Smart Grid Components: Functionalities and Benefits

White Paper

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November 2021

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1 INTRODUCTION

The requirement of reliable and efficient electricity transmission and distribution systems is of greatest importance. Traditional electrical networks are generally centralized, comprised of a unidirectional grid which transmits electricity from centralized generation facilities via high voltage network, through the transmission and distribution systems, to the customer at medium or low voltage, with very little monitoring and only basic control along the way.

However, worldwide power utilities are advancing towards the next-generation grid which includes decentralized generation, the introduction of prosumers who both produce and consume electricity, changing traditional load patterns and advanced control systems which enable flexibility options such as Demand Side Management to reduce peak demand and alleviate network congestion. To enable the required functionality of the grid of the future it must incorporate system wide monitoring, automated control and 2-way communication technologies.

Electrical networks are moving from “supply follows load” to “load follows supply” operation.

For betting understanding the centralized vs. decentralized energy system is illustrated in the below Figure 1 Centralized and Decentralized Energy System

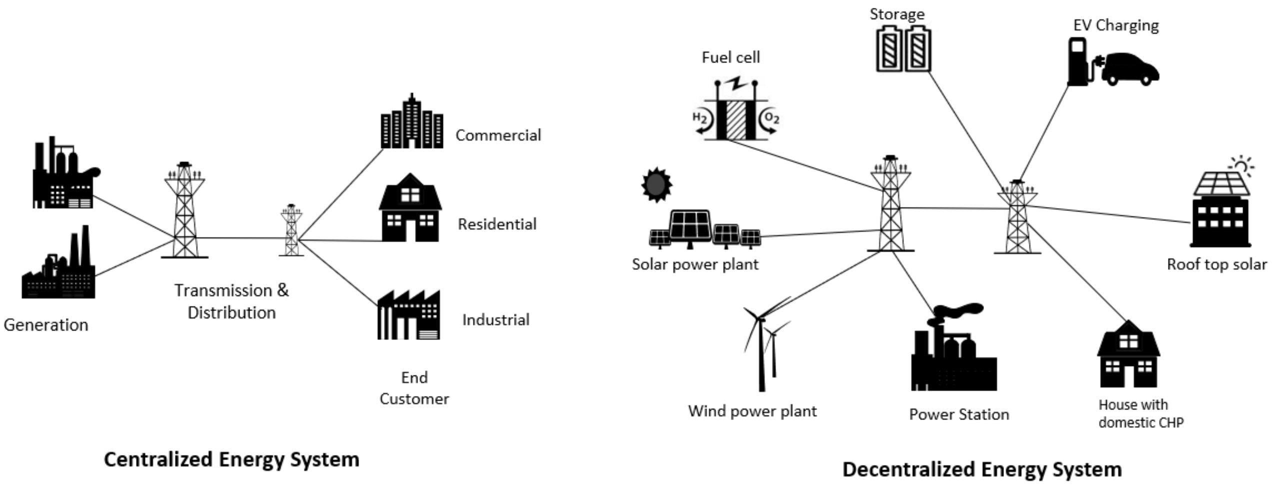


Figure 1 Centralized and Decentralized Energy System

Smart Grids are a key component of increasingly complex decentralized energy systems and energy systems of the future.

This is the first of three (3) white papers intended to help power utility companies, financing institutions and regional decision makers understand the various smart grid technologies, identify the current level of automation maturity of their local network and identify key business drivers for smart grid investments.

1) White Paper 1: Smart Grid Components - Functionalities and Benefits.
2) White Paper 2: Framework for assessing level of network automation maturity.
3) White Paper 3: Case Studies for next step smart grid investment road map.

This whitepaper” Smart Grid Components - Functionalities and Benefits”, describes the innovative technology components which could make up what is loosely called “smart grid” and maps the individual components to their functionalities/applications. In a second step, these functionalities are mapped to the resulting benefits. This assists in identifying which technology should be considered as next step investment given the local network conditions and the business case motivating the investment.

Smart Grid can play a significant role in both developed and developing countries, by offering improved monitoring, control, and communication to enhance system efficiency, reliability, transparency, energy utilization and minimizes the costs. [1] In general, a Smart Grid is an innovative infrastructure that improves generation, transmission and distribution systems with integrated information and communication systems.

The White Paper at hand is structured as follows:

- *Chapter 2* gives general definition and motivation of Smart Grid implementation
- *Chapter 3* maps the various component with their functionalities & functionalities onto their benefits
- *Chapter 4* provides annexure with keywords, abbreviation and references

2 SMART GRID

2.1 General Definition

The primary objective of implementing smart grids is to achieve a sustainable, secure and competitive energy supply, while maintaining safe, stable and efficient system in terms of cost and energy. There is no single universal definition of a smart grid but there are numerous definitions by various organizations. e.g., International Energy Agency (IEA), Institute of Electrical and Electronics Engineers (IEEE), International Electrotechnical Commission (IEC), European Commission (EC) etc.

Organization	Definition
SmartGrid.gov [2]	Smart Grid is a digital technology that allows two-way communication between utility and consumer. It represents an unprecedented opportunity to move the energy industry into a new era of reliability, availability, and efficiency that will contribute to our economic and environmental health.
IEEE [3]	Smart grid is a revolutionary undertaking-entailing new communications-and-control capability, energy sources, generation models and adherence to cross-jurisdictional regulatory structures
IEA [4]	Smart grid is an electricity network system that uses digital technology to monitor and manage the transport of electricity from all generation sources to meet the varying electricity demands of end-users.
EC [5]	A smart grid is defined in the TEN-E Regulation as an electricity network that can integrate in a cost-efficient manner the behavior and actions of all users connected to it, including generators, consumers and those that both generate and consume, in order to ensure an economically efficient and sustainable power system with low losses and high levels of quality, security of supply and safety.
IEC [6]	Smart Grid is a term which embraces an enhancement of the power grid to accommodate the immediate challenges of the near future and provides a vision for a future power system in the long term. Also, Smart Grid is an increased level of observability and controllability of a complex power system

Table 1 General Definitions of Smart Grid

In general, a Smart Grid is an electricity and communications network that allows two-way flow of data and electricity by integrating the next generation information and (intelligent) communication technologies which improves the level of observability and controllability of a complex power system thereby providing an efficient, reliable and sustainable power supply. Below Figure 2 Smart Grid - Intelligent Power Grid depicts the conceptualization of smart grid system.

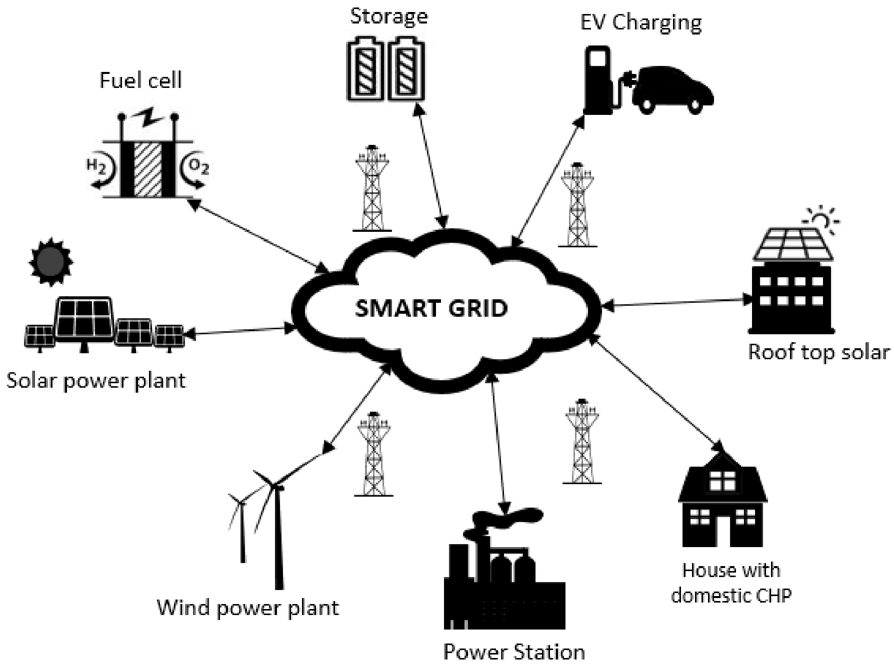
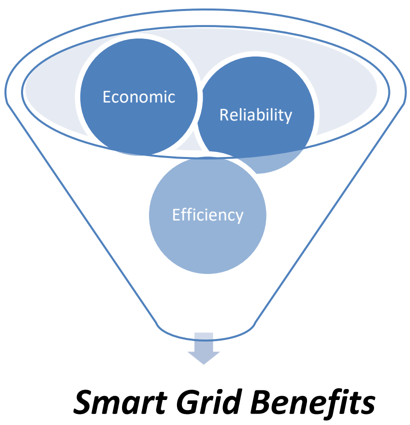


Figure 2 Smart Grid - Intelligent Power Grid

2.2 Why Smart Grids? – Motivation

A Smart Grid is a system composed of various sub-systems, it incorporates different communication and information technologies with controls and sensors to offer a wide range of benefits to both utilities and consumers. There are numerous motivations for smart grid implementation which apply for a variety of stakeholders including utilities, energy service companies, regulators, consumers, prosumers, and governments.



Security/ Reliability	Electricity security refers to the power system's ability to continuously fulfill its function considering possible adverse situations (of techno-economic, geo-political etc. nature). Reliability of the grid is related to its ability to deliver the required amount of electricity when and where it is needed. Integration of smart grid technologies such as Advanced Metering Infrastructure, Advanced Distribution Management Syste and automated fault location, isolation and restoration, improve grid reliability through automated response.
Economic	The economic feasibility of the grid is a function of the cost to implement and operate the network. Functionalities, such as demand side management,, substation automation and smart meters, enable the system to operate more efficiently and can prevent or delay investment requirements, thus providing econmic benefit.
Efficiency	Efficiency of the grid is related to the ability to serve the load in the most efficient and optimized way. Improved efficiency reduces the cost of producing and serving electricity. Advanced monitoring and control systems in the dispatch centres as well as on the substation level, combined with modern telecommunication infrastructure are used to increase the observability and the efficiency of the electrical grid. SCADA and ADMS systems, fault identification devices, RTU are used to increase the efficiency through an increased level of monitoring and control.
Environmental	Environmental aspects are those which impact the environment particularly related to GHG emissions. Reducing losses, enabling integration of Variable Renewable Energy (VRE) and smart applications result in environmental benefits through enabling the use of less GHG intensive power.

Figure 3 Types of Smart Grid Benefits

The benefits of smart grids are the result of the key functionalities of the components. These benefits can be clustered into the categories; economic, reliability, efficiency and environmental, and they are tabulated in Table 2 from the perspective of each of the beneficiaries (stakeholders) shown in Figure 4: Electricity System Stakeholders

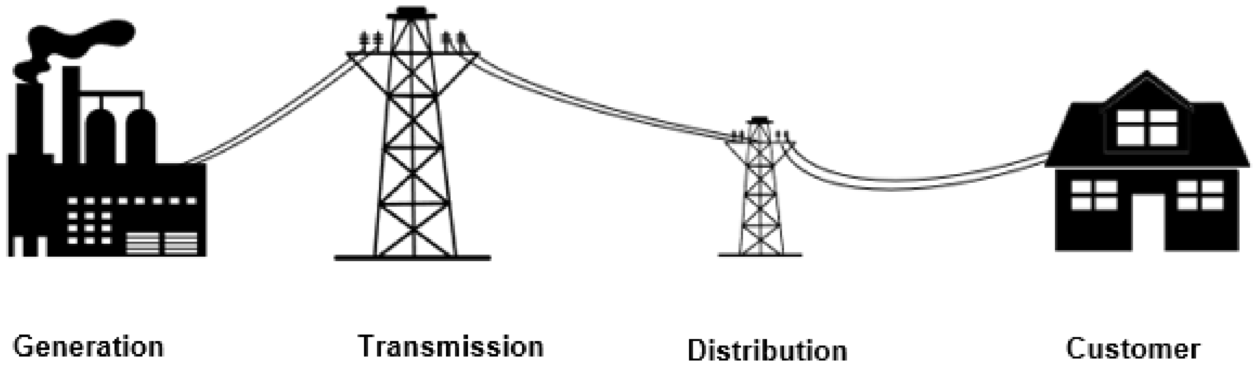


Figure 4: Electricity System Stakeholders

<table>
<tr><th>Stakeholder</th><th>Smart Grid Implementation Motivation</th></tr>
<tr><td>CONSUMERS</td><td>RELIABILITY:
• Improved service level.
• Peak demand management (or demand side management) leading to more reliable service.
ECONOMIC:
• Improved usage transparency leading to reduced consumption, resulting in reduced electricity bills.
• Ability to participate in flexibility markets through Virtual Power Plant – aggregation of DERs and monetization of these assets.
EFFICIENCY:
• Improved billing accuracy and reliability.
ENVIRONMENTAL:
• Increased opportunity to procure energy from distributed energy resource.
• Enables opportunity for EV-charging thus reduced GHG emissions from transportation.</td></tr>
<tr><td>DISTRIBUTION</td><td>RELIABILITY:
• Reduction in outage incidents through improved monitoring and peak shifting capabilities
• Reduction in fault duration time (e.g., automated fault locators and restoration).
• Improved customer satisfaction rating and improved customer relationship.
• Active energy management of localized distributed generation reducing peak demand allowing to reduce stress on the network thus mitigating fault.
ECONOMIC:
• Increased revenue due to reduced power distribution losses.
• Reduced operating costs through improved billing and revenue management.
• Opportunity for additional revenue streams through new markets such a flexibility, microgrid deployment and operations and new business models such as time of day tariffs.
• Reduced operating costs due to increased automation.
• Reduction or delay of investments for network reinforcement.
• Implementation of advanced asset management models, which maximize the equipment resources utilization and increase reliability.
EFFICIENCY:
• Reduced commercial and technical losses.
• Increased efficiency and observability through improved automation and monitoring technologies.
• Improved operational management systems extend the life of system assets.</td></tr>
</table>

	ENVIRONMENTAL: • Enables increased integration of intermittent renewable resources. • Reduced emissions through reduced losses. • Enabling electrification of new loads (i.e. e-mobility, highly efficient heating systems like electric heat pump).
TRANSMISSION	**RELIABILITY**: • Wide Area Monitoring (e.g., Phasor Measurement Unit) improves stability of the system. • Increased planning investment accuracy due to more detailed system data. • Self-healing through automation will enable the network to reconfigure dynamically to recover from network component failures, natural disasters, faults etc. • Real-time control and monitoring based on fast and accurate data exchanged across the grid will enhance the system reliability and security whilst optimizing the transmission assets. **ECONOMIC**: • Reduced operating costs due to increased automation. • Peak shaving/shifting reduces and/or postpones investment costs. • Distributed generation and storage create new market opportunities (i.e. Flexibility market). • Flattening the load profile minimizes operating and maintenance cost (O&M). **EFFICIENCY**: • Reduced transmission congestion improves system efficiency and reduces re-dispatch. • Enables higher order EMS and network application functionality such as AGC, economic dispatch, optimal power flow etc. **ENVIRONMENTAL:** • Enables increased integration of intermittent renewable resources thereby reducing GHG emissions.

Table 2 Smart Grid Motivation – Stakeholder View

2.3 Smart Grid Technologies

Smart Grid integrates multiple technologies which increase the efficiency and security of the power system. Together these technologies provide for the bi-directional flow of energy and communications which enable monitoring and control capabilities, enabling new functionalities. At the same time this also leads to increasingly complex systems. In its simplest terms a Smart grid consists of three primary layers: the power system layer, communication layer and information technology layer. Each layer fulfilling a different function to achieve different goals. The simplified version of layers is shown in below Figure 5 Smart Grid Technology Layer.

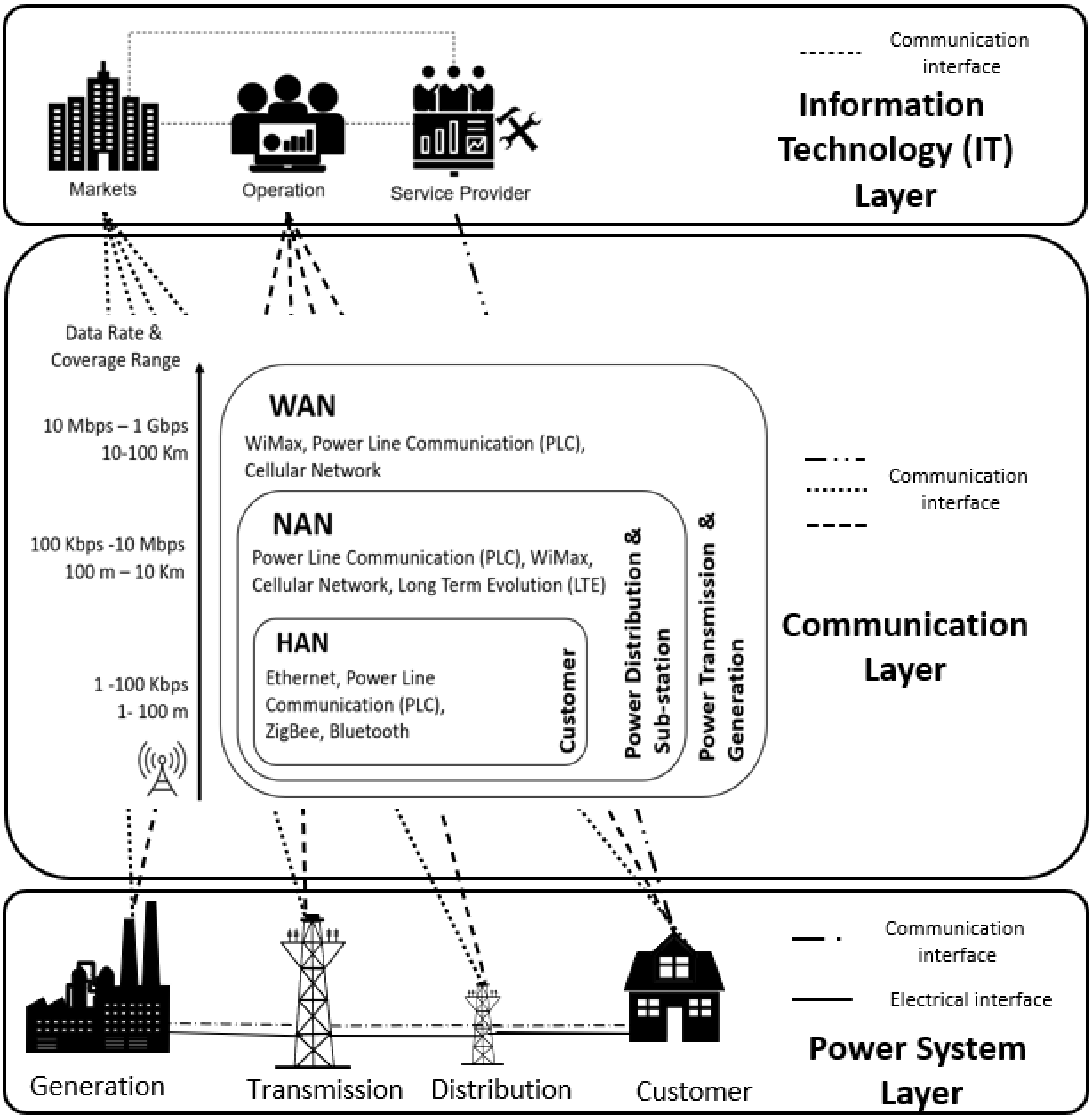


Figure 5 Smart Grid Technology Layers

2.3.1 Power System Layer

The physical components of the grid system; generation (centralized and distributed), transmission, substations, distribution, smart home appliances and storage make up what can be thought of as the power system layer.

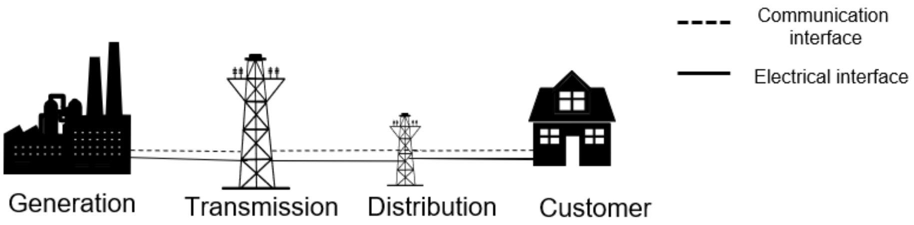


Figure 6 Smart Grid - Power system layer

Transmission system: The efficient transmission network will carry power from the bulk generation, at high and medium voltage levels, to the power distribution system. This network is monitored in real-time and protected against potential disturbance to ensure stability and secure operation of the system. Here the communication interface exists between generation stations, distribution system, power market, and system operation.

Distribution system: The distribution networks distribute the electricity from received from the transmission system, at medium and low voltage levels, to residential, industrial, and commercial end-customer as well as functions as a feed-in point for small scale distributed (renewable) energy. In this layer, communication takes place between the transmission system operator, end-users, power market, and system operation to carry out the most efficient operation of the network. In a smart grid system, substation automation and distribution automation are key enablers for efficient and reliable distribution power. Integration of distributed energy resource (DER) benefits the grid by reducing the distance energy is transmitted and this system congestion, system losses, enhancing reliability and power quality improvement.

Customers: The customers/end users are classified into residential, industrial, and commercial users. Consumers can play an active role towards the more efficient operation of the distribution system through participation in demand response mechanisms. The smart applications installed in buildings and homes, such as smart light, smart switch etc., can monitor and control demand, thereby minimizing energy consumption and electricity cost. In this layer the communication interface is between distribution system, power market and system operation.

2.3.2 Communication Layer

A robust communications network is a pre-requisite for an operational smart grid. Smart Grid systems integrate several communication technologies, each with different speeds, functionalities, strengths and weaknesses. Recent advancements in communication technologies play a significant role in the management of optimal smart grid operation enabling the coordination between different components in the power system. The exchange of process data between several control systems and IEDs distributed in the smart grid environment puts high requirements on the telecommunication system in terms of data transmission capacity. It can be expected that the number of process parameters as well as the sampling rates of data collecting equipment (RTU / PMU) will further increase in the future, especially given the expected increase in decentralized generation facilities and higher levels of grid automation.

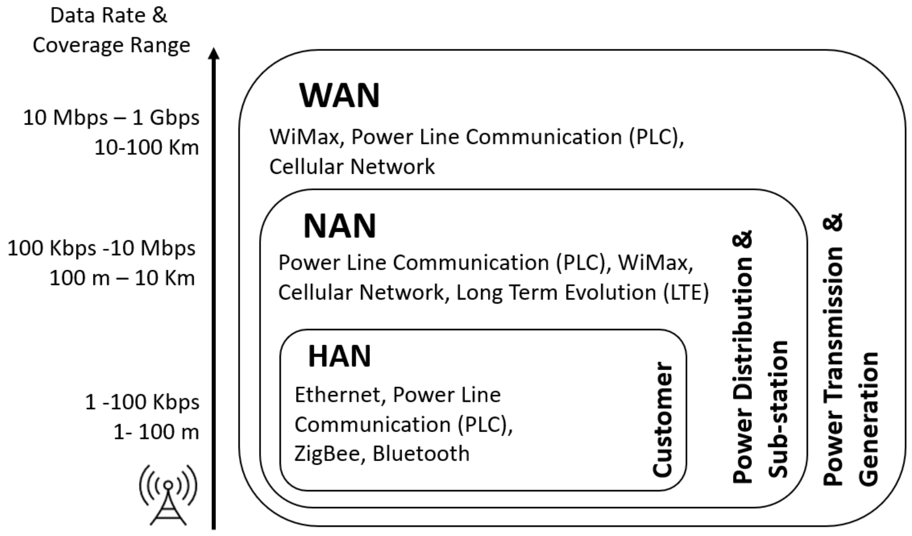


Figure 7 Smart Grid - Communication Layer and Technologies

The communication infrastructure of the smart grid is broadly divided into three networks: Home Area Network (HAN), Neighborhood Area Network (NAN) and Wide Area Network (WAN). Each of these communication networks have their own standard for data rate, coverage range and technologies and is chosen based on the requirements of the smart grid to ensure reliable and secure communication through the system. The networks utilize both wired and wireless communication technologies for efficient data communication.

The HAN network is near the end user and provides communication flow between computers, mobile and other network connections inside home or a small area, for example for smart home applications. The data from smart home devices are acquired and transmitted to smart meters via HAN. Several HANs are connected to a single NAN network which collects information and provides communication to WAN. WAN has multiple NANs and performs high-capacity communication between different components in the smart grid from the end user to utilities. A visual representation of smart grid communication infrastructure and their technologies are shown in the Figure 7 Smart Grid - Communication Layer and Technologies

2.3.3 Information Technology layer

The information technology layer of the smart grid takes a prominent role in transforming the traditional grid into the smart grid. This layer consists of various computing platforms, operational systems, system operation, power market, business application & services, and data tools.

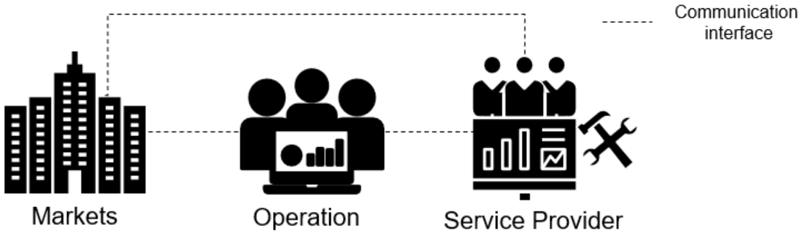


Figure 8 Smart Grid - Information Technology layer

Smart grid operations require a communication interface with the bulk generating facilities, transmission system, distribution system (substation automation & distribution automation), Distributed Management Systems (DMS), customers and energy markets. The power system operators need to interact with the various service providers to ensure the power functioning of the smart grid. Metering, recording, operations control, and real-time load monitoring by exchanging information with the power market are also implemented under operations. Aided through smart grid technology, power market operators have communication interfaces with generation, transmission and distribution systems, energy service companies as well as consumers who are acting as prosumers or participating in DMS programs by providing the pricing information for shorter intervals.

The large volume of data which flows within and between each level of the smart grid makes it challenging for the utilities to process. Therefore, data management techniques to properly facilitate smart grid applications managing high volume data must be ensured by using advanced analytics solutions. Advanced Distribution Management Systems (ADMS) integrates Outage Management System (OMS), Customer Information System (CIS), Advanced Metering Infrastructure (AMI) and Geographic Information System (GIS), to manage, process and act on the high volume of data which is obtained. The Demand Response Management Systems (DRMS) also relies heavily on fast and accurate data management because of its active interaction with many other systems/components in the grid.

To summarize, the Power System, Communication and Information Technology layers each individually have their own functionalities which in turn interacts and cooperates with the other layers to enable the overreaching systems benefits such as an increased level of integration of renewable energies, improved reliability, reduced energy consumption and minimized load not served.

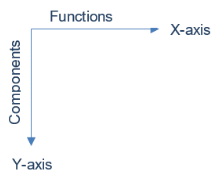
3 FUNCTIONALITIES AND BENEFITS OF SMART GRID

A smart grid is not a single device, but a system of components working together, each enabling different functionalities to obtain the overall desired benefit. In fact, most components cannot work independently. For example, a SCADA system is a prerequisite for any system automation functions, however implementing a SCADA system alone does not enable automated control.

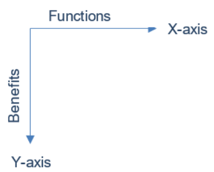
In a distribution network, the functionality of real time load management is achieved through a combination of Advanced Distribution Operation (Advanced Distributed Management System + Advanced Distribution Automation), IED installed on field level and a highly reliable telecommunication system in between. Real time monitoring and control requires fast transmission of process data in both directions and low latency times of the network automation components installed.

The functionality of Automated Volt/VAR control in transmission & distribution (T&D) networks is based on the combination of advanced measuring equipment and corresponding installations such as generators, Advanced Distribution Operation, controlling/power inverters, phase angle regulating transformer, FACTS and bi-directional communication components working together.

In Table 3 Components onto their Functionalities, the components are listed on the Y- axis and functions of the components are listed on the X- axis. The functionalities are further sub-classified as Transmission, Transmission & Distribution, Sub-station & consumer along the same X-axis. ■ denotes the mapped function of the component.



In Table 4 Functionalities onto Benefits, the benefits are listed on the Y- axis and functions of the components are listed on the X- axis. The benefits are clustered into following categories; economic, security/reliability, efficiency & environmental along the Y-axis. Whereas the functions are further sub-classified as Transmission, Transmission & Distribution, Sub-station & consumer along the same X-axis. ■ denotes the mapped benefit of the functionality.



Note: Definitions of the functionalities and abbreviations are provided in the Annex.

COMPONENTS	FUNCTIONS																		
	TRANSMIS-SION		TRANSMISSION & DISTRIBUTION									DISTRIBUTION		SUB-STATION		CONSUMER			
	Power flow control	Wide Area Monitoring	Automated Volt/VAR control	Power outage management	System isolation and restoration	Adaptive protection	Short circuit current reduction	Voltage flickering reduction	Real time load monitoring	Automated feeder switching	Dynamic capability rating	Fault identification & protection	Network maintenance & management	System condition identification	Fault current limiting	Electricity usage information	Real time load management	Adoption of intelligent home technologies	System security (Data protection)
Smart meters (AMI/AMR)			■										■			■	■	■	■
Advanced Distribution operation (ADMS + ADA)			■		■	■			■	■	■		■	■			■		
Phasor Measurement Unit (PMU)		■		■															
Fault Detection, Location, Isolation and Service Restoration (FLISR)				■	■				■	■		■	■	■					
Equipment Health Monitoring (EHM) system											■		■	■					
Power Inverter			■		■														
Remote Terminal Unit (RTU)									■	■		■		■					
SCADA / EMS				■	■				■	■		■		■					
Phase angle regulating transformer	■		■				■												
Fault current Indicators							■								■				
Intelligent Electronic Devices (IED)				■		■			■			■	■						
Remote Intelligent Switch (reclosers)				■			■								■				
2-way communication		■	■		■	■				■			■	■			■	■	
Smart appliances																	■	■	
Energy Storage Solutions	■			■	■														
FACTS devices (STATCOM)	■		■					■											
Distributed Energy Resource Management System (DERMS)					■				■				■			■	■		■

Table 3 Components onto their Functionalities

BENEFITS		TRANSMISSION		TRANSMISSION & DISTRIBUTION									DISTRIBUTION		SUB-STATION		CONSUMER			
		Power flow control	Wide Area Monitoring	Automated Volt/VAR control	Power outage management	System isolation and restoration	Adaptive protection	Short circuit current reduction	Voltage flickering reduction	Automated feeder switching	Real time load monitoring	Dynamic capability rating	Fault identification & protection	Network maintenance & management	System condition identification	Fault current limiting	Electricity usage information	Real time load management	Adoption of intelligent home technologies	System security (Data protection)
SECURITY/ RELIABILITY	Reduced sustained outages		■		■	■	■		■	■			■	■	■			■		
	Reduced system transients			■	■				■				■							
	Reduced major outages occurrence		■		■	■								■				■		■
	Reduced restoration time	■	■		■		■						■							
	Reduced wide-scale blackouts	■	■		■						■	■			■					
	Self-healing capability					■				■	■		■		■					
	Increased privacy																	■		■
EFFICIENCY	Reduced line losses	■		■	■			■	■				■							
	Improved demand side management											■		■				■	■	
	Reduced congestion	■	■												■					
ENVIRONMENTAL	Reduced GHG emission	■		■						■							■	■	■	
	Increased integration of renewable energies																		■	
	Integration of EV				■														■	
	Increased storage				■															
ECONOMIC	Reduced electricity cost																■		■	
	Reduced meter reading cost																	■		
	Reduced equipment failure								■			■	■	■	■	■				
	Efficient revenue management										■						■	■	■	
	Reduced operation cost			■									■	■						
	Reduced maintenance cost				■				■	■			■							
	Reduced ancillary service cost		■																	
	Reduced congestion cost	■	■									■						■		
	Reduced commercial losses													■			■	■		

Table 4 Functionalities onto Benefits

4 ANNEX

4.1 Glossary

2-way communication: 2-way communications between components improves monitoring and control of the network by sharing network condition and energy consumption data.

Adaptive protection: Adaptive protection uses adjustable protection relay systems such as current and voltage in real time. It is implemented by monitoring the status of the protection devices and then applies the changes based on the mode of operation.

Advanced Distribution Operation (ADMS + ADA): Advanced Distribution operation is the software platform control system which comprises of Advanced Distribution Management System and Advanced Distribution Automation by supporting the performance of distribution management and grid optimization.

Advanced interrupting switch: The advanced interrupting switches interrupts the faults quickly and isolates that faulty part by completing disconnecting them from the grid to avoid outage.

Bluetooth: It is a wireless LAN technology based on the IEEE 802.15.1 standard designed to connected mobile and other fixed devices using low power radio transmission.

Cellular Network: Due to its high data transfer rate i.e., up to 100 Mbps, well established infrastructure and available security algorithm it is largely deployed in many countries. It is used for communicating different components and devices in the smart grid using several existing cellular communication technologies like GSM, GPRS, 2G, 3G, 4G, LTE and WiMAX.

Equipment Health Monitoring (EHM) system: Health monitoring systems are designed to monitor and provide real time status of the equipment and generate an alarm when the system deviates from the normal or predefined settings in order to prevent the grid from outages.

Ethernet: Ethernet are frame based communication technology with IEEE 802.3 standard used for wired LANs. It is a simple network technology with an advantage to integrate new technologies and reliability in low cost.

FACTS: FACTS – Flexible AC transmission system are Fast Acting Control Strategies devices which are composed of static equipment used to increase the reliability of the grid by improving the power transfer capability and enhanced controllability.

Fault current limiters: Fault current limiters or controllers are the devices which minimize the fault current in the grid without disconnecting them during the fault condition.

Fault detection devices: Fault detection devices are those which quickly and automatically detect faults before the system is affected.

Fiber Optical Communication: In power system it is well suited for controlling and monitoring purposes like connecting substation to the utility control centers. It has long range and high data rate but more expensive than other alternate technologies.

Flow control: In transmission the flow control influences the path of active or reactive power.

Phase angle regulating transformer: ´These transformers regulate the voltage phase angle by controlling the flow of active power on transmission grid and improve the stability of the transmission system.

Phasor Measurement Units (PMU): PMUs are the devices which can measure the phase angles and current & voltage at a certain or selected station of the power grid. PMU's are also used for monitoring the power system which increases the reliability of the power system stability.

Power Line communication: In power line communication (PLC) technology the data is exchanged using the electrical power lines and it is implemented using modulated carrier signal. It is a matured and reliable technology covering various frequency band range with a data rate up to 10Mbps. Therefore, it is utilized in various smart grid environment especially in the Neighborhood Area Network communication.

Power or Smart inverters: Power or smart inverters have the ability to control the active & reactive power flow, sensing faults etc., Also, these inverters will act as an interface to the Distribution energy resource (DER) to the grid.

Remote Terminal Unit (RTU): RTU collects real time data from the physical devices in turn transmits them to the station.

Smart appliances: Smart appliances are the devices that incorporates communication technologies to enable automatic remote control for the purpose of demand side management (DSM).

Smart meter – AMI & AMR: AMR is Automated Meter Reading (benefit reduced billing operations costs) whereas AMI is Advanced Metering System are meters which can be controlled via 2-way communication as opposed to only reading the data.

STATCOM: Static Synchronous Compensator is a shunt-connected FACTS that is primarily used for reactive power control and voltage fluctuations reduction.

Supervisory Control and Data Acquisition (SCADA): SCADA systems allows the remote monitoring and control of the power systems thereby enabling remote operation.

Sustained and major Outages: The sustained outage is the deenergized condition of the power transmission line which lasts less than 5 minutes. Whereas major outage last for more than 5 minutes and its often due to equipment failure or overloading of the system.

WiMAX: Worldwide Interoperability for Microwave Access (WiMAX) is a wireless technology based on the IEEE 802.16 standard. It utilized Orthogonal Frequency Division Multiple Access (OFDMA) technique to provide both the fixed and mobile connectivity. It is used in Neighborhood Area Network (NAN) and Wide Area Network (WAN) communication in smart grid. Its data rates are up to 75 Mbps for fixed connection and 15 Mbps for mobile connections with a coverage range up to 50 Km.

WLAN: A Wireless Local Area Network (WLAN) connects two or more devices in the grid using spread spectrum and it is based on IEEE 802.11 standard. It is a low cost and highly deployed technology around the world with the working frequency range between 2.4 GHz to 3.5 GHz frequencies.

ZigBee: Zigbee is based on the IEEE 802.15.4 standard. It is an open wireless network with short range, long battery life, low cost and data rate. But it is an energy efficient technology operating on four different frequency bands which covers ranges till 100 meters. This technology allows up to 60,000 devices to be connected to its networks and supports various applications like smart meters, home displays, smart lights and switches which required short range wireless transfer rate.

4.2 Abbreviation

ADA – Advanced Distribution Automation
ADMS - Advanced Distribution Management Systems
AMI - Advanced Metering Infrastructure
DA – Distribution Automation
DER - Distribution energy resource
EC - European Commission
EV – Electric Vehicle
FACTS - Flexible AC Transmission System
HAN - Home Area Network
ICT – Information & Communication Technologies
IEA – International Energy Agency

IEC - International Electrotechnical Commission
IEEE - Institute of Electrical and Electronics Engineers
LTE - Long Term Evolution
NAN - Neighborhood Area Network
PLC - Power Line Communication
PLC - Programmable Logic Controller
PMU – Phasor Measurement Unit
RTU - Remote Terminal Unit
SCADA - Supervisory Control and Data Acquisition
STATCOM - Static Synchronous Compensator
VAR - Volt-Amp Reactive
VPP - Virtual Power Plant
WAN – Wide Area Network
WiMAX **-** Worldwide Interoperability for Microwave Access
WLAN - A Wireless Local Area Network (WLAN)

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