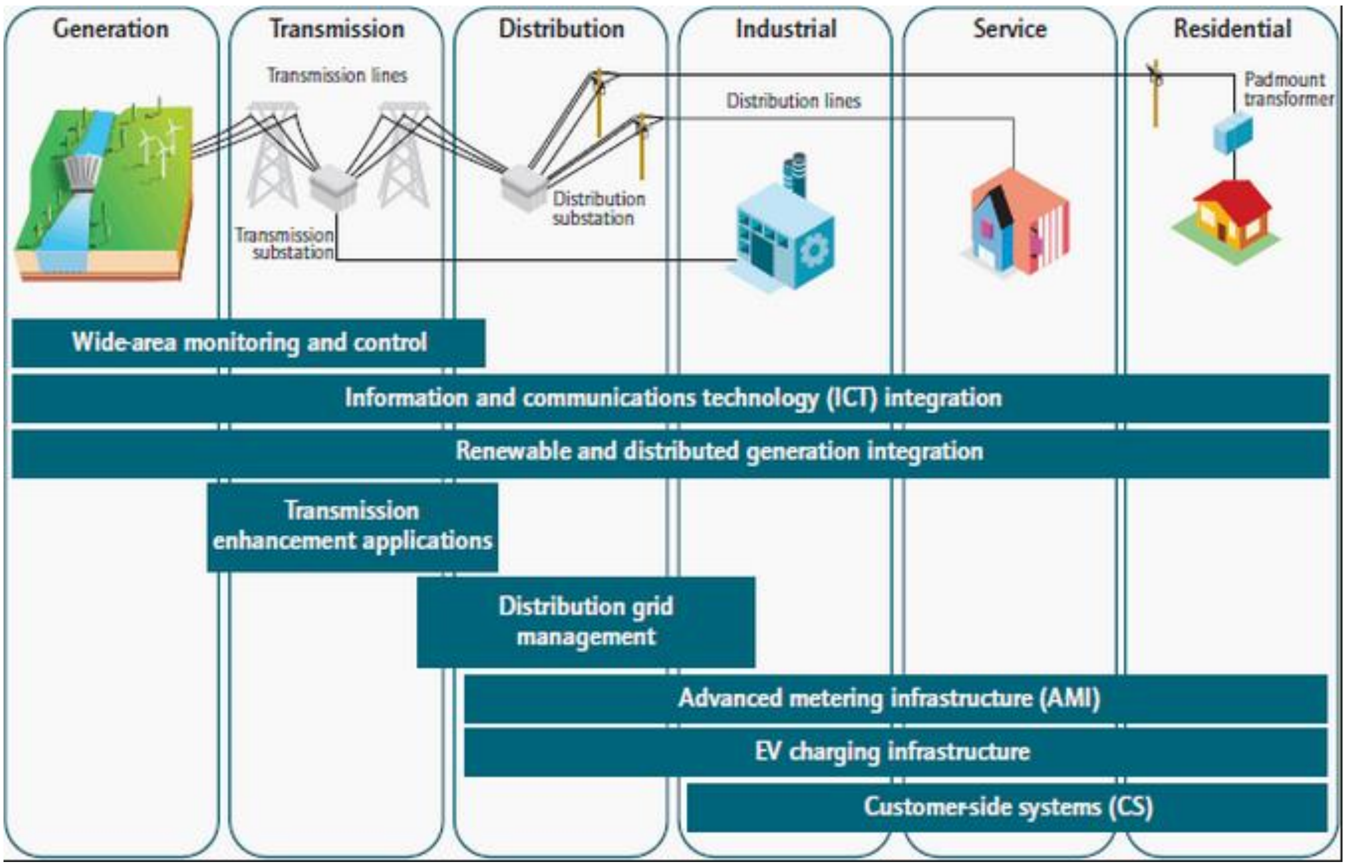
The deployment of these technologies effectively operates and creates an environment to improve the following key areas – reliability, economics, efficiency, environmental, Safety and security.

Smart Meters – Advance Meters are similar to the meters use in Advance Metering Infrastructure (AMI) (Refer Annexure 3) and they provide a path for communication from the generation plant to the smart sockets and smart grid enabled devices. These devices can be shut down during peak demand. These meters are digital meters and it has replaced analog mechanical meters and gives data in real time.

PMU – Phasor Measurement Units are speed sensors and are distributed throughout the network. It is used to monitor power quality and it can respond automatically. These gives waveforms of AC and in real time data with the most desirable shape. In1980, the clock pulse from GPS could be used for precise time measurements in the grid. With the advent of PMU, there is a hope that there will revolutionized changes in the grid with real time operation as it can compare shapes from alternating current readings everywhere on the grid. Because it can respond to system conditions in a rapid, dynamic fashion.

WAMS - Wide-Area Measurement Systems can provide real time monitoring technique and it can take place in regional as well as in the national scale. If WAMS was implemented, the northeast power blackout of 2013 could have been contained to a much smaller space as per the analysis of the researchers.

Figure 2: Smart Grid Implementation In Power Sector (Source : www.google.com)



The above figure shows the implementation of smart grid in the Power Sector. The different technological tools used in the implementation are shown here. Smart Grid can be implemented in Generation, Transmission, Distribution. The consumers can be industrial, residential, agricultural, services or commercial, transport.

2. Literature Review

vii. Literature Review

Smart Grid is a new grid with two way communication with two way power flow and meets customer feedback and distributed generation and also peer to peer interaction. Smart Grid meets an overall new form of methodology for generation of energy, delivery and use.

a Challenges in Smart Grid Implementation

There are two kinds of challenges which evolve in the system – procedural and technical challenges.

Table 2: Challenges in Smart Grid Implementation

CHALLENGES	REFERENCES	INFERENCES	RESEARCH GAP
PROCEDURAL			
Broad Set of Stakeholders	M Hashmi, S Hanninen, K Maki - Innovative **Smart Grid**, 2013 - ieeexplore.ieee.org	The Smart Grid will affect every person and every business related to its operation. There needs to be coordination and inter co relation between the broad spectrum of various stakeholder (as seen in the case of Amsterdam - Nieuw West). Although not every person will participate directly in the development of the Smart Grid, the need to understand	Each stakeholder is working on different parts of the system. Each might have different decision and these needs to be integrated and the stakeholders cannot work independently. Major gap in the present scenario is integration of the different providers. Also utilities should be more holistically focus on the overall capabilities of smart grid then merely

		and address the requirements of all these stakeholders will require significant efforts.	implement smart meters. Lack of funds is one issue among the stakeholders.
Complexity of the Smart Grid	M Hashmi, S Hanninen, K Maki - Innovative **Smart Grid**, 2013 - ieeexplore.ieee.org	The Smart Grid is a vastly multifaceted machine, with some parts racing at the speed of light. Some aspects of the Smart Grid will be complex to human response and interaction, while others need sudden, automated responses. The smart grid will be driven by forces ranging from financial pressures to environmental requirements.	To have a well-balanced successful system, the demand side should be equally involved. The gap remains in the lack of work force to tackle the smart grid problems, unaware customers and unknown benefits of smart grid among the masses. Energy Consumers needs to be aware of the consumption pattern of energy and also low carbon emission.
Transition to Smart Grid	M Hashmi, S Hanninen, K Maki - Innovative **Smart Grid**, 2013 - ieeexplore.ieee.org	The transition to the Smart Grid will be lengthy. It is impossible (and unwise) to advocate that all the existing equipment and systems to be ripped	The existing network were not build with smart grid on mind. Adapting them can be complex. It is not easy to transit from existing grid to smart grid. The fundamental

		out and replaced at once. The smart grid supports gradual transition and long coexistence of diverse technologies, not only as we transition from the legacy systems and equipment of today, but as we move to those of tomorrow. We must design to avoid unnecessary expenses and un warranted decreases in reliability, safety, or cyber security.	infrastructure is an issue for transition to the new grid. The infrastructure may need updating, ownership can be split several ways, with each stakeholder wanting their part used in their own way.
Ensuring Cyber Security of Systems	H Khurana, M Hadley, N Lu, DA Frincke - IEEE Security & Privacy, 2012 - computer.org M Hashmi, S Hanninen, K Maki - Innovative **Smart Grid**, 2013 - ieeexplore.ieee.org	Every aspect of the Smart Grid must be secure. Cyber security technologies are not enough to achieve secure operations without policies, ongoing risk assessment, and training. The development of these human-focused procedures takes time and needs to take time	The need for an integrated network is needed for safety of the network. There should be training, policies and legal actions against cyber security break, risk assessment of network.

		to ensure that they are done correctly.	
Consensus on Standards	M Hashmi, S Hanninen, K Maki - Innovative **Smart Grid**, 2013 - ieeexplore.ieee.org	Standards are built on the consensus of many stakeholders over time; mandating technologies can appear to be an adequate short cut. Consensus-based standards deliver better results over.	Different stakeholders participate on the different works in the system. Each might have their own specifications and thi might create chaos in the system. There should be set standards and consensus among all the providers to work on a set standard.
Development and Support of Standards	M Hashmi, S Hanninen, K Maki - Innovative **Smart Grid**, 2013 - ieeexplore.ieee.org	The open process of developing a standard benefits from the expertise and insights of a broad constituency. The work is challenging and time consuming but yields results more reflective of a broad group of stakeholders, rather than the narrow interests of a particular stakeholder group. Ongoing	A strong sense of Inter co-relation and coordination is required among the different stakeholders. Different standards needs to be set and policies and regulatory framework should be present.

		engagement by user groups and other. organizations enables standards to meet broader evolving needs beyond those of industry stakeholders. Both activities are essential to the development of strong standards	
Research and Development	M Hashmi, S Hanninen, K Maki - Innovative **Smart Grid**, 2013 - ieeexplore.ieee.org	The smart grid is an evolving goal; we cannot know all that the Smart Grid is or can do. The smart grid will demand continuing R&D to assess the evolving benefits and costs, and to anticipate the evolving requirements.	The benefits and the characteristics of smart grid should be well known to the stakeholders, industry and technical expertise group. The future prospect of smart grid should be drafted with a well-known roadmap, policy and regulatory framework.
Regulatory and Policy	M Hashmi, S Hanninen, K Maki - Innovative **Smart Grid**, 2013 - ieeexplore.ieee.org	To maintain a consistent regulatory and energy policy framework over a transition period that will be lengthy. Further, to achieve a	The lack of a firm regulatory framework to adopt smart grid has left the utilities without a knowhow of the path to testing, adoption and

		National modernization of the distribution grid the regulation of the grid is delegated to local and state authorities.	implementation of the smart grid. Lack of awareness among the customers is an issue policy makers will be facing.
TECHNICAL			
Smart equipment	M Hashmi, S Hanninen, K Maki - Innovative **Smart Grid**, 2013 - ieeexplore.ieee.org	Smart equipment refers to all field equipment which is computer-based or microprocessor-based, including controllers, remote terminal units (RTUs), intelligent electronic devices (IEDs). It includes the actual power equipment, such as switches, capacitor banks, or breakers. It also refers to the equipment inside homes, buildings and industrial facilities. Smart Equipment also includes previously electromechanical switches, reclosers, voltage controllers, and other actuated	The smart grid network is made up of smart technologies. India particularly has a strong drive for the Advance Distribution Management System and Advance Meter Infrastructure. Also there should be proper plan to integrate and maintain AMI system. This Smart technology can bridge the gap between the smart grid lunching and the basic infrastructure ensuring. For smart grid, there should be seamless connectivity with technology.

		hardware that have been retrofitted with sensors and controls used to monitor state, transmit that state to an external analysis point, and execute control commands returned from that point. Some of these packages are outfitted with local intelligence, used to carry out analysis and instructions when remote analysis is unnecessary or not economical. This embedded computing equipment must be robust to handle future applications for many years without being replaced	
Communication systems	M Hashmi, S Hanninen, K Maki - Innovative **Smart Grid**, 2013 - ieeexplore.ieee.org	Communication systems refer to the media and to the Developing communication protocols. These	There is high operating cost and benefit constraint by the regulatory framework. Since there is large

	Y Yan, Y Qian, H Sharif, D Tipper - Communications Survey, 2013 - ieeexplore.ieee.org	technologies are in various stages of maturity. The smart grid must be robust enough to accommodate new media as they emerge from the communications industries and while preserving interoperable, secured systems.	communication network required, it escalates the capital and hardware cost to a great extent. A smart grid can be a success in the short run but it can be less attractive with due course of time if proper regulatory network is not built. In India, the communication system is in the initial phases of development. This will reduce positive impact during delivery of services.
Data management	M Hashmi, S Hanninen, K Maki - Innovative **Smart Grid**, 2013 - ieeexplore.ieee.org	Data management refers to all aspects of collecting, analyzing, storing, and providing data to users and applications, includes the issues of data identification, validation, accuracy, updating, time-tagging, consistency across databases, etc.	The quantity of data to be handled is huge and the system of managing data has to be sound and strong with good technical back up and support system. There is a lot of data to be transmitted. There is delivery risk with the network. Even if there

		Data management methods which work well for small amounts of data often fail or become too burdensome for large amounts of data – and distribution automation and customer information generate lots of data. In many cases entirely new data models and techniques (such as data warehousing and data-mining) are being applied in order to handle the immense amount of synchronization and reconciliation required between legacy and emerging databases. Data management is among the most time-consuming and difficult task in many of the functions and must be addressed in a way that will	is technological development are aligned there is the issue of integration of entire hardware to manage the high volume of data. It requires complicated data models to manage the various data from formats that flow into the system. As of now, there is no system in India and it needs to be developed.

		scale to immense size.	
Cyber Security	M Hashmi, S Hanninen, K Maki - Innovative **Smart Grid**, 2013 - ieeexplore.ieee.org H Khurana, M Hadley, N Lu, DA Frincke - IEEE Security & Privacy, 2012 - computer.org	Cyber security addresses the prevention of damage to, unauthorized use of, exploitation of, and, if needed, the restoration of electronic information and communications systems and services (and the information contained therein) to ensure confidentiality, integrity, and availability.	There should be presence of strong regulatory network and policies to ensure cyber security to customer as well as the network parameters and stakeholders interest as well. There is necessary of an integrated framework
Information and Data privacy	M Hashmi, S Hanninen, K Maki - Innovative **Smart Grid**, 2013 - ieeexplore.ieee.org H Khurana, M Hadley, N Lu, DA Frincke - IEEE Security & Privacy, 2012 - computer.org	The protection and stewardship of privacy is a significant concern in a widely interconnected system of systems that is represented by the Smart Grid. Data integrity and non-repudiation is needed for succinct, reliable communication across the grid. Additionally, care must be taken to	There is a lot of data transaction in the smart grid. The information and data security and privacy is a risky affair and there should be strong legal laws against any breach of security. An Integrated network protect privacy and information and customer data should remain private.

		ensure that access to information is not an all or nothing at all choice since various stakeholders will have differing rights to information from the Smart Grid.	
Software applications	M Hashmi, S Hanninen, K Maki - Innovative **Smart Grid**, 2013 - ieeexplore.ieee.org H Khurana, M Hadley, N Lu, DA Frincke - IEEE Security & Privacy, 2012 - computer.org	Software applications refer to programs, algorithms, calculations, and data analysis. Applications range from low level control algorithms to massive transaction processing. Application requirements are becoming more sophisticated to solve increasingly complex problems, are demanding ever more accurate and timely data, and must deliver results more quickly and accurately. One of the most prominent software development evolutions is shifting	Smart Grid applies to the involvement of IT in the working of the grid. There should be implementation of the latest technology in the network and also the best minds should be there to do the task.

		from a peer-to-peer integration environment to a services oriented architecture (SOA) (Refer Annexure 4 for SOA) built upon on a robust analysis, simulation, and data management infrastructure. Software engineering at this scale and rigor is still emerging as a discipline. Software applications are at the core of every function and node of the Smart Grid.	

3. Research Functionalities

viii. Research Gap

Implementation of Smart Grid is of ardent necessity in India. With a population of 1.2 billion and about one-third of this population living without access to energy, there is an immediate need for an efficient and effective affordable electric infrastructure which is reliable. With the rapid growth in energy demand and increase in per capita consumption, all the sectors like industry, residential, commercial, transport and agricultural needs electricity. There is a need for smart grid in the whole of the country.

The government and the regional utilities have implemented around 14 smart grid pilot projects in India. Also there is the launch of ISGF and ISGTF for implementation and planning of smart grid in the country. Despite all these endeavours, India still lags in the process to become one of the successful model in the world in smart grid technology.

There are various challenges regarding the fundamental infrastructure, policy and regulatory framework, customer and industry awareness, lack of technology etc. India has to meet all the mentioned challenges in order to come at par with the global market and technology. The shortcoming of the electrical network like the significant line loss, theft of electricity, irregular grid operations has to be overcome to avoid an unstable network. For all these and also low carbon emission technology, smart grid is fruitful. There is also need for the education of the among utilities, generation, transmission and distribution network and government leaders about the positive of smart grid. India must invest in systematic way on smart grid and the stakeholders should go for capacity building. Investment should be made on ADMS (Advance Distribution Management System) and AMI (Advance Metering Infrastructure) in India. Demand Side Management is necessitates at the moment.

ix. Research Problem

The Research problem lie with the different barriers that are holding back the implementation of smart grid in Global as well as in Indian platform. The main barrier is that of the regulatory issues and the fact that they are out of sync with the industry and society's broader perspective of modernisation with implementation of technology.

The below shown table gives the different reasons for holding back of investment in India and also global platform. Most of these **barriers** are the one that are related to the regulatory framework and are present to support the present power delivery system.

Table 3: Barriers to Smart Grid

BARRIER	DESCRIPTION
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 or private sector investment.
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. Within 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
Technological 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

	agreed standards have not emerged. 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.
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.
Access to Affordable Capital	Utility companies are generally adept at tapping the capital markets; however, where delivery risks are high and economic frameworks are variable, the relative 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 and government will be the key to accessing the cheapest capital possible. In the case of municipalities and cooperatives, this challenge may become amplified as the ability to manage delivery risk is reduced.
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.
Cyber Security and Data Privacy	Digital communication networks and more granular and frequent information on consumption patterns raise concerns in some quarters of cyber in security 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.

x. Research Objective

The main purpose is to study about Smart Grid and analyse the barriers and challenges in the implementation of smart grid in India and thereby to find out solutions to solving the barriers and define a roadmap to implement Smart Grid in India.

Also to have a global perspective on smart grid implementation in South Korea, (JEJU island Smart Grid Model), Japan (Yokohama Smart Community Model) and Netherlands (Amsterdam-Nieuw West Smart Grid Project) and analyse the successful model of Smart Grid Implementation of these three countries. The opportunities and Challenges for all the three models are studied and how these models can help implement smart grid in India are defined.

xi. Research Methodology

The Research Methodology that is implemented to analyse the Smart Grid Implementation Model in India with Reference to three successful Global Smart Grid Model (JEJU Island, Yokohama Smart Community Model and Amsterdam-Nieuw West smart Grid Model) is based on **Qualitative Approach – Content Analysis Method.**

The Research is carried on by analysing the three country model and Identifying their barriers and challenges. Thereby, finding the solutions that the countries implemented to overcome the barriers.

On the Indian perspective, barriers and challenges to smart grid are identified and solutions are provided. Learnings from the three country smart grid model are identified and are presented.

The Research Design Implemented is **Exploratory Research Design**.

Data Source:

The data source is secondary data source from published journal, reports, websites.

4. The Indian Smart Grid Context

xii. Overview

India’s Smart Grid policy is an emerging part of its nationwide energy policy. The policy is being jointly developed by a collaborative grouping of central and state governmental bodies and subject matter experts from industry, academia and non-governmental research and development organizations.

Origins of India’s Smart Grid efforts are multi-factorial in nature but primarily concern three main issues which are the subject of current or planned government backed initiatives:

- Increased load needs as one of the world’s fastest growing economies, which today cannot be met by present supply and hence results in frequent “brownouts”;
- The drive to electrify a large segment of its rural population, which have yet to receive electrical services and finally
- The need to optimize electrical usage by being able to manage loads and mitigate operating inefficiencies (the losses in the system, both financial and technical, are amongst the highest in the world).

In a country of 1.2 billion people (2010) India has one value that sets it apart from the rest of the industrialized countries of the world and that is that one of the largest shares of total electrical loads comes from agricultural use, chiefly those associated with water pump sets usage. The absolute pump sets load may not be unusual but in the context of low per capital total loads, it is high. One driver is that two-thirds of the population is associated with agriculture for their livelihood

Governmental Energy Organizations and Laws

Energy is considered a concurrent subject in the Indian constitution — both state and central. As a matter of operational services the central government is most actively involved in generation and transmission domains whereas the states control distribution services. This in itself is an important issue in India today as the state of distribution finances are not significant enough to provide for the increased demands which are being requested of them. State governments are looking to the central government to provide funding and resources which will allow for upgrades, expansion and re-engineering at an unprecedented rate. One of the main projects associated with this effort is the rural electrification and modernization project known as (RGGVY).

The portion of the central government that is most directly associated with the development of energy policy and Smart Grid efforts in India is the Ministry of Power (MoP). Other sub-agencies and nodal agencies of the MoP that are involved include the Central Power Research Institute (CPRI), the Central Electric Authority (CEA), the Power Finance Corporation (PFC), not to mention the Bureau of Indian Standards (BIS) outside of the Ministry of Power. Central government involvement in the Smart Grid has recently expanded beyond the confines of the MoP into an inter-departmental task force known as the Smart Grid Task Force (SGTF). This group includes the aforementioned MOP organizations, the Ministry of New and Renewable Energy (MNRE), the Ministry of Communications and Information Technology (MCIT), and the Department of Science and Technology (DST). In addition to this governmental body, the Ministry of Power has set up the India Smart Grid Forum as a public-private partnership, bringing in utilities, industry, academia, etc. as well.

The chronology and lineage of legislative efforts, programs and associated schemes which have led up to the development of a Indian Smart Grid originate with a fundamental shift towards private involvement in energy production and transmission and the unbundling of the power sector from total government control in the 1990s.

The government desired to formulate a scheme to encourage India’s electric grid to make three fundamental improvements to the existing grid:

- Advanced metering to reduce AT&C (Aggregate Technical and Commercial) losses that are at an unacceptably high-level presently;
- Automation to measure and control the flow of power to/from consumers on a near real-time basis and improve the system reliability;

Moving to a smart grid to intelligently manage loads, congestion and shortfall.

Other important changes in energy laws including the Electricity Act of 2003 and the important National Electricity Policy of 2005 have set forth a formative set of national energy objectives including:

- Access to Electricity - Available for all households in next five years
- Availability of Power - Demand to be fully met by 2012. Energy and peaking shortages to be overcome and adequate spinning reserve to be available.
- Supply of Reliable and Quality Power of specified standards in an efficient manner and at reasonable rates.
- Per capita availability of electricity to be increased to over 1000 units by 2012.
- Minimum lifeline consumption of 1 unit/household/day as a merit good by year 2012.
- Financial Turnaround and Commercial Viability of Electricity Sector.
- Protection of consumers' interests

The next most important Smart Grid related national energy policy decision occurred in 2008 with the implementation of the Re-Structured Accelerated Power Development and Reforms Program (R-APDRP). This program is designed to take 3-5 years to implement and has several parts. The first part is concerned with the information and communications technology (ICT) enablement of power systems and investments of power infrastructure in an effort to first measure and then mitigate losses associated with operating inefficiencies and energy theft. The primary goal of the program is a reduction in losses, with subsequent portions focusing on physical re-engineering of the grid as indicated by the ICT driven data. Other goals of R-APDRP include:

- Renovation and modernization (R&M) of power plants
- Strengthening and improvement of sub-transmission and distribution networks
- Development of adequate spinning reserves
- Development of power systems automated controls

Hybrid Governmental/Industrial Organizations

Besides governmental participants, there are numerous other hybrid-governmental and non-governmental organizations who are vital contributors to the development of India's Smart Grid vision, and who are also associated with the SGTF and the Forum. Most notable of these private non-profit science and technology organizations is the Center for Study of Science, Technology and Policy. (CSTEP) To complement the Smart Grid Task Force, public-private efforts are being fostered by the Ministry of Power to help develop India's Smart Grid vision on an advisory, informational and non-binding basis. Most notable of these groups is the Smart Grid Forum which works in direct coordination with the Smart Grid Task Force.

India's Smart Grid vision as expressed by the India Smart Grid Forum includes five fundamental objectives:

- End of Load Sharing- peak load shifting through a combination of direct control and differential pricing (demand response/dynamic (DSM))
- Reliable Power- Robust systems with Self-healing capabilities through monitoring
- Cheaper Power- Dramatic improvement in AT&C losses, real time monitoring load sources
- Shifting the Peak away from Costly Power- Better utilization of Assets
- More Sustainable Power- Integration of green and renewable resources at a massive scale, enough to increase energy independence

xiii. ISGF- Indian Smart Grid Forum

In the year 2010, the ministry of power (MOP) initiated a program for the accelerated development of Smart Grid technology in India. This is the Indin Smart Grid Forum which is a public private partnership initiative of the MOP and GOI (Government of India) in the Indian power sector, whereby industry, utilities, academia and other stakeholders can participate in the smart grid development in the country and give there relevant inputs.

Objectives of ISGF:

- To help the Indian power sector deploy smart grid technologies in an capable, cost effective, innovative and mountable manner by bringing together all key stakeholders and permitting technologies
- To create a platform for public and private stakeholder members, research institutions and power utilities to exchange ideas and information on smart grids and develop use case scenarios for India.
- To bring together experts from regulation, policy, and the corporate sector to build support for smart grid policies.
- To conduct research on the capabilities of smart grids in the Indian context through case studies, cost-benefit analysis, study of technical advancements in renewable energy sources and other ancillary activities.
- To make recommendations to the Government, Regulators, Utilities and Consumers through reports, white papers, technical seminars, etc.

Mandate of ISGF is to direct government on policies and programs for promotion of Smart Grids in India, work with national and international agencies in standards development and to help utilities, regulators and the Industry in technology selection, training and capacity building. ISGF has 10 effective groups on : WG1: Advanced Transmission; WG2: Advanced Distribution; WG3: Communications for Smart Grids; WG4: Metering; WG5: Consumption and Load Control; WG6: Policy and Regulations; WG7: Architecture and Design; WG8: Pilots and Business Models; WG9: Renewables and Micro grids; and WG – 10: Cyber Security.

ISGTF

This is a inter-ministerial group formed in 2010 which helps in developing the roadmap for smart grid projects in India.

Five Working groups have been constituted to take up the different tasks related to SMART GRID activities i.e.

WG1 – Trials/Pilot on new technologies.

WG2 – Loss reduction and theft, data gathering and analysis.

WG3 – Power to rural areas and reliability & quality of power to urban areas.

WG4 – Dist Generation & renewable.

WG5 – Physical cyber security, Standards and Spectrum.

xiv. Regulatory Support for Smart Grid projects in India

The growth of a dynamic regulatory environment is a pre-requisite to motivate the market towards Smart Grids in India. Providing clear signals to different stakeholders such as utilities, investors and technology providers of the direction of the market and thus providing some certainty and confidence for the necessary investments. Through incentives and performance guarantees, consumers can be motivated to also take an active role and demonstrable cost benefits will convince regulators of the necessary investment requirements.

Regulatory support for Smart Grids is required across 3 key dimensions:

- Economic Regulation;
- Safety and Standards; and
- Awareness and Capacity Building

Consumer awareness and capacity building at all levels will need to be pursued Throughout to ensure buy-in and involvement. It is important to mention that many regulatory Instruments will need to be interrelated, and hence coherence across these will be necessary. Within India several entities including ISGTF, BIS and CEA have already been working on a wide range of activities covering the different instruments required under the above framework. However, there is still a need for an institutional setup that ensures strong coordination among all.

xv.Smart Grid Pilot Projects in India

In total basically there are 14 smart grid pilot projects running in India. A brief overview of the projects with their current status are presented here along with their location specifications, consumer details and also the project summary and the benefits envisioned from the projects:

Table 4: Smart Grid Pilot Projects in India

STATE	PROJECT SITES DETAILS	PROJECT SUMMARY	BENEFITS ENVISAGED
ASSAM	Utility-Assam Power Distribution Company Area for Project-Guwahati Distribution Region Consumer - 15000	The project covers a customer base of 15000 with input energy of 90MUs.The project aims for the advance metering infrastructure (AMI) for residential and industrial consumer for peak load management (PLM), Outage management system (OMS), PQM and DG.	Reduce in AT&C loss, increase in quality power and availability, increase in power in peak hours and improve management for power procurement options and revenue increase for power quality measurement and power factor penalty.
CHHATTISGARH	Utility- Chhattisgarh State Power Distribution Company Limited Area for project-Siltaraanrd DDU Nagar of Raipur Consumer - 1987	The project includes installation of smart meters at 508 H.T and L.T industrial consumers. Peak Load Management by implementing AMI-I for industrial consumers.	Reduce in T&D loss, reduction in peak load consumption by shifting peak loads to non-peak loads time thereby saving UI charges and also benefits cost of billing.

GUJARAT	Utility- Uttar Gujarat Vij Company Limited Area of Project- Naroda of Sabarmati Circle and Deesa-2 of Palanpur circle Consumer - 39422	The project covers 20524 customers for Naroda and 18898 customers for Deesa-2(agricultural unmetered customers) with input energy of 1700 MU. The functionalities include Outage management system and PLM by implementing the AMI for agricultural, residential, commercial and industrial consumers.	Reduction in AT&C loss, reduction in peak power purchase cost by reducing the peak load, reduction in transformer failure rate, reduction in outages and meter reading cost etc.
HARYANA	Utility- Uttar Haryana Bijli Vitaran Nigam Limited Area of Project- Panipat City Sub Division Consumer - 31914, revised to 11000	The area has around 131.8 MUs input energy consumption. The functionality of peak load management is covered under implementing of AMI for residential as well as for industrial consumer. There is outage management system and also SCADA/DMS	Reduced Distribution losses and Reduced peak load consumption along with reduced cost of billing.

HIMACHAL PRADESH	Utility- Himachal Pradesh State Electricity Board Limited Area of Project- Industrial town of KalaAmb Consumer - 1251	The functionality of the peak load management comes under implementation of AMI for the industrial customers. Also power quality meters are deployed at HT customers fo Power Quality Management, Distribution automation and substation Automation, Outage Management.	Reduction in peak loads for industrial consumers by shifting the peak load and reduce outages.
KARNATAKA (MYSORE)	Utility- Chamundeshwari Electric Supply Corporation Limited Area of Project- VV Mohalla, Mysore Consumer - 24532	The functionality of the peak load management comes under implementation of AMI for the industrial customers as well as residential consumers. Outage management also. Here is a good mix of residential, industrial, commercial and agricultural customers. Also there are 473 distribution	Reduction in AT&C loss, Reductions in peak loads and shifting of peak demand of industrial and residential consumers at peak periods, Reduction in meter reading cost and also reduction I unforeseen outages.

		transformer and input energy fo the area is 151.89 MUs.	
KERALA	Utility- Kerala state Electricity Board Project Area- Restructured to the R-APDRP towns (8 in numbers) Consumer- 25078, Revised to 15700	The functionality lies with implementation of 100% Advanced metering infrastructure – Industrial consumers for LT, Accurate and timely metring and billing, No costly field visits for meter reading, PLM by load restriction for remote disconnection and reconnection and TOD tariff.	Incremental Tariff for peak hours by TOD tariff, savings in meter reading, reduction in the AT&C losses and also in manual losses and theft etc.
MAHARASHTRA	Utility- Maharashtra State Electricity Distribution Company Limited Area of Project- Baramati Town Consumer- 29997	The consumers are a mix of industrial, residential, and commercial sectors. The functionality of Outage management System is met by implementing AMI for both residential and industrial customers. Load curtailment program, where reduced load is	Reduction in AT&C loss, Reduction in meter reading cost and bringing efficiency in meter reading and also reduction in quantity of field staff due to reduced outage management.

		supplied instead of no load, time of use metering dynamic and real time pricing an demand forecasting.	
PUDUCHERRY	Utility- Electric Department of Government of Puducherry Area of Project- Division 1 of Puducherry Consumers- 87031	Among the total customers 79% is domestic consumer. The area has around 367 MU of input energy consumption. He module of AMI for residential and industrial are implemented in the area. Revenue collection efficiency for energy auditing and AT & C loss reduction.	Reduction in distribution loss, reduction in billing cost and increase in the revenue collection efficiency.
PUNJAB	Utility- Punjab State Power Corporation Limited Area of Project- Industrial Division of City Circle of Amritsar Consumer- 9818	The implementation of AMI for the peak load management, installation of 9000 smart meters and transformer monitoring, SCADA implementation and GIS mapping.	Reduction in feeder outage restoration time and reduction in the transformer restoration time and altogether reduction in outages.
RAJASTHAN (JAIPUR)	Utility- Jaipur Vidyut Vitaran Nigam	The functionality of Peak Load	Reduction in AT&C losses and reduction

	Limited Area of Project- VKIA, Jaipur Consumers- 34752	Management is carried on by implementing the Advanced Meter Infrastructure for both domestic and residential consumers where industrial consumers are more than 50% of the total consumer base.	in peak load consumption by shifting the peak Load demand.
TELANGANA	Utility- Telangana Southern Power Distribution Company Limited Area of Project- Jeedimetla Industrial Area Consumers- 11904	The area covers 11904 consumers. It is covered under RAPDRP scheme, DAS, IT and SCADA will be implemented. The functionalities of Peak Load Management and Outage Management will be covered by implementing of AMI in both residential and industrial consumers in the area.	Reduced AT&C loss and reduced cost of power in peak hours.
TRIPURA	Utility- Tripura State Electricity Corporation Limited Area of Project- Electrical Division No	The area is covered under RAPDRP scheme and IT implementing and system strengthening,	Reduced distribution loss and reduced Peak Load Consumption and reduced cost of billing.

	1 of Agartala town Consumer- 46071	The functionality of Peak Load Management (PLM) is covered by implementing AMI in both residential and domestic consumers.	
WEST BENGAL	Utility- West Bengal State Electricity Distribution Company Limited Area of Project- Siliguri town in Darjeeling District Consumer- 4404	The project takes up 4 numbers of 11 KV feeders for implementation of smart grid covering all 4404 customers. Input energy of Area is 42 MUs. The functionality of Peak Load Management (PLM) is covered by implementing AMI in both residential and domestic consumers	Reduced distribution losses and reduced AT&C losses.

xvi. Conclusion

Implementation of Smart Grid is of ardent necessity in India. With a population of 1.2 billion and about one-third of this population living without access to energy, there is an immediate need for an efficient and effective affordable electric infrastructure which is reliable. With the rapid growth in energy demand and increase in per capita consumption, all the sectors like industry, residential, commercial, transport and agricultural needs electricity. There is a need for smart grid in the whole of the country.

The government and the regional utilities have implemented around 14 smart grid pilot projects in India. Also there is the launch of ISGF and ISGTF for implementation and planning of smart grid in the country. Despite all these endeavours, India still lags in the process to become one of the successful model in the world in smart grid technology.

There are various challenges regarding the fundamental infrastructure, policy and regulatory framework, customer and industry awareness, lack of technology etc. India has to meet all the mentioned challenges in order to come at par with the global market and technology. The shortcoming of the electrical network like the significant line loss, theft of electricity, irregular grid operations has to be overcome to avoid an unstable network. For all these and also low carbon emission technology, smart grid is fruitful. There is also need for the education of the among utilities, generation, transmission and distribution network and government leaders about the positive of smart grid. India must invest in systematic way on smart grid and the stakeholders should go for capacity building. Investment should be made on ADMS (Advance Distribution Management System) and AMI (Advance Metering Infrastructure) in India. Demand Side Management is necessitates at the moment.

5. The International Context

xvii. South Korea

b South Korea Electricity Sector

South Korea is among the 10th largest energy consumer in the world according to 2011 report and had an electricity production capacity of 496.89 GW in 2011. But there was shortage of the domestic reserves and due to which South Korea mostly depended on imports of LNG, Coal or Crude oil. The coal found in South Korea is of low quality. Mostly energy dependence in on Thermal, followed by Nuclear and Renewables. The overall losses in the system is about 4% which is one of the best in the world having the least loss in the system. The electricity uses among the consumers varies with industry (51%), Residential (13.8%), Agricultural (1.6%), Commercial (32.5%), Transport (0.5%) and others (0.6%). The quality of power in South Korea is very good with blackout being 17 mint/home/year).

Energy Consumption in South Korea have been peeking since 2000 mainly due to the rise in the industry sector. This has resulted in a heavy concern on the environmental front as expanding industries impose high prices on the environment due to the emission of CO2 and other greenhouse gases. There are two main objective of South Korea energy Sector:

- Reduction on dependency on fossil fuel via secure energy security and improve trade balance.
- Increasing the efficiency in using electric energy to implement measures on UNFCCC (UN Framework Convention on Climate Change).

South Korea has one of the world’s best IT Infrastructure which is young and smart. South Korea is symbolic for newer equipment, ability of operation and high efficiency. Also it is believed that employing smart grid would help the country use more energy sources and cut overall energy consumption. A smart grid which helps cut energy consumption and accommodate more wind and solar power lessens the harmful gases from the environment as power sector emits the maximum greenhouse gas.

In South Korea there is a definition of Smart Grid, and it has to meet two criteria. The first criteria is that the smart grid has to be self-scrutinising and self-healing, Smart Power grid means that the grid has to have an open power platform and set up systems against failure and forecast it and also automatic recovery. Korea aims to have a healing grid that will act against blackout and other accidents.

South Korea energy sector have the following governing bodies:

- Ministry of Knowledge Economy which is responsible for implementing and developing

Energy policy.

- The Korean Electricity Commission (KOREC) which is the regulator for the sector and controls retail tariffs, quality and security matters.
- The Korean Electric Power Exchange which operates system and controls market.

State Controlled Korea Electric Power Corporation still controls, owns and operates most of country's generation , transmission and distribution assets. Basically South Korea's electricity sector is ran by state controlled vertically integrated monopoly for the fields of generation, transmission and distribution. South Korea has a closed grid but the government has a wish to move towards a regionally interconnected supply system.

c Smart Grid in South Korea

South Korean Economic strategy lies on the innovating and exporting of the green technology and has this as the pillar for growth and development. South Korea is very advance in and active smart meters and grid activities. The South Korean legislature approved the Smart Grid Stimulus Law which gives the outline for the sustainability of smart grid projects and also a play for development of Smart Grid. The government has a plan to installation of smart meters by 2016 in half of the household and by 2020 replace all analog meters. In 2011, the Smart Grid promotion act was passed which gives ideas for development, deployment and commercialisation of Smart Grid..

The **Reason** for success of smart grid in South Korea lies in the following facts:

- Level of coordination and support between the government and industry to get the target economic growth on green revolution.
- The Korean Smart Grid Association plays a critical role as a mediator between government and private sector stakeholders.
- The Deployment of many pilot project in Korea and zeal to achieve target of national smart grid by 2030.

Challenges that Korea is facing lies on the transition of energy since it is focussing on the management of energy consumption , renewable energy sources introduce and lowering carbon emission. Korea wants to reduce the fossil fuel usage and increase the renewable energy use and go green and improve the power quality. Korea wants to improve the power grid by including the EV and self-healing and distributed generation.

Korea Smart Grid **Challenges/Necessity** adheres to the following points:

- Increase in the power demand continuously.
- Attempt to lower the carbon emission and greenhouse gases with the advance of industrialisation.
- Increase in the quality of life.
- Transfer of demand from primary to secondary energy.
- Poor transmission facilities, severe constraints of constructing power line tower even after constructing the generation equipment. Example being delay in the Shingori-Bukgyeongnam 765kv construction delay.
- Bidirectional, smart and distributed power system is needed.

Korea’s Smart Grid Progress

- 2005- Launch of Power IT Projects which enhances power infrastructure and created additional services. It’s a technology driven policy.
- 2008- Power IT as a new growth machine, development of energy technology and focus is on export oriented integrated model

- 2009- Adaption of Smart Grid program, which is a business model driven policy.
- 2009- Korea was designated as a major Smart Grid oriented country which introduced open grid structure
- 2010- Created the new Jeju smart grid demo project and launched total operation centre where 168 countries participated.

d JEJU-

The most ambitious smart grid project of South Korea which will influence the other projects in the country is the JEJU Smart Grid Demonstration Complex which has the objective to set up world's largest test bed for smart grid. The policy goal of South Korean government of the Five Year Master Plan (2012-2016) is to establish Smart Grid pilot projects for cities in seven (7) different areas which will have five (5) strategic fields which corresponds to the project domain:

- **Smart Place-** Reduction in the consumption of energy by installation of AMI in the homes and buildings and thereby allowing of re sell of stored energy by the consumers. It also gives easy access of consumed electricity via media such as internet, TV and mobiles etc and provides incentives too. It connects all smart appliances to AMI and operate micro grid. Also there is provision of interconnection between telecommunication and electricity.
- **Smart Transport-** EV charging infrastructure development and also minimise effects on the charging on grid. Forming of business model for auto repair, parking management an navigation etc. Also development of charging infra using distributed energy and develop EV charging system.
- **Smart Renewable-** Testing of technology for electric power network and also test various modes for betterment of quality of stored renewable energy. Also it provides stability to irregular power generation of wind and solar.
- **Smart Power Grid-** Deployment of next generation network using smart grid. Also it provides two way communication for the supplier and consumer and have self-automated recovery system.
- **Smart Electric Service-** Establish and also operates a high quality system which gives real time pricing and also ensure good quality electricity.

Korea has built the world's first nationwide Smart grid community which is the largest in the world. JEJU was selected as the test bed for several reasons- abundant supply of renewables, independent power grid and JEJU is an island with the world natural heritage.

JEJU Smart Grid test bed has the following features:

- Integrated test bed
- Public and private sectors close collaborations
- Verification of various power market models
- Participants are Korea Electric Power Corporation (KEPCO) along with automakers, telecommunication companies and home appliances manufacturers. It Includes major companies like LG, SKT, KT and Samsung
- Open to foreign companies

JEJU has a funding of 77billion KRW from the government and 173 KRW from private parties and together with several companies KEPCO has taken JEJU Island as the most prominent smart grid demonstration project of South Korea. The island of JEJU is a special autonomous province having 200km south of mainland Korea and presents a unique area for smart grid demonstration having an independent power grid connected to the 300 MW HVDC line to the mainland.

The project has the prime objective to have the largest test bed in the world and it incorporates renewable generation (solar and wind), distributed automation, distributed management system , EV structure, advanced metering infrastructure, energy storage along with network monitoring and telemetry.

The JEJU project includes all main domains indicated by the government roadmap- the smart power grid, smart transportation project, smart renewables energy sourcing project, consumer participation and smart place project along with smart electricity service project.

For the smart power grid it has micro grid operation centre which integrate and control the power generation and storage, smart meters, distribution automation system. It basically optimises power system operation and monitor power quality and operational grid.

The project team is implementing a smart transportation system with EV system which works faster and has a smart battery charger along with GPS based charging places and emergency information and services. The infrastructure is completely wireless communications. The figures for this project included 12 consortiums approximately 6000 households, 72 EV , 89 charging stations, 9 home (3kWh) and building (150 kWh) storage units and 1 wind power energy storage system.

The Renewable Energy project consist of the micro grid demo which has large volume of wind generation and also intelligent output stabilisation and also high volume of BESS (2 MVA) and many battery technologies (Li-ion, lead acid, redox flow). This project include 2 wind generators (750 kw), Energy storage system 2MVA-500kWh and 72 Lead Acid Energy Storage System 275kW-137.5kW.

The smart grid green place project has houses and building has integrated energy management processes to manage their energy usage in better way. This project included has 600 households.

In the first phase the consortium had made electric vehicle charging stations and installed solar panels rooftops, smart appliances development and also smart meters and technology implementation. In the second phase the pilot project development gave rise to a fully functional smart grid connected system for 6000 households, with wind farms and four distribution lines.

Now a **summary** of the progress by practice follows:

Smart Transportation: As a sole power utility company, KEPCO leads the Smart Transportation practice and has been working closely with Hyundai Motors. KEPCO and Hyundai aim to start Korean standards for fast- and slow-charging interfaces for charging stands, plug-in and contactless chargers, and comprehensive charging infrastructure models. The two companies are also working to develop a dynamic charging tariff for EVs.

Meanwhile, SK Energy and GS Caltex, one of the leading oil and gas station players in Korea, have formed a different consortium. These players are focusing on the battery management systems used in charging stations for EVs. In addition, the GS Caltex consortium has completed the architecture for micro grid systems (5 kW fuel cell and solar power generation) dedicated to EV charging stations.

Smart Place: The deployment of smart meters and AMI has been the key emphasis of this practice. Four consortia in the practice (led by SK Telecom, Korea Telecom, LG, and KEPCO) invited 1,000 households to volunteer for the deployment and installation of smart meters, data concentrator units, smart plugs, and in-home displays to support overall AMI functional programs in conjunction with two-way communications over smart meters, HEMS, and demand response. Of note, LG Electronics acquired 36 Korean patent cases in the smart meter and AMI fields. The integration of micro grids with solar power is one of the core focus items of the Smart Place practice.

Smart Renewable: Compared with the other practices, the Smart Renewable practice was slow-footed and more focused on securing field test configurations for the second phase. Participants completed their ongoing in-house development of field test systems, including: energy storage, PCS (power conversion systems), EMS (energy management systems), STATCOM (static synchronous compensators), and grid stabilizers for wind power generation. In the next phase, participants plan to link the operations of EMS with renewable power generated by small solar, wind, and ocean hydropower plants.

Smart Power Grid and Smart Electricity Service: KEPCO has been focusing on substation intelligence, real-time and dynamic pricing schemes, and IT architecture adequate for the Energy Marketplace environment.

e Smart Grid Promotion Act:

It is the law to stimulate smart grid implementation to achieve the roadmap set by government and also to have successfully implemented pilot projects specially JEJU test bed project.

Background

Provision for the legislative support for smart grid, basically to address the climatic change issue and competition in the global market for green energy. Also major economies like USA and EU are addressing this issue to have legislations, support R&D and smart grid deployment. Act is necessary to make possible the convergence to different sectors and businesses. There is a need to facilitate Smart Grid regulations to achieve the roadmap set by government and also to have successfully implemented pilot projects specially JEJU test bed smart demonstration project.

Framework for Smart Grid Policy:

- Development and Execution of primary plan for smart grid. (Article 5,6,7)
- Designation of the Smart Grid promoting agency. (Article 19)
- Register business licensee for Smart Grid.(Article 12)
- Support Smart Grid investment (Article 14)
- Smart Pilot city selection (Article 18)
- R&D support (Article 10)
- International collaboration (Article 11)
- Verification of technology and standards (Article 15, 17)
- Compilation of personal data (Article 22)
- Sharing of information on Smart Grid (article 23)
- Optimum use of information (Article 24)
- Information security for smart grid (Article 26)
- Securing compatibility for smart grid (Article 28)
- Securing information and preventing violation (Article 25, 27)

Enacting of Smart Grid Promotion Act:

- Coordinates roadmap, pilot projects and demonstration project for success
- Gives technological and institutional support for the Jeju smart demonstration project.
- The project outcome from Jeju demonstration project gives coordination to smart grid businesses and deployment
- The act will give a solid foundation to grid projects and invite more and more investment.

f Conclusion about Smart Grid in South Korea

South Korea targeted in establishing a national smart grid by 2030. The technology demonstrated or followed in JEJU will be used in other countries (smart homes, e schools, e-vehicles, smart platforms etc) which will be used in other parts of South Korea. The JEJU project demonstrate a systematic way of implementing smart grid. JEJU test bed gives significant emphasis to R&D development and smart homes and smart places. South Korea does not have re development urban project but it has a semi urban project test bed in JEJU. The project gives emphasis on the smart homes and e-mobility.

This test bed gives the foundation of the commercialisation and industrial export of the technologies of the smart grid. South Korea has made some $155 million for the testing of the technologies on the countries test bed of JIJU island between 2015-2017. Exporting of technology has boosted the efficiency of the system. Smart Grids are used in South Korea as a business item as well as an export item. KEPCO has made its first export deal with the Canadian power company POWERSTREAM in September 2014.

KEPCOS smart grid technologies are deployed even locally in phrases starting from major cities like SEOUL and Incheon by 2017 and then across the country by 2030. Korean market players boast that equated with other global smart grid and clean tech projects, the JEJU Smart Grid Demonstration Project is brilliant because of its wide collection of test categories, which range from AMI to renewable energy to EVs. Specifically, the project has five different practice fields: Smart Transportation (electrified vehicles, charging solutions, and EV batteries); Smart Place (AMI, smart meters, and HEMS [home energy management systems]); Smart Renewable (renewable energy sources and micro grids); Smart Power Grid (the advancement of existing transmission and distribution systems in power grids); and Smart Electricity Service (Energy Marketplace and electricity retail service).

JEJU is a successful model of smart grid implementation and Korea has a positive market environment for the smart grid in terms of the technological and manufacturing competitiveness of Korean market players. By leveraging its technology leadership in the IT and communications space, Korea aims to form an advanced smart grid structure. The country’s likely ultimate goal is to lead the global standards arena with the technological outcomes and business models developed by the JEJU Smart Grid Demonstration Project.

xviii. Japan

g Japan Electricity Sector

The electric power industry of Japan have the generation, transmission, distribution and electricity sale in Japan where according to a 2012 report, electricity production is 936.2 billion kWh and electricity consumption is 859.7 billion kWh. The overall losses in the system is 5%. The primary electricity users contains public and commercial services (38%), residential (30.6%), industrial (28.9%) and transport (2.1%). Japan has a total land area of 377915 km2 .

The Japanese national electric grid is unique in that it is actually composed of two distinct grids that operate at different frequencies and are allied by only three converter stations, which, together, can push only 1.2 GW of power east or west. The eastern grid operates at 50 hertz with most of its bequest equipment originating from Germany. The western grid operates at 60 hertz with equipment tracked from the United States. The eastern grid is divided into four service areas, and the western grid is divided into six service areas. Each service area is basically self-sufficient but is interconnected with adjoining service areas. The Japanese grid is found to be very reliable. The service area in Japanese grid are owned and operated by single electrical power company under monopoly utility which handles everything from generation, transmission, distribution up to retailing. Interestingly, the Japanese electricity supply industry has been privately owned since 1951. In the late 1990s, the Japanese government executed reforms which slackened the generation sector somewhat and permitted independent power generators to sell directly to medium and large consumers. Still, the ten power companies account for approximately 85% of generating capacity within specific geographic regions. Retail tariffs are controlled based on cost of production plus a fair rate of return.

The Japanese electricity market is divided up into 10 regulated companies:

1. Chugoku Electric Power Company (CEPCO)

2. Chubu Electric Power (Chuden)

3. Hokuriku Electric Power Company (HEPCO)

4. Hokkaido Electric Power Company (Hokuden)

5. Kyushu Electric Power (Kyuden)

6. Kansai Electric Power Company (KEPCO)

7. Okinawa Electric Power Company (Okiden)

8. The Tokyo Electric Power Company (TEPCO)

9. Tohoku Electric Power (Tohokuden)

10. Shikoku Electric Power Company (Yonden)

In 2010, the largest utility in Japan, TEPCO, had 28.2 million customers, revenues of $58.0 billion, 38,671 employees, and generated 293,389 GWh of electricity. KEPCO and Chuden are the second and third largest utilities with 13.5 million and 10.5 million customers in 2010, respectively.

In Japan, there is no independent regulator. The ministry of economic Trade and Industry (METI) is launching energy policy in the country. The Japan Electric Power Exchange (JEPX) is the sector's wholesale power exchange market. JEPX is privately owned and operated, and participation in the JEPX is voluntary. The Electric Power System Council of Japan is an independent, non-profit entity that establishes rules for the industry regarding system development, access and operation of interconnection facilities, and market oversight. It also acts as its dispute settlement forum. The Council's membership is made up of Japan's major electrical utilities, independent power producers, and academics.

Japan is not self-sufficient in terms of energy. It can produce a maximum of 20% of the final energy consumption. And since the Fukushima accident, Japan produced 11% of the domestic energy demand on its own. In the UK energy security goes up to 68.9%, while China produces 88.3% of its energy consumption demand. In Japan more than half of the imports are oil, imported from the Middle East. The two other major fuels used are LNG, which is mostly bought from South East Asia and Australia, and coal coming from Australia. Japan has a CO_2 emission cut target of 25% which is to be met by 2020. Japan proceeded to energy diversification by shifting away from fossil fuels and relying more on nuclear and renewable energies. Although fuels still needed to be imported to meet the demand, nuclear power led to better energy security at the same time it contributed to the reduction of GHG emission reduction. Nuclear energy provided up to one fourth of the electricity prior to March 2011 while the share of renewable sources slowly grew. In this context, the first Smart City projects were initiated in late 2009, as high tech urban demonstrators of advanced quality of life. Pilot projects sponsored by the METI and other pilots privately funded were inaugurated. The interest in smart grids sparked by the 2009 Green New Deal in the USA also stimulated the METI to invest in such projects.

Post the nuclear disaster in Fukushima Daiichi, Japan had become highly dependent on fossil fuel, boosting coal an LNG consumption. As a result in 2012, Japan had become the second biggest net importer of fossil fuel after China, and the fifth largest producer of CO_2 in the world.

The production, transmission and distribution of electricity until the Great East Japan Earthquake was competent enough that no radical reform was needed, particularly as the power companies disparate it, while after 3/11 it was clear that a thrust towards more efficiency and through energy sector freedom was necessary.

h Smart Grid in Japan

Japan is one of the foregoing country in the world going for smart grid technologies and strengthening the grid post the nuclear disaster of Fukushima. Also it has ample of solar technologies, the need for promotion of energy saving for the general customers and also to strengthen the voltage system and stabilize it. Japan wants to deploy a low carbon society. Japan has to shift from efficient energy producing system to efficient energy usage system. It has to create a new energy system and shift from single directional to multi directional energy system. Japan is a world leader in smart grid technologies and it incurs huge investments in the smart grid technologies and was a undisputed leader in the 1990s.

After the 2011 Nuclear disaster, Japan has now focused on the reforming its energy policy and its basis lies on the pillar of energy security, environmental protection and energy sufficiency in the county. The concept of **Smart Community** has evolved in Japan with a few set of defined objectives and rules to be implemented in the country. This a smart clean technology action plan which covers the implementation of smart grid in the country. The definition best encompassing the different types of projects is provided by the Japan Smart Community Alliance (JSCA)

*"A **smart community** is a community where various next-generation technologies and advanced social systems are effectively integrated and utilized, including the efficient use of energy, utilization of heat and unused energy sources, improvement of local transportation systems and transformation of the everyday lives of citizens."*

Also, a means of comparison, the latest report produced by the European Parliament on Smart City projects in Europe proposes this definition: *"A smart city is a city seeking to address public issues via Information and Communication Technology (ICT)-based solutions on the basis of a multi stakeholder, municipality based partnership".* All the smart communities' projects, all projects aim at the optimization of management in at least one of the six following areas: economy, environment, government, living, mobility and people.

Smart cities are a new style of city providing supportable growth and designed to encourage healthy economic activities that diminish the burden on the environment while cultivating the

QOL (Quality of Life) of their residents. The lessening in the burden on the environment through activities as cutting back on CO2emissions, which is a global issue, is an extremely important prerequisite. The reason for promoting the establishment of smart cities lies here: in their bid to adopt recyclable energy sources through the use of solar power and wind power, etc. The ICT (Information and Communication Technology) provides smart cities with the technology to solve the emerging problems in an unprecedented scale. It is actually a quest to bring about innovation in the lifestyle of people. The widespread distribution of electric vehicles (EV) that can be recharged by each individual home and the batteries of which can be used to supply electricity in emergencies is one of the modern technological advancement. The development of smart communities have now actually become a tool for energy management in Japan. The central government is the main actor for the Japanese smart grid projects, along with METI.

The Smart Grid technology consists mainly of smart metering, electric vehicles (EVs), renewable energy devices. Urban-scaled management systems have been established. The Community Energy Management System is completed by three other types of Energy Management System (EMS): House EMS (for residential premises), Building EMS for business and offices and Factory EMS. There are many Smart Grid projects in Japan, but four of them have a definite urban approach that aims not only at green mobility but at an improvement of the energy management at all levels of the urban scale: transportation but also residence and office energy cause large CO2 emissions. The four projects are in **Yokohama, Kitakyushu, Keihanna Science City and Toyota City (home of Toyota motors)**, all of which are technological clusters gathering major Japanese companies like Panasonic, Mistubishi, Toyota, and Toshiba. The four projects are not advertised as purely Smart Grids but are called Smart Cities within which different green urban initiatives are taking place.

The following table gives an overview of the pilot project details in Japan :

Table 5: Test Project Details of Japanese Smart Grid Implementation

PROJECT	TARGETED POPULATION	BUDGET (BILLION ¥)	TECHNOLOGY	TARGETS	MAIN COMPANIES
Keihanna Eco City (Kyoto, Ohara and Nara prefectures)	102024 people	13.5 (€97.6 million)	EMS, Power DR, EV	-20% CO2 emission in households by 2030. -40% CO2 emissions in transport and 1000 houses with PV	Fuji Electric, Furukawa Battery, Mitsubishi, Osaka Gas and Sharp
Kitakyushu Smart Community (Fukuoka prefecture)	225 households	16.3 (€117.9 million)	PV, wind power, heat energy hydrogen, EMS, EV, data centre	-50% CO2 emissions in household, residential & transport by 2030 10% of production = new energy Smart	Azbil, Fuji Electric, IBM Japan, JX Nippon Oil & Energy, Mitsubishi Heavy Industry, Sharp, Toyota Group

				meters for 70 firms and 200 households	
Toyota Low Carbon Society (Aichi prefecture)	227 households	22.72 (€164.3 million)	PV, biomass, EMS, EV & ITS	-20% CO_2 emissions in households -40% CO_2 emissions in transport 3,100 EV	Chubu Electric, Fujitsu, Hitachi, HP Japan, Mitsubishi, Sharp, Toshiba, Toyota Group
Yokohama Smart City (Kanagawa prefecture)	4,000 households	74 (€535.1 million)	PV, storage batteries, EMS, EV	-30% CO_2 emissions by 2025 (to 2004 levels) 27,000 kW PV 2,000 EV	Accenture, Hitachi, Mitsubishi Estate, Nissan Motor, Panasonic, Sharp, TEPCO, Toshiba

i Yokohama- Smart Grid Project

As one of the largest cities in Japan, Yokohama aims to build the ”Next Generation Energy Infrastructure and Social System” that maximizes CO2 reduction in the forefront of innovation. Yokohama has the ambitious vision of reducing the CO2 by 30% by 2025. The aim of the Yokohama Smart City Project is to build a low-carbon society in a big city, involving 4,000 smart houses. This project is a five-year pilot program. It focuses on the development of the EMS, which integrates the home EMS, the building EMS, and EVs. It is expected to generate

PVs with a capacity of 27,000 KW. The EMS, which integrates suburban, urban, and apartment areas, will have PV use of heat and unused energy. There were 900 units of PV systems installed in the so-called progressive city of Yokohama in 2009, and the Japanese government plans to install about 2,000 more ten years

Background lies on the following facts:

- Increasing need for Energy Security
- Economic Development (Green Innovation)
- Cities as center of CO2 emission
- To develop an environmentally friendly city

Diverse three areas of Yokohama are:

Table 6: Area of Smart Community in YOKOHAMA

AREAS-LOCATION	CHARACTERISTICS
Urban- Minatomirai 21 Area	• Highly developed urban center • High-rise office buildings, international convention center
Residential- Kohoku New Town	• 60s development zone designed to address Yokohama's housing demand • Suburban commuter zone with low-rises and shopping centers
Industrial- Yokohama Green Valley	• Industrial redevelopment area on reclaimed land • Home to Yokohama's local small to medium sized factories, amusement parks and housing complexes

The Yokohama Smart City Project (YSCP) is an determination to develop a model for smart cities by virtue of cooperation between citizens, private companies and the municipality, and to export the successful model to Japan and the rest of the world. Large-scale operational experiments are being carried on with Yokohama, a large, advanced city with a diverse topographical range of districts. Purpose of the project is to renovate a city already provided with social infrastructure into a low carbon city while maintaining the comfort of its residents.
Two housing complexes, one apartment complex, 83 houses are involved in the operational procedure for technology verifications, 4,000 houses and apartments for social verifications.
As for the workplaces, 4 office buildings, 2 commercial buildings, 1 large-scale factory are used, whereas the number of EV (Electric Vehicles) amounts to 50.

The main operational themes that will be employed in the project are :

- PV (Photo Voltaic) Generation
- Storage Batteries
- CEMS (Community Energy Management Systems)
- HEMS (Home EMS)
- BEMS (Building EMS)
- FEMS (Factory EMS)
- EV (Electric Vehicles)
- Charging Infrastructure
- SCADA (Supervisory Control And Data Acquisition)

A confirmation experiment involving the integrated management of many BEMS (Building Energy Management Systems) was started as a part of the Yokohama Smart City Project(YSCP) in January 2013. This indicates Japan's first ever attempt to experiment with integrated BEMS that linkage large scale buildings together. The targets of the integrated BEMS is commercial facilities and large scale factories located in residential areas. With this aim, both PV generation sources and storage batteries have been installed close to the facilities, so that mixtures of electricity from the power grid (commercial electricity) and distributable power sources maintain optimal levels of energy operation. Important Japanese companies are participating in the project, which are involved in the development of BEMS and FEMS, respectively.

In addition to such preliminary results related to technology developments, in a residential home exhibition plaza (“Housing Plaza Yokohama”) a second part of the YSCP-related project is taking place, with Such houses are being equipped with the most advanced technological concepts of energy saving and optimal energy efficiency in heating, air conditioning, lighting, etc., in addition to solar power electricity generating systems, storage batteries and EV recharging stands. All of this will pivot on electrical power control devices known as smart power units. The system is equipped with an automatic function to shift peak consumption times on the power grid by operating the connected loads in coordination. The Yokohama Smart cells which are 80 eccentric model houses are created with an aim to have houses of the same model like the same plant cells. The widespread installations of HEMS in normal households, which city of YOKOHAMA is placing most emphasis on goes for high **energy saving** methodologies. This is the nation’s largest program for social implementation.

j Opportunities and Conclusion

Post Japanese earthquake and tsunami disaster in March, 2011, Japan has reformed its national energy policy based on the columns of energy security, environmental protection and efficient supply. So, smart grids and clean technologies are a way to achieve Japan goals. Constructing a more energy-efficient environment, less vulnerable to natural disaster, is a crucial target for Japan. With its great endeavor to create a new society, Japan has designed a grand picture where different aspects of human life could be recreated in a smart grid and green environment by utilizing clean technologies. This integrated environment for human living is being designed in a inclusive action plan called Smart Community. There are a wide range of Japan and global initiatives on various projects on smart grid. Several South East Asian countries as well as China and India are now working meticulously with Japanese partners. Japan projected to install smart meters on every commercial, industrial and residential building by the early 2020s.

Opportunities:

- Japanese conglomerates are investing in U.S. and other international projects to gain implementation experience, and to create a competitive advantage for them in their enormous home market. The sheer scale of investment is creating a huge appetite for supply.

- There are several key drivers that influences and pace up the growth of the Japanese market in Smart Grid, which is already a world class successful model in smart grid globally: reduction in the Power Outages and getting the energy efficiency goals, technological leadership, have a vision for social change, Increase use of renewables, broader infrastructure for EV, getting energy efficiency by reducing peak loads by shifting the peak hours.
- To remain a world leader in smart grid, Japan will be investing in order to achieve electricity modernization over the next few years, as its transmission and generation infrastructure is already modern as compared to India or many others so the major share will go to smart grid and new technology.
- A new type of power transmission network is of the highest demand in the sector today, modern implementation of network functionalities to reduce losses in the system and to have peak load management and apt outage management system. This is a huge opportunity for power transmission suppliers, manufacturers, IT Consultants and Smart Grid Integrators alike to invest in the Japanese market as well as global.
- The smart grid development will accelerate the EV market and infrastructure specially in Japan which has a motive of reduction of carbon emission and go for cleaner energy sources.
- Japan with a strong basis in electricity generation and distribution, will invest heavily in smart meters and Smart Grid over the next 20 years. Then, the smart meter market will drive investment in other smart solutions, e.g. smart homes and communities, distributed generation, EV infrastructure, renewables, communications infrastructure, IT applications and HEMS which will drive the market globally.
- With its vision of smart homes, cities and communities, smart appliances for pilot Smart Grid creativities will come out of Japan to global platform. With a technologically-advanced and change-receptive middle class, Japan is one of the most rapidly growing smart appliance market in the world. Companies should craft strategies to capitalize on the household smart appliance market in Japan. Toshiba, Panasonic and Hitachi, for example, are already actively involved in interactive, attractive, and smart consumer electronics and appliances

xix. The Netherlands

k The Dutch Electricity Sector

The Netherlands is a major European gas producer and infrastructure hub. It is the second largest producer of natural gas and a significant producer. Its dependence on external energy supply is about 35%, oil accounting for 80% of the imports and solid fuels for 17%. Electricity is mainly produced from gas (65.5%) and solid fuels (19.1%). The use of renewable energy sources is growing but it is less important in the energy mix. Installed capacity has amplified in recent years, and the Netherlands has moved from being reliant on electricity imports to meet generation adequacy standards to having a capacity surplus. The power sector is considered by a opened market with reasonable market concentration. The generation mix is controlled by natural gas and coal. Renewable power made up only 4.2 percent of consumption in 2011; however, the Netherlands has set the goal for 14 percent of energy consumption to come from renewables (including transport) by 2020. The Dutch government has a number of policies and regulations for the de carbonization. The Green Deal programme, introduced in 2011, aims to identify and support sustainable projects, including in the power sector. The Green Deal programme, introduced in 2011, aims to identify and support sustainable projects, including in the power sector.

Between now and 2020, 9 GW of coal and gas fired generation are expected to come online. Interconnection capacity is expected to grow from 5.2 GW in 2013 to 8.1 GW in 2020. Several more transmission projects are planned to reinforce the grid due to increased domestic supply and imports, particularly from northern Germany. The total population of Netherlands is 16.8 billion according to 2013 report and total electricity consumption is 118.6 GW (2012).

Regulation:

The Authority for Consumers and Markets (ACM) is responsible for ensuring efficient operation of the electricity sector and for consumer protection in the Netherlands. The ACM is responsible for ensuring compliance with the Electricity and Gas Acts, and sets transmission and supply tariffs. The ACM also monitors prices for consumers in order to ensure consumer protection. It is also active in regional initiatives relating to framework guidelines, network codes, and market development. The Ministry of Economic Affairs is responsible for formulating energy policy in the Netherlands. This sets forth the renewable energy policy.

The following table gives an overview of the various Dutch companies associated with generation, transmission and distribution sector of the country. These are:

Table 7: Market Share of Dutch Electricity Companies

SECTOR	LEADING COMPANIES	COMBINED MARKET SHARE	REMAINING COMPANIES
Transmission	TenneT	100%	None
Distribution (8 total)	Liander Stedin Enexis	>90%	Rendo, Cogas, Westland Infra, Delta, Endinet, 30000-210000 customers base
Generation (25 total)	Essent, E.ON, Elecrabel, Nuon	75%	Intergen, Delta, Horticulture sector, industry sector, others
Retail(35 total)	Nuon, Essent, Eneco (Stedin)	80%	Electrabel, Greenchoice, NEM, Oxxio and others

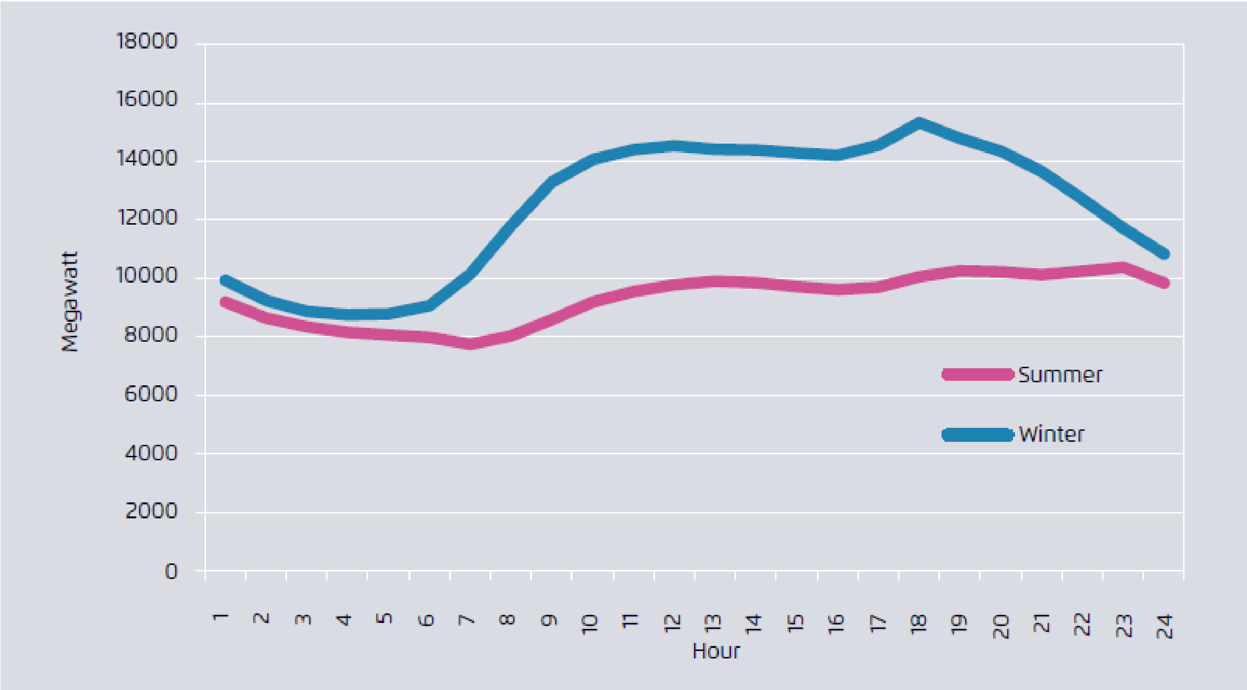
Installed Capacity:

The Netherlands has approximately 31.25 GW of installed capacity. The power mix is dominated by natural gas, followed by hard coal and wind. Approximately one third of total installed thermal capacity is co-generation capacity. There is very little nuclear and solar capacity.

Peak Demand:

The peak demand occurs in the winter period when industrial/ commercial and lighting loads overlap at around 18.00 hrs. There is not a particularly strong season-related component, with a maximum/minimum demand ratio (ratio between winter peak and summer minimum demand) of around 200 percent. Fluctuations in electricity consumption mostly occur throughout the day. The focused peak demand of Netherland up till 2020 is going up to 20.51 GW according to a national report on National Power Sector.

Figure 3: Netherlands- Typical summer and winter electrical demand profile (Source : (Edith Bayer, 2014))



A typical figure showing the fluctuation in load during summer and winter in Netherlands is presented above (Edith Bayer, 2014).

The total interconnected capacity tends to increase to 8.8 GW by 2020 and it is currently 5.9 GW. The significant interconnection capacity between the Netherlands and its neighbors has led to large volumes of imports and exports. The Dutch electricity market conforms to the typical liberalized West-European model with parties able to trade bilaterally via brokers using "over the counter" standard contracts, or via power exchange platforms such as the Amsterdam Power Exchange (APX).

In 2011, the industrial sector accounted for about 36 percent of all electricity consumed in the Netherlands, and the residential sector consumed about 62 percent of all electricity. The transport sector accounted for the remainder of electricity consumption. Supply tariffs are not regulated in the Netherlands. There is however a form of tariff surveillance with regard to the retail energy market. Suppliers are required to submit all tariff proposals to ACM, who will check the reasonableness of the proposals. ACM has the authority to regulate consumer prices if thought to be excessive, although this power has yet to be used.

De Carbonization:

Under the EU Emissions Trading System (ETS) Directive, the Netherlands is part of the EU-wide cap requiring covered sectors in the EU to cut GHG emissions 21 percent below 2005 levels by 2020. The Dutch climate mitigation strategy and long-term energy strategy are based on four areas of activity: reducing demand for energy, biomass, CCS, and CO2-free electricity (including nuclear). The Government aims to reduce dependence on fossil fuels while maintaining a strong energy sector that is both reliable and affordable to customers.

The recent National Energy Agreement for Sustainable Growth sets policy objectives and measures to achieve the Dutch energy and climate target in the context of the EU's 2020 goals (as well as some domestic targets for 2023). 10 basic components are listed in the Energy Agreement to, amongst others, reach a share of renewables in the energy mix of 16 percent by 2023, and achieve final energy savings of 1.5 percent p.a. Concrete renewables deployment targets comprise a wind onshore capacity of 6000 MW in 2020 and 4450 MW of wind offshore in 2023.

l Smart Grid in Netherland

In parallel to the liberalization of the energy market, concerns about dependency on foreign supplier, exhaustion of fossil fuels, and climate change led the Netherlands to pursue a transition approach for sustainable energy. The Netherlands was the first country to introduce in 1989 an all-inclusive national environmental policy plan that was structured along three main axes: emissions reduction, energy use and waste management. A second plan in 1993 and a third one in 1998 followed the first national plan. All these three policies were successful and they were giving positive side to sustainable development.

In 2007, based on the transition platforms recommendations, the Dutch government presented the white paper "New energy for the climate" which lays out the national climate policy framework.

This working program set four main targets:

- Reducing greenhouse gas emissions by 30% from the 1990 level by 2020
- Increasing the share of renewables in the energy mix by 20% by 2020
- Achieving annual energy efficiency improvements of 2% by 2020
- Making a big step in the transition towards a more sustainable energy system by 2020 (IEA, 2008).

To get an sustainable energy model the implementation of smart grid is of utmost importance. Energy transition is possible only by smart grid technology. For the period 2012-2016, the Dutch government has given a green deal with concrete goals:

- 10% reduction of the investment and operational costs of the reinforcement of the energy grids and of the costs for balancing power due to the integration of renewable energy sources.
- Lower the costs of energy consumption of 'Smart Grid consumers' by at least 5%.
- Cost reduction of Smart Grid technologies to increase market size, such as sensing and measurement devices and telecommunications to all levels of the Dutch electricity, gas and heat distribution grids.
- An increase in turnover of the participating Dutch companies in the Smart Grid market of at least 5 times the governmental funding in the 2012-2016 period.
- Further expansion and consolidation of the existing top-3 position in R&D in Europe with respect to Smart Grids.

m Amsterdam- Smart Grid Implementation

Amsterdam has laid the foundation for the development of smart grid technologies in the country. Basically it is a move towards attaining sustainable development of energy systems and reduction in the emission of CO2. At the start of the energy transition strategy it is emphasized to have focus on the following parameters:

- **Buildings:** Basically most of the energy consumed in the city is from the buildings in the city around 70% of the total electricity and heating, there local authority is promoting insulation and efficient building installations. From 2015 onwards, only climate-neutral buildings will be constructed in the city. From 2025, existing buildings must attain a minimum energy efficiency of label B.

- **Transport**: To ensure a developed and energy efficient transport facility, there is exclusion of the polluting lorries, and there is deployment of the metros and trams running on green energy and also the electric vehicles are introduced in the system. From 2015-2025, the city has given the goal of achieving the electric vehicles target of 40000.
- **Achieving a sustainable energy Port and Industry**: The port is one of the largest in the Europe for coal and transshipment. The goal is to transform it in to a sustainable port in the next 30 years, with shore power supplies, wind turbines and solar panels. Reduction of carbon by -40% CO_2 by 2025.
- **Sustainable Energy**: The city aims to develops its renewable Energy sources and also heating network supply. Also the implementation of Solar and Wind turbines. In 2025 the city wants to generate 25% of sustainable energy within the country boundary.

Amsterdam Smart City (ASC) Project:

The ASC is a collaborative project of the local government authorities, companies and knowledge institutions. ASC was initiated by Amsterdam city, ICT company, Liander and KPN (the leading telecommunications and ICT service provider of Netherlands). Basic aim was to increase renewable energy and reduce energy consumption. Among the different projects under ASC, Nieuw West smart Grid Project is among the best in the country.

n Nieuw West Smart Grid Implementation

Nieuw West has around 40000 homes and 130000 residents in total. It was announced a district after the second world war and now several modifications are done for the homes in these areas. The plan for the modification and restructuring of the houses were done by Amsterdam city with all the planning and funding coming from Amsterdam, the implementation was carried on with full vigor and there by the Nieuw West was formed with whole new expectation and also new methods of implementation. The operation was led by the municipality, in close cooperation with housing corporations and the city of Amsterdam.

In parallel, Nieuw West was also chosen by the grid operator **Liander** to become the first smart grid district in Amsterdam. Today, Liander's new smart grid serves 10,000 out of the existing 40,000 households and introduced smart meters to 225,000 households. This makes Nieuw West the neighborhood in Amsterdam with the highest dissemination of smart meters in Amsterdam.

The reason why the grid operator Liander selected Nieuw West as the area for the construction of the smart grid system were the deteriorating state of Nieuw West's infrastructure, which led to a high number of black-outs. Liander wanted eminently to reduce the peak load, and Nieuw West was the area to try to achieve it through the deployment of their smart grid concept. Nieuw West is one of the only areas in Amsterdam that still offers the possibility to expand and construct new buildings, especially since the municipality, in conjunction with housing corporations and the city of Amsterdam were carrying out the renovation plan in the district.

The New Smart Grid:

The grid system in Nieuw West has been fortified with computer and sensor technology at key nodules of the network to uninterruptedly monitor and control the grid and the voltage. Also, the existing network power has been amplified in key areas and the structure of the network bettered in order to make inactive power outages visible and thereby to prevent them. The risk of power catastrophes in this flexible, bi-directional, transparent system is lesser, but also Liander will be allowed to commit targeted maintenance and to resolve 70% of the problems in a much faster way. The intelligent electricity network also makes it possible to generate large-scale durable and decentralized energy and deliver it back to the grid. These functions were not available in the absence of smart grid.

The key components used in Liander' Smart Grid concept are:

- Continuous monitoring
- Intelligent substation
- Intelligent secondary Substation
- Flexible bidirectional grid
- Fiber optic telecom to all connections
- Smart metering in the homes that deliver vision into energy consumption

The Stackholders of the Nieuw West Project:

Table 8: The Nieuw West Stakeholders Benefits and Challenges

STAKEHOLDERS	STAKEHOLDER BENEFITS IN THE PROJECT	STAKHOLDER CHALLENGES IN THE PROJECT
Liander	The System can: • Match the supply and demand of electricity to reduce the peak load; • Avoid massive investment in the grid; • Allow for more capacity • Increase flexibility • Increase reliability • Reduce the number and length of outages; • Facilitate the growth of e-vehicles and heat pumps; • Facilitate the growth of wind and solar • Allows the reuse of 90% of medium voltage grid and 95% of low-voltage grid existing assets, making this concept also financially feasible	• Firstly, it needs to increase citizens acceptability to their network operations. • Citizens are concerned on their data privacy, or wary about the ultimate goal of energy industry actors or they don't consider that the new technological devices meet their needs. • The distributor operator still has today limited ability control on the grid losses emissions from electricity transmission and distribution. • high investments are still required to install replace all 10kV cables with 20kV cables. • Uncertainty of peak

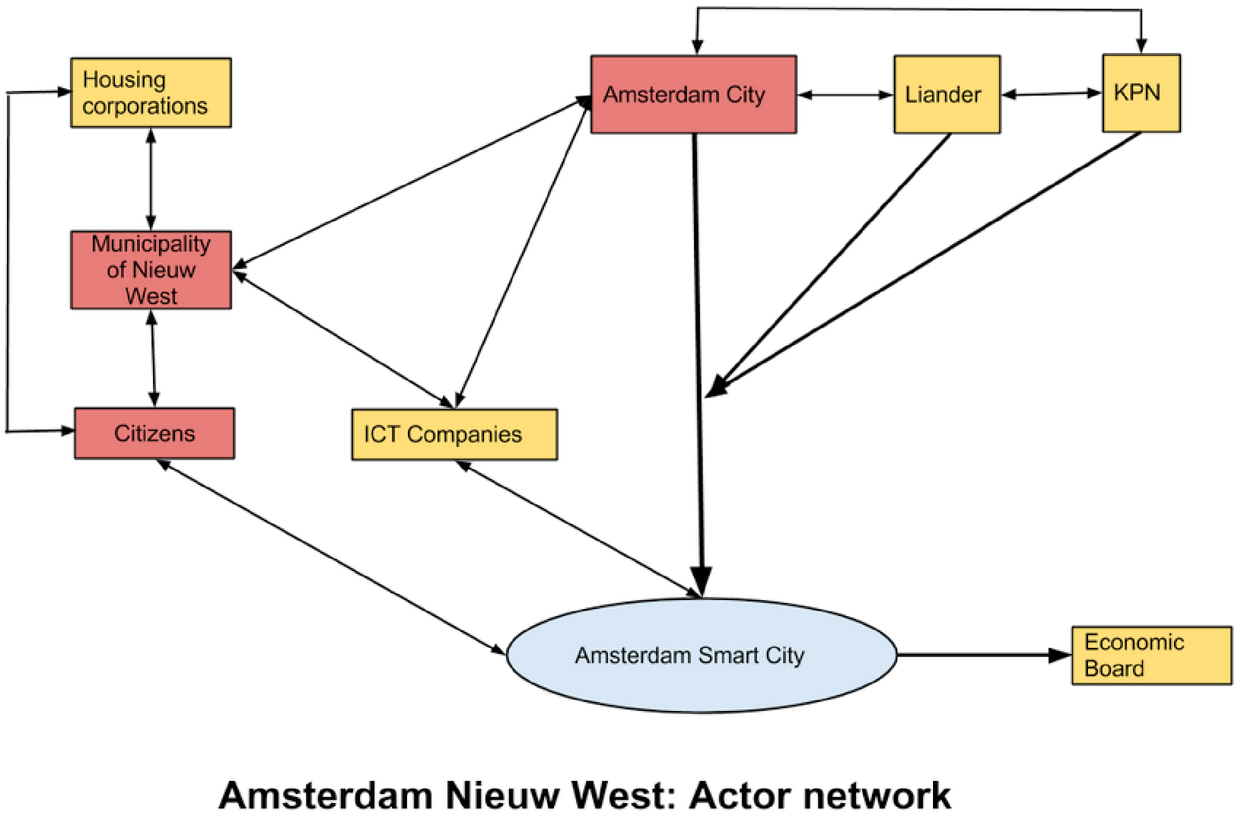
		load increase and evolve to control the peak load. • Higher cost of maintenance, expansion and renewal of grid.
Amsterdam City	• Reduces CO2 emission • Follows and Fosters the model of sustainable energy growth. • The city of Amsterdam uses the Amsterdam Smart City platform to attract business and promote projects. • Enhancement the development of the green energy an enhance the development of smart products and services.	• Amsterdam needs to make sure that companies and civil society actors not integrating the platform can also make their way into the platform. • standardization of the technological devices being created is crucial. • Easy integration of system and not become an isolated and private project.
Municipality of Nieuw West	• Reduction of energy consumption • The increasing attractiveness of the district, both for business and middle-income residents.	• To build Energy efficient buildings (climate neutral houses) and the area has one of the largest quotas of houses in Amsterdam in need to

		be refurbished. • To increase the potential of waste management. All new housing needs to be integrated to the housing grid, although with old housing this is not compulsory since there is no public funding for it. • Public transportation system, biking lanes, and electric vehicles • Encouraging smart grid project and attract business to invest here.
Housing Corporation	• Energy Improvement • Free market • House gets better conditions and labelling	• Following strict housing rules and regulation regarding energy in Netherlands • Insulation measures in old houses • Insufficient national funding • Higher rents/ tax/ prices
ICT Companies	• Peaking shaving • Blackout prevention • Reduced time to re-	• Lack of standard norms for the technological sector

	establish operation • Frequency and voltage control • Phase balancing • Customer Feedback • Market Potential	stand, every company creates its own model. • Companies developing their technologies to reduce consumer consumption but there needs to be taken care of the demand side as well when designing the technologies.
Citizens	• Better feedback of citizens on consumer-produced electricity • Reduce their consumption on energy. • Reduce Outages • Increase the flexibility to accommodate citizens increasing demand of electricity coming from their use of electrical vehicles and solar panels	• Data safety and privacy protection • Not taking customers feedback into account. • Full public participation

The main actors in the project- Nieuw West, Amsterdam City, Liander- Distribution network, ICT companies, Housing Corporations, Municipality Nieuw West, Citizens all need to maintain coordination and apt work behavior and support each other to get the project successful. Specially the citizens of the project needs to be equally involve from the start of the project. All the work are inter related and all the actors need to play their part.

Figure 4: Actor Network for the Amsterdam- Nieuw West Smart Grid Project (Source : (Badalova G. P., 2013)



The above diagram shows the interrelation of the different actors and the coordination that is required to carry on the task (Badalova, 2013).

Barriers and Proposition of the Amsterdam- Nieuw West Smart Grid Project-

Table 9: Barriers and Proposition for Amsterdam- Nieuw West Smart Grid Project

LEVEL	BARRIERS	PROPOSITION
STATE LEVEL	Funding- Despite state involvement and funding on energy policies, both local authorities and housing corporations argue that this funding is insufficient.	There should be proper and apt regulations and policies for the investment policies. The citizen should not be harassed to pay the extra money during such situation in place of state.
STATE LEVEL	Regulation- Contradiction and	The state should thus enlarge

	unavailability of policies and codes for old/existing building	policies on energy efficiency to effectively encompass existing buildings. Policies and tools should not be contradictory to existing building codes (especially for the refurbishment and installation of solar panels in old protected buildings). The regulatory frameworks for renewable energy storage should be clearly stipulated
CITY LEVEL	Integrated Institutionalization- Local Level implementation of project resulting in difficulty for outside and new actor to participate in the model and on-going work format. No practical knowledge of their interests and risks associated to the projects as not reflected	A well written formatted document with all the know how of the project and also including the risk and interest of the project should be there. A well-constructed training and induction program for the new members should be formulated.
CITY LEVEL	Standardization of Practices- The city of Amsterdam verifies that the different public charging poles for Electrical Vehicles being installed in the city are compatible models. However, there is no such correspondent action for the charging poles	This approach should be removed as early as possible, every policy should be drafted against any private action. The longer the wait for the standardization of models, the more costly will become to re-design the already Implemented models and the

	being implemented privately. Currently energy and ICT companies are developing their own models in the hope that their models will become the norm and that the rest with the need to adjust accordingly	less energy efficient it will be. There should be defined set of practices.
MUNICIPALITY LEVEL	Citizen's Involvement- Lack of share of knowledge with citizens and so they are indifferent about the new technologies. Also there is a gap between industry and citizens. The municipality acts as a mediator.	Citizen should be involved as they are a part of the important stakeholders. Citizens should be in direct contact with the industry and they should be familiar with the new technology, tariff, the industry etc.
MUNICIPALITY LEVEL	Smart Grid Community Based Model- If the community of the area considers that the energy transition is not going to be on their benefit, this will hinder the legitimacy of municipality efforts to reach a higher rate of smart grids. It will render ineffective the efforts made and make stakeholders to push for a new energy efficiency model.	The community based model can be accepted. the energy transition is going to be really profitable for the citizens residing in the area. The municipal authority can therefore play a role to shift the excess of focus on the production side to the demand/consumer side the smart grid project as a whole is implemented with a community-based approach, responding to the needs of the community as a whole

INDUSTRY LEVEL	Exploring Citizen's Need- in Nieuw West in particular, the penetration of energy intelligent devices is low because citizens do not rely on them or do not find them as useful as the industrial actors do.	If they want citizens to accept the new technology and change their behavior accordingly, they need to incorporate citizens' needs and concerns. And they need to target not only early adaptors, but also those citizens for whom the measures will have a bigger impact.

- **Conclusion**

State Involvement in the project-

Leading the Change – The shifting of the energy policy of Netherlands to get to reduce energy consumption and diversify supply is a successful model of implementing smart grid. The various changes affecting the energy system and infrastructure have led the state to put emphasis on Smart Grid.

Merging of Efforts – Increasing use of renewables to green buildings to achieving energy efficient system.

Modes of Collaboration – State brought together all the different actors on the same platform with its designing tactics to stabilize an institutionalized and structured method of implementation.

Funding – For many matters, state funded in several occasions for project directed for energy efficiency.

Energy Stakeholders Engagement

The Dutch government integrated approach adopted since the 1990s, according to which the different stakeholders (and particularly the energy industry actors) were engaged in the negotiations and formulation of national energy strategies have also contributed to incorporate the different actors in the promotion of a new sustainable energy model, to voice their interests and concerns and thus, facilitate the signature of voluntary covenants with industry to energy consumption or reduce CO2 emissions. Within this logic, stakeholders were not simply seen as actors that needed to comply with regulation, but as actors that could solve the energy-related problems.

6. Findings and Analysis

From the perspective of implementation of smart grid in India, Seven (7) barriers have been discovered. These barriers have resulted in the holding back of implementation in India. They have reduced the investment in smart grid projects. These barriers are:-

- Policy and regulation
- Business Case
- Technological Maturity and Delivery Risk
- Lack of Awareness
- Access to affordable capital
- Skills and Knowledge
- Cyber Security and Data Privacy

xx. Solutions to Barrier for Smart Grid Implementation

The following are the **Solutions** to removing the barriers:

Table 10: Solutions to Barriers in India for Smart Grid Implementation

SOLUTION	DESCRIPTION
Forming Political and Economic Framework	A framework is to be formed which guard the investor from risk to attract more investment into smart grid and to get the result at a low cost at the customer level. A strong incentive model has to be formed to attract more private investors. The rate of return should be based on output produced. Rewards and Penalty measurement should be there for encouraging the utility for efficient performance.
Moving towards a Societal Value System	Movement from a utility centric investment decision to a societal level decision which gives wider scope for Smart Grid. This would help adaptation of Smart Grid Technology by

	society.
Achieving Greater Efficiency in Energy Delivery	Risk associated with smart grid is to be shared by all members of the value chain. While making the framework, the regulator should address how much risk utility can pass on to contractors, suppliers and customers. By having proper balance, incentives can be got. Reduction in losses, peak load demand. Incentives for low technical loss can be given.
Enabling Distributed Generation and Storage	Each household and business will be empowered to be a micro generator. Onsite photovoltaic panels and small-scale wind turbines are the major examples, developing resources involve of geothermal, biomass, hydrogen fuel cells, plug-in hybrid electric vehicles and batteries.
Increasing Awareness on Smart Grid	There is a need for the society and policy makers to understand the advantages and benefit of smart grid in the country. It promotes a low carbon society and built a more effective grid so it not be seen as a investment decision only but as a National Program.
Creating a fresh pool of skills and knowledge	Requirement of engineers and managers who are aware of the transmission and distribution network. Investment in T&D should be limited.
Addressing cyber Security and Data Privacy	Threat of cyber-attack on the grid should be looked into as the consumers consumption data can be misused by the utilities or third party. Customer information should be handled by authorized personal.

xxi. Learning from South Korea- JEJU Island Smart Grid Model

1. **Strong Regulation and Policy Framework**
    - The South Korean legislature approved the "**Smart Grid Stimulus Law**" which gives the outline for the sustainability of smart grid projects and also a play for development of Smart Grid.
    - In 2011, the **"Smart Grid Promotion Act"** was passed which gives ideas for development, deployment and commercialisation of Smart Grid.
    - Technology and Business Model driven policy – power infrastructure and created additional services.
    - High Incentives for smart grid implementation
2. **JEJU Island Smart Strategic Business Model**
    - The area of implementation is identified and it is divided into five sectors. The project has five different strategic practice fields- Smart Place, Smart Transport, Smart Renewable, Smart Power Grid, Smart Electric Service Deployment.
    - The model is an integrated technological business and export model, which can enhance the country's GDP growth and energy security
    - EV charging infrastructure development and also minimise effects on the charging on grid.- Smart Transport.
    - Smart Renewable power technology - which provides stability to irregular power generation of wind and solar
    - The integration of micro grids with solar power is one of the core focus items of the Smart Place practice
3. **High Investment Model**
    - Open to foreign companies for investments, 168 countries participated.
    - Close coordination of public and private sector has given rise to high investment. Foreign and local private companies have participated equally. Like, Hyundai Motors, GS Caltex- for EV charging, SK Telecom, Korea Telecom, LG, and KEPCO for AMI.
    - The Korean Smart Grid Association plays a critical role as a successful mediator between government and private sector stakeholders.

4. **Other Reasons**
   - Open Grid Structure
   - Implementation of AMI & DMS- Establishment of AMI Functional program
   - Good Demand Side Model
   - Wide collection of test categories, which range from AMI to renewable energy to EVs.
   - Positive market environment - In terms of the technological and manufacturing competitiveness of Korean market players.
   - Technology leadership in the IT and communications space.

xxii. Learning From Japan-Yokohama Smart Community Model

1. **Policy and Framework**
   - New Energy Policy is formed in Japan, post the Fukushima Daiichi Nuclear disaster based on Smart Grid implementation in the country.
   - The interest in smart grids sparked by the 2009 Green New Deal in the USA also stimulated the METI to invest in such projects
2. **Successful model of Implementation**
   - Implementation of smart community models- The Community Energy Management System is completed by three other types of Energy Management System (EMS): House EMS (for residential premises), Building EMS for business and offices and Factory EMS.
   - Implementation of Information and Communication Technology (ICT)-based solutions on the basis of a multi stakeholder, municipality based partnership
   - Adopting model of Recyclable energy sources through the use of solar power and wind power.
3. **Technological Advancement**
   - The widespread distribution of electric vehicles (EV) that can be recharged by each individual home and the batteries of which can be used to supply electricity in emergencies is one of the modern technological model for advancement.

- Low-carbon society model in a big urban city, involving 4,000 smart houses- It focuses on the development of the EMS, which integrates the home EMS, the building EMS, and EVs. The EMS, which integrates suburban, urban, and apartment areas, will have PV use of heat and unused energy.
- Integration of BEMS that linkage large scale buildings together- The targets of the integrated BEMS is commercial facilities and large scale factories located in residential areas. With this aim, both PV generation sources and storage batteries have been installed close to the facilities, so that combinations of electricity from the power grid (commercial electricity) and distributable power sources maintain optimal levels of energy operation.
- Creation of "ultimate smart houses".- for urban society, "Housing Plaza Yokohama" equipped with the most advanced technological concepts of energy saving and optimal energy efficiency in heating, air conditioning, lighting, etc., in addition to solar power electricity generating systems, storage batteries and EV recharging stands.
- Implementation of Smart Power Units- which is equipped with an automatic function to shift peak consumption times on the power grid by operating the connected loads in coordination..

4. **Huge Investments in Japan**
   - Huge Investments from METI and private players in the sector. And there is immense coordination between the two. Participation of private companies like major Japanese companies like Panasonic, Mistubishi, Toyota, and Toshiba - green urban initiatives are taking place
   - Invest heavily in smart meters and Smart Grid - . Then, the smart meter market will drive investment in other smart solutions, e.g. smart homes and communities, distributed generation, EV infrastructure, renewables, communications infrastructure, IT applications and HEMS which will drive the market globally.
   - Huge investment on Modernization of distribution and transmission network- This is a huge opportunity for power transmission suppliers, manufacturers, IT Consultants and Smart Grid Integrators alike to invest in the Japanese market as well as global.

- Japanese conglomerates are investing in U.S. and other international projects to gain implementation experience, and to create a competitive advantage for them in their enormous home market. The sheer scale of investment is creating a huge appetite for supply.
- Companies craft strategic investments to capitalize on the household smart appliance market in Japan. Toshiba, Panasonic and Hitachi, for example, are already actively involved in interactive, attractive, and smart consumer electronics and appliances.

xxiii. Learning From Amsterdam - Nieuw West Smart Grid Model

1. Regulatory and Policy Framework

- The Green Deal programme, introduced in 2011, aims to identify and support sustainable projects in the power sector. EU to cut GHG emissions 21 percent below 2005 levels by 2020.
- The recent National Energy Agreement for Sustainable Growth sets policy objectives and measures to achieve the Dutch energy and climate target in the context of the EU's 2020 goals.
- In 2007, based on the transition platforms recommendations, the Dutch government presented the white paper "New energy for the climate" which lays out the national climate policy framework. (Refer Annexure 1)
- Dutch government has given a green deal with concrete goals. (Refer Annexure 1)

2. Successful Model of Amsterdam-Nieuw West

- Nieuw West is one of the only areas in Amsterdam that still offers the possibility to expand and construct new buildings, especially since the municipality, in conjunction with housing corporations and the city of Amsterdam were carrying out the renovation plan in the district. This gives deployment of smart grid in the area.
- Collaboration of different stakeholders successfully- ASC is a collaborative project of the local government authorities, companies and knowledge institutions. ASC was initiated by Amsterdam city, ICT company, Liander and KPN (the leading telecommunications and ICT service provider of Netherlands.
- Investments were high.

- The city of Amsterdam uses the Amsterdam Smart City platform to attract business and promote projects.

3. **Technological Advancement**
   - The grid system in Nieuw West has been fortified with computer and sensor technology at key nodules of the network to uninterruptedly monitor and control the grid and the voltage
   - The existing network power has been amplified in key areas and the structure of the network bettered in order to make inactive power outages visible and thereby to prevent them.
   - The risk of power catastrophes in this flexible, bi-directional, transparent system is lesser
   - The intelligent electricity network also makes it possible to generate large-scale durable and decentralized energy and deliver it back to the grid
   - Key components in the smart grid concept are Continuous monitoring, Intelligent substation, Intelligent secondary Substation, Flexible bidirectional grid, Fiber optic telecom to all connections, Smart metering in the homes that deliver vision into energy consumption.

7. Further Scope of Study

- To study about the Challenges and Barriers that are faced by the 14 pilot projects in India individually and the state-wise analysis of the projects fulfilment and success rate.
- To find out solutions to the barriers and challenges of each project.
- To find out the places for successful implementation in India based on the model of JEJU Island Smart Grid, Yokohama Smart Community and Amsterdam – NIEUW West.

8. Conclusion

India with a population of over a billion and a GDP growth of 8% is one of the fastest growing economy in the world. With the robust economic growth, India still lags in term of electricity access to all in the country. Around 40% of the people of rural India are without power today The next Generation automation of power grid is of utmost importance in Indian Power System. It is the need of the hour to meet the rising demand of the different sectors in India- industry, domestic, commercial, agriculture, transport etc. But India faces a lot of challenges in adopting a smart grid technology nationwide. But by accessing the market demand, it is a way forward to move towards smart grid technology at full vigour and implement a National Plan for its full-fledged implementation.

India is a developing nation and it faces several challenges in the network, smart grid is a way to get id of many such problems. Also smart grid encourages renewable technology in the country. Smart grid basically manages the problems of intermittency associated with renewable energy like the sun or wind can happen only at certain time of the day and it enhances distributed generation. It is of utmost necessity to change the design of the grid to a better tomorrow. India faces several other problems and needs smart grid to overcome them. Stopping of power theft, Higher quality and reliability of power, Modified grid structure, outage management, peak load management. India has now started implementing ADMS (Advance Distribution Management System) and AMI (Advance Metering Infrastructure).

To conclude, Smart Grids would be a way to avoid power shortages in the country, it has the capacity to automatically detect a fault in the supply line and thereby reinstates power to all the affected areas. In short, smart grid is the way to allow Indian power sector to flourish without power cuts, wear and tear of network system and old electric distribution and transmission network.

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10. Annexures

xxiv. Annexure 1 : Smart Grid Policy in Netherland

In 2007, based on the transition platforms recommendations, the Dutch government presented the white paper **"New energy for the climate**" which lays out the national climate policy framework.

- This working program set four main targets:
- Reducing greenhouse gas emissions by 30% from the 1990 level by 2020
- Increasing the share of renewables in the energy mix by 20% by 2020
- Achieving annual energy efficiency improvements of 2% by 2020
- Making a big step in the transition towards a more sustainable energy system by 2020 (IEA, 2008).

Green Deal Policy

To get an sustainable energy model the implementation of smart grid is of utmost importance. Energy transition is possible only by smart grid technology. For the period 2012-2016, the Dutch government has given a **green deal** with concrete goals:

- 10% reduction of the investment and operational costs of the reinforcement of the energy grids and of the costs for balancing power due to the integration of renewable energy sources.
- Lower the costs of energy consumption of 'Smart Grid consumers' by at least 5%.
- Cost reduction of Smart Grid technologies to increase market size, such as sensing and measurement devices and telecommunications to all levels of the Dutch electricity, gas and heat distribution grids.
- An increase in turnover of the participating Dutch companies in the Smart Grid market of at least 5 times the governmental funding in the 2012-2016 period.
- Further expansion and consolidation of the existing top-3 position in R&D in Europe with respect to Smart Grids.

xxv. Annexure 2 : Current Status of Smart Grid Projects in India

Table 11: Smart Grid Pilot Project in India- Current Status

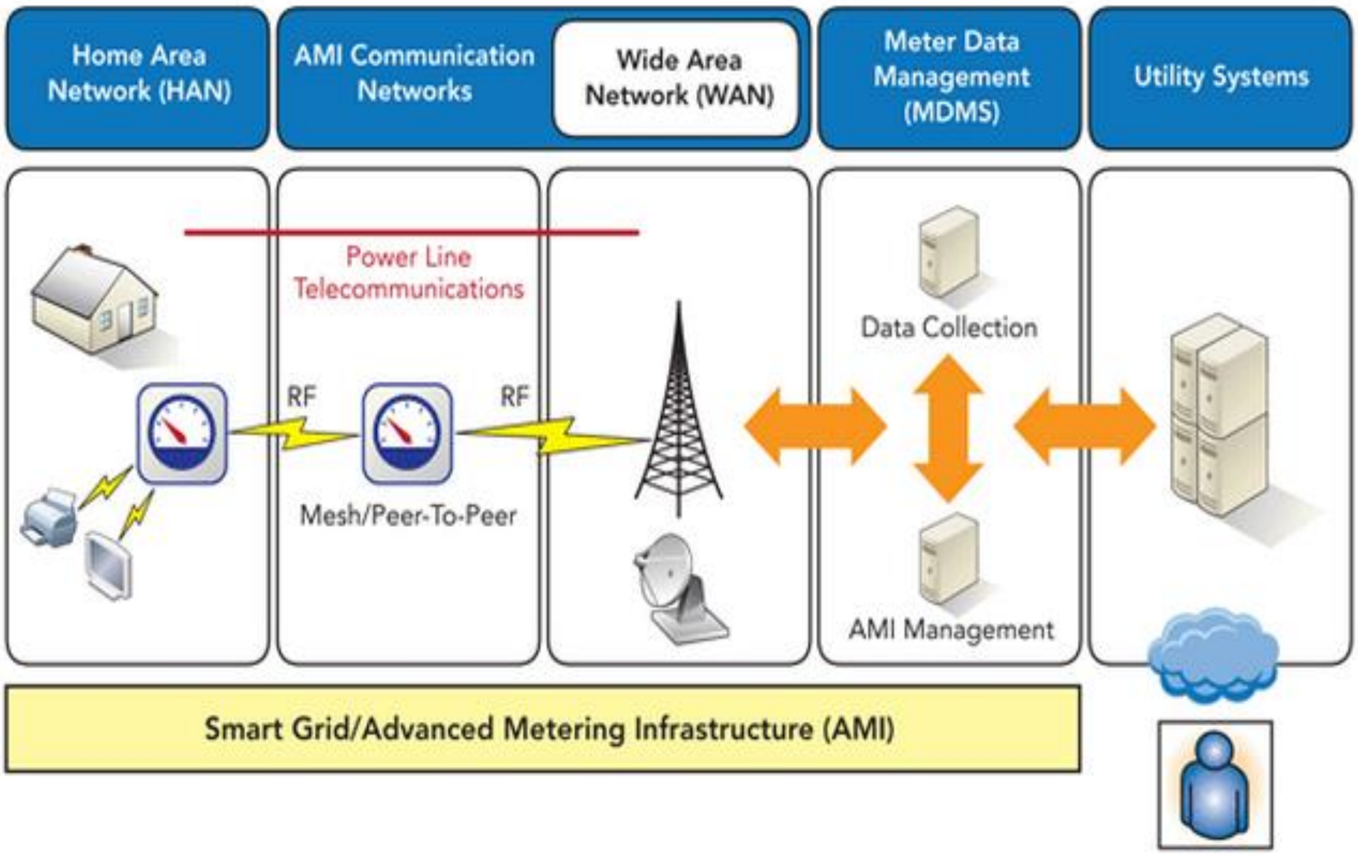
PROJECT	PROJECT STATUS
Assam	M/s Phoenix IT Solutions, an ISGF member (in consortium with Securo, Kepco and Nuri Telecom), is the successful bidder. Contract signing and kick-off meeting scheduled end of March 2015.
Chhattisgarh	Larsen & Tubro Limited and AMITech (India) Pvt. Ltd. Put up proof of Concept (POC) demos. Price bids were opened on Feb 28 2015 and put up to management for approval.
Gujarat	Price bids opened on Dec 10 2014, L1 price 69.54% higher than the sanctioned cost. Steering Committee convened for revision of Smart Grid Pilot Project cost for UGVCL from Rs. 48.78 Cr (MOP share of Rs 24.39 Cr) to Rs. 82.70 Cr (MOP share of 41.35 crore approved). Internal approvals for UGVCL share is under Process
Haryana	Project is executed under a grant from NEDO, Japan. NEDO has completed the feasibility studies and the report has been approved by UHBVN and MOP. NEDO has awarded the contract for detailed engineering and project implementation to a consortium of Japanese companies led by Fuji Electric. The project work started on Dec 4 2014.

Himachal Pradesh	Project awarded to M/s Alstom T&D India (L1) on Feb 28 2015 for Rs. 19.45 Crores.
Karnataka (Mysore)	Project awarded on Apr 30 2014 to a Consortium led by Enzen Global Solutions Pvt Ltd. M/s Enzen has engaged M/s Cyan Technology for the AMI component of the project and rollout expected to start form June 2015.
Kerala	2 bids received in Mar'14 (L&T and EDMI), but the prices were much higher than sanctioned project cost. Pilot area has been restructured to the R-APDRP towns (8 nos.) and revised DPR submitted on Dec 31 2014 and approval of MOP (Ministry of Power) awaited. Retendering is proposed.
Maharashtra	Lowest bid price was much higher than the sanctioned project cost. Cancellation of the project is proposed by the utility. Decision is awaited from the MSEDCL Board.
Pondicherry	DPR being revised for consumers limiting to 34,000. NIT documents are under finalization.
Punjab	Price bids opened in Dec'14. M/s Kalkitech is the lowest bidder. BOD meeting held in Mar 2015.LOI by end of March 2015.
Rajasthan (Jaipur)	Project location has been changed. Consultant to prepare documents.
Telangana	Technical evaluation is under progress by CPRI. CPRI to hold a meeting with bidders on the clarifications submitted by the bidders. Award likely in Apr 2015 .

Tripura	Price bids opened on Dec 27 2014. L1 bidder is Wipro. Since bid price was 3.5 times higher than sanctioned project cost, proposal has been submitted requesting complete funding from Ministry of Power. Decision awaited.
West Bengal	5 Bids received (Kalkitech, Chemtrol, TCS, JnJPowercom, Spanco). Two bidders (Kalkitech, Chemtrol) submitted price bids on Mar 18 2015. Under evaluation.

xxvi. Annexure 3 : Advanced Metering Infrastructure (AMI)

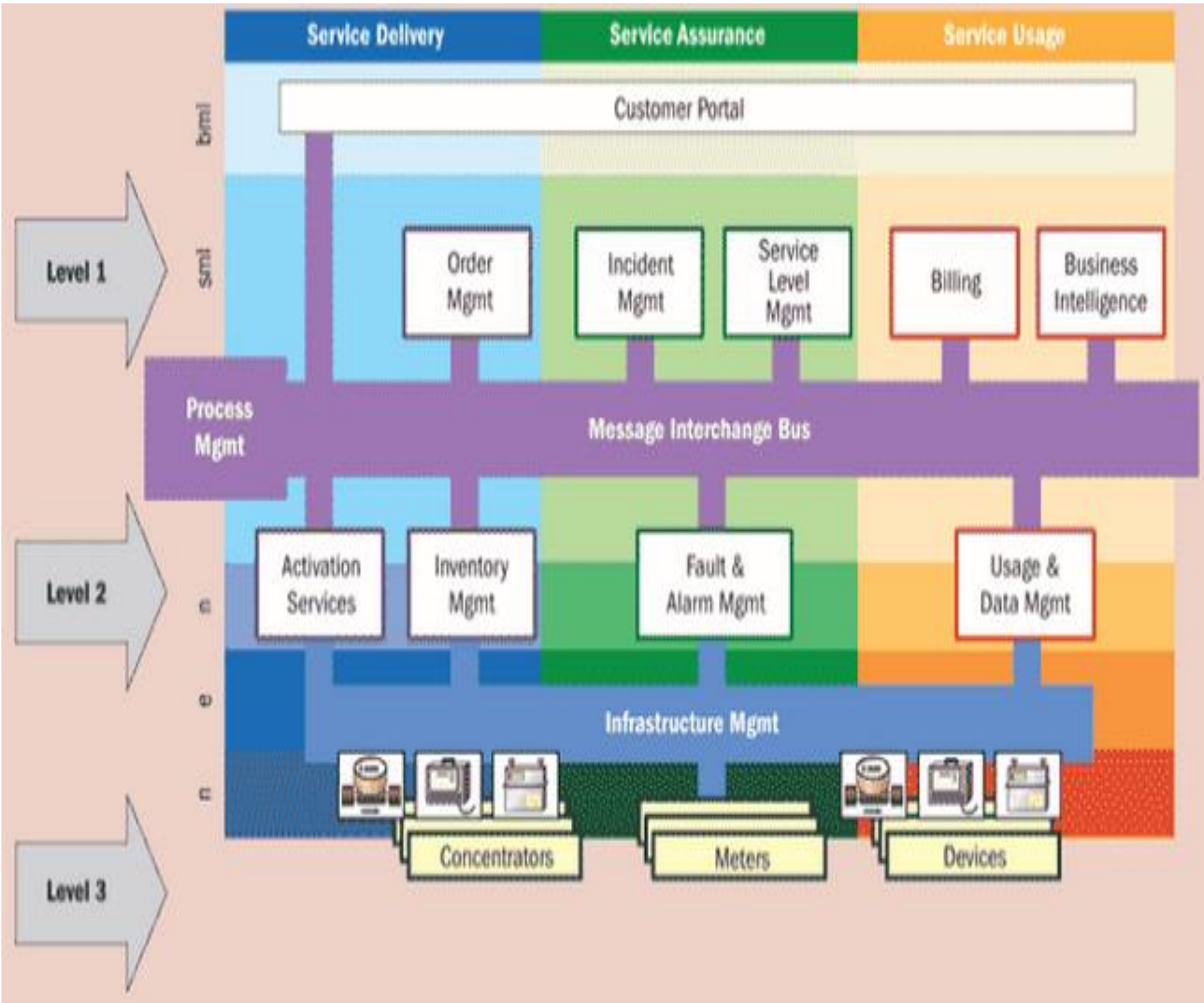
Figure 5: Advanced Meter Infrastructure (Source : Google.com)



The above figure shows an advanced metering infrastructure which is use in smart grid implementation for smart meters and it is an integrated system of smart meters and it has communication networks and also DMS (data management systems) that makes possible a two way communication between utilities and customers in the system.

xxvii. Annexure 4 : Service Oriented Architecture

Figure 6: Service Oriented Architecture SOA (Source : www.google.com)



The above diagram shows a Service Oriented Architecture where the application components gives services to other components and works on communication networks . It is independent of vendors, product or technology.