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Smart Grid: A Brief Assessment of the Smart Grid Technologies for Modern Power System

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Abstract: The smart grid has been supporting in developing nations and built up nowadays to adapt to the bottleneck of sustaining substantial supplies in energy consumption such as industry and substitute development. As another idea for the power structure, Smart Grid includes a considerable evaluate of cutting-edge modern technologies. Extraordinary strategies, and original structures in supervision, a business operation to take care of issues such as derivation of upgrading resources allotments, grid improve wellbeing and reliability and transmit energy in a more capable, reliable and standard method. These papers fundamentally overview the descriptions, abilities, technologies of the Smart grid system. The benefits of the automatic features of the smart grid have illustrated. Energy management, challenges, and executions also assessed in the paper.

Keywords: Smart Grid, Power System, Conventional Grid, Modern Electric Grid

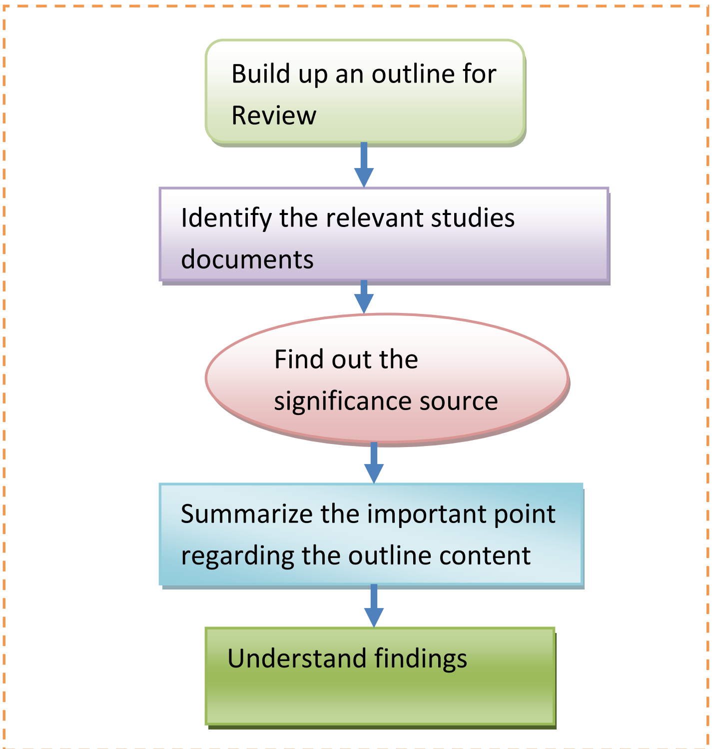
1 Introduction

Electrical power and electronic interchange are one of the primary technologies that have permitted the fast improvement of human advancement in the twentieth century [1]. Alexander Graham Ringer and Thomas Edison were in the fundamental foundations of power and communication. Entering the twenty-first century, Edison would probably still perceive all the real parts utilized as a part of the power grid, which alludes specifically to the level of distribution, where current innovations are as yet truant. Ringer, in correlation, would perceive not very many of the segments of the cutting edge broadcast communications system [2]. This perception emphasizes the strength of thought and the economy of the plan of the current electric system. It also requires a review of the present practice to figure out what can implement new technologies. The power industry should be changed to address the issues of modern digital society. Consumers require a higher nature of energy, high power quality and a more critical assortment of extra services. Furthermore, consumers also need the costs to be lower. On a fundamental level, the smart grid is an upgrade to the power grid of the twentieth century, which generally originates energy from some nuclear generation nodes to a large number of users [3]. Smart grid instead can course the power all the more ideally to react to an extensive variety of conditions and to charge a premium to the individuals who utilize energy during peak hours. Smart

Grid does not rise anyplace. They have increased as a reaction to the need to modernize the power grid, make it all the more naturally inviting and enhance the supply of energy [4]. Since smart grid systems are more self-ruling and increment the proficiency and effectiveness of energy supply, benefits organizations can utilize existing foundation and limit the need to produce more power stations and substations. Smart grids allow renewable power source assets to associate safely to the system to incorporate the power supply with distributed generation energy and storage. This paper tries to display a summary of the smart grid system with its features of intelligent technologies [5].

2. Methodology

The approach of this paper is recapitulated below:



The paper express with Smart Grid definitions and a discussion of the essential framework. It at that point moves to an elaboration of the Smart Grid functions. To follow the beginnings and see the improvement of the technologies related to Smart Grids refers to a bit of history.

3 Smart Grid

Smart Grid models have conversed about; Extended, created by plainly understood affiliations, inquire about establishments and legislative divisions around the world. There is no contending definition for the smart system; even the particular countries have the distinctive thought of the smart grid. For instance, China would like to set up a comprehensive and robust intelligent system framework that joins all the age, transmission and dissemination portions to utilized, while the smart structure is portraying inside the national structures of Association of the structure [6]. Numerous dispersions center on "What are the remarkable purposes of the smart grid" or "what sort of advancements devoted to smart grid " Rather than "What is the Smart Grid." Figure1 appears about the central uses that are occupied with the smart grid, joining similarity with all energy generation, electric vehicle structure, more decisions of battery recollections and more choices of the nature of energy for Purchasers, demand-side management and self-recoverable abilities [7].

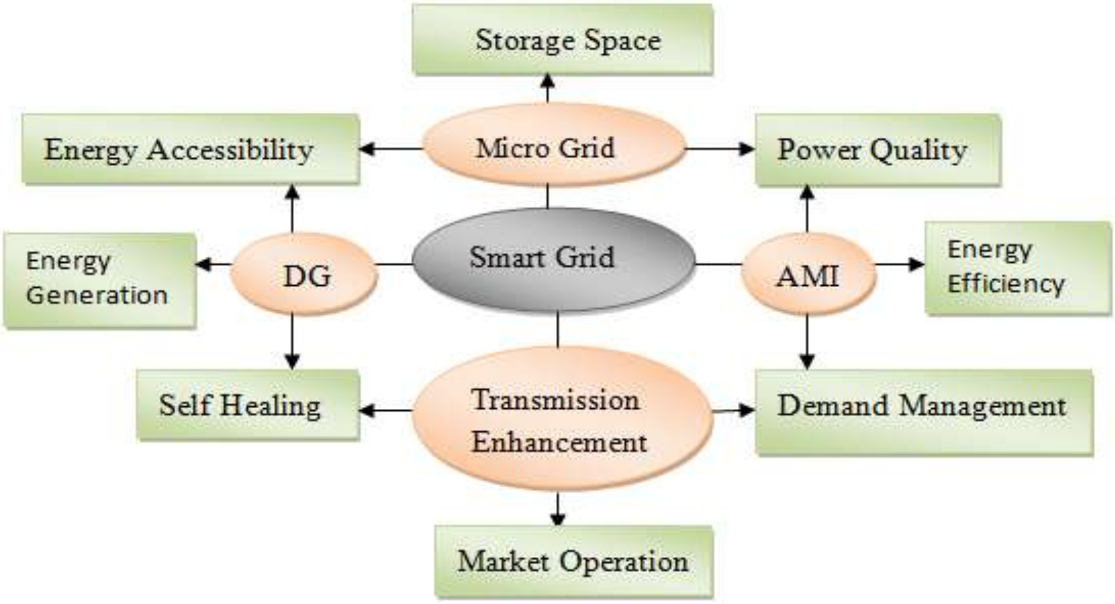


Fig. 1 Smart Grid

As per DOE NETL (Division of Vitality, Research center Innovation, USA), a smart grid operates propelled innovation to enhance the nature of energy, assurance, and effectiveness (monetary and vitality) generation of electrical management. Power systems for energy purchasers and a developing number of distributed generation and capacity [8]. The operation of the smart grid covers an extensive variety of breaking points and organizations of energy systems empowered through communication and information innovation, with the purpose of enhancing power quality, operational profitability, flexibility to Perils and our impact on Earth [9]. The IEA (Universal Vitality Office, USA) indicates Smart Grid How to "A power framework that utilizations automatic and different technologies worked to monitor and concur with the power vehicle of all wellsprings of generation to meet the unique energy needs of the end consumers. A smart grid is an electrical system that can make intelligent the incorporation of the activities of all customers associated with it-generators, customers, and individuals who do both-so that the ultimate goal of vital support, economic and of protection [11]. The "smart grid "Represented by IEEE is a modern energy generation framework, described by the expanding use of data innovations and communications in the generation, delivery and use of power [12].

4 Differences between Conventional Grids Vs. Smart Grid

Table 1 summarizes the contrasts between the intelligent network system and the conventional electrical system. The Smart gird applies to bi-directional innovations so that customers can be interested in network activity [13]. For instance, photovoltaic solar energy tables introduced on the rooftops of customers ' homes could produce electricity to generate the day and offer surplus energy supply to the system around the evening time, sunlight based boards cannot make power in the home, and Energy provides transportation in the house as expected[14-15]. Also, modern technologies as like distributed generation, exhaust vehicles, electric recharge, flexible alternating current transmission systems (FACTS) and apply to the power grid to improve energy efficiency, improve power quality and reduce Carbon emissions. New issues are composed of some new applications transmitted [16].

Table.1 Evaluation of the conventional grid VS smart grid

Aspect	Conventional Grid	Smart Grid
Interconnection with Consumer	Consumers inactively accept a benefit from the grid	Consumer participation in the Grid activity
Renewable Energy	That includes problems with renewable access	Integration with renewable sources development
Option of Consumer	There have no choice for the consumer	With the automated market trade, PHEV, more choice for the consumer
Power quality Issue	There have an alternative on Power Quality	There have different Power quality level for consumers
System Operation	There have no effective operation	Operations optimization, less energy loss
Protection	Fault detects manually	has self-healing abilities, less damage affected by the failure
Security and Reliability	Ready for physical and cybernetic attacks	More reliable for public safety and human protection

5 FEATURES OF SMART GRID TECHNOLOGIES

Rather than the conventional power framework, Smart Grid is the landing time of the energy transport System, which fuses an expansive number of inventive features with new technologies [17]. NIST of Smart System division in seven zones as showed up in Fig. 2, with thoughts in the arranging of help administration, the change of Establishments, Documentation with Relationship of the best and getting a higher assembly of interrelated frameworks and parts that incorporate the smart grid framework [19-20].\

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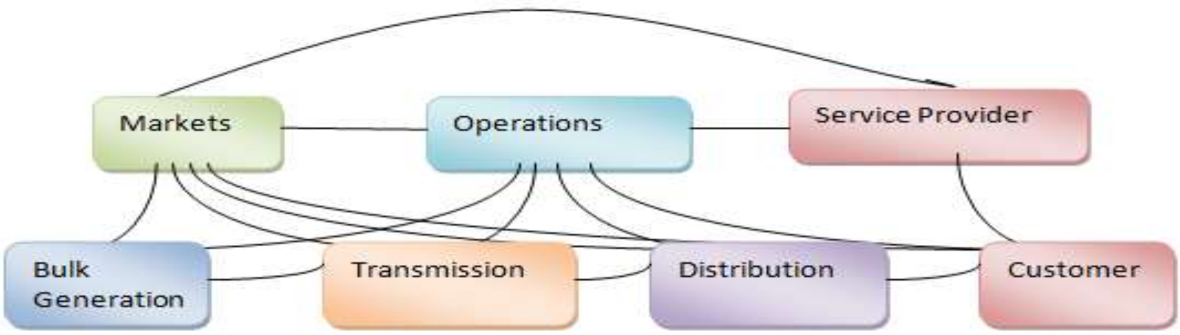

Fig. 2 NIST Smart grid is comprising of secure correspondences and electrical streams in 7 Smart grid areas

NETL has tended to 8 mechanical answers for accomplishing a improve power quality, economy, efficiency, condition, security, and security, as demonstrated as follows[21]:

- Advanced metering infrastructure (AMI)
- Consumer Side coordination (CSC)
- Electric vehicle charging systems (EV)
- Transmission line improvement appliance
- Distributed management side (DMS)
- Combination Renewable energy
- Information and communication technology (ICT)
- Wide-area monitoring and control.

Different parts of technology installed across the system of the electrical system of Generation next to the customer (Figure 3). To fuel consumer demand, the virtual energy market assembling to explore more alternatives for consumers [23].

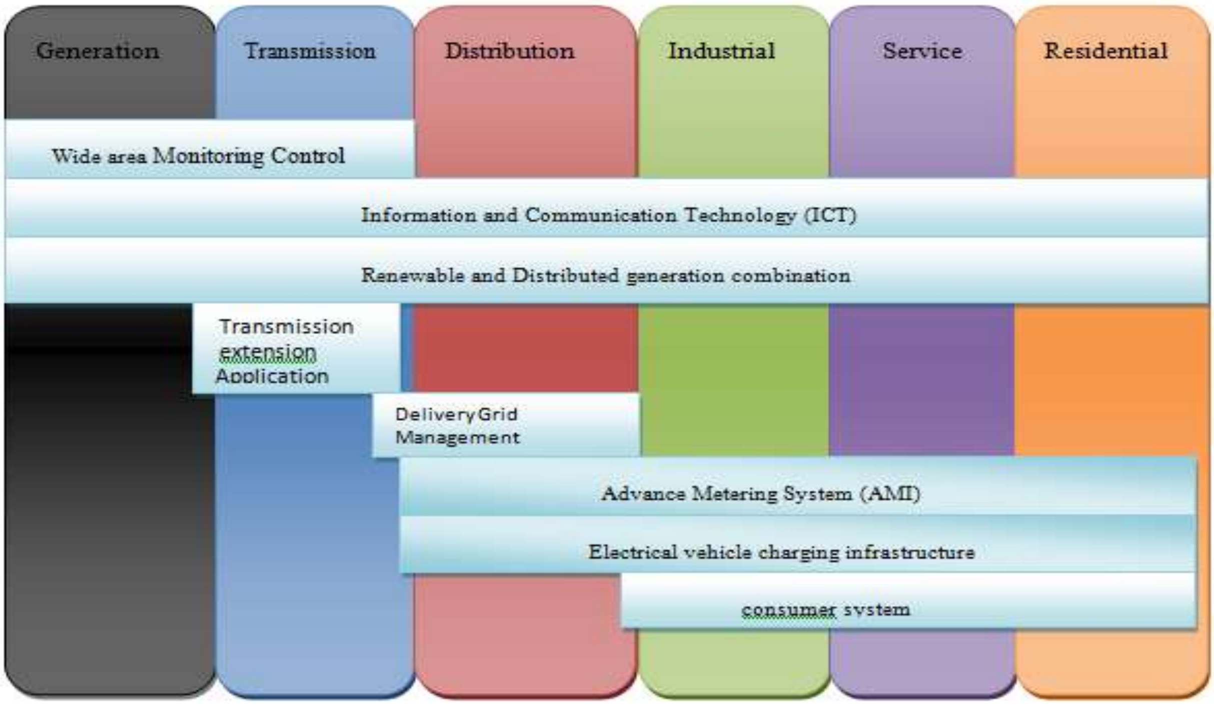

Fig.3 Smart grid technologies deployment in power systems

A. Advanced Metering Infrastructure (AMI)

AMI introduces the two-way communication control to allow customers and public services to get the real-time cost and energy consumption. AMI specifies the energy losses and the location of the electrical theft. AMI provides customers with the data needed to decide on smart options, the ability to decide on those options, and various options for the benefit of the customer [24-25].

Meanwhile, the system can improve public service operations and help the development of AMI data management to enhance customer monitoring.

Moreover, AMI provides a fundamental link fixed between the networks, consumers with their loads, and generation as well as storage space resources through the merging of different technologies such as intelligent evaluation, starting zone systems, coordinated exchanges, Data management applications, and institutionalized programming interfaces. AMI and the interface for residential, commercial and industrial progress have appeared in Fig. 4[26]

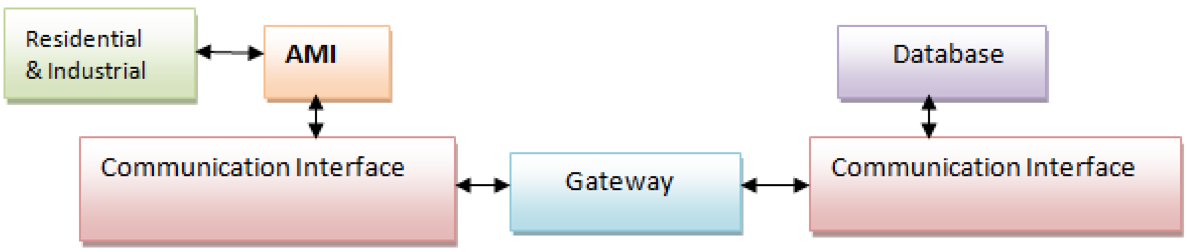

Fig.4 AMI Interface

Though, the execution of AMI, the risk of communication, which is a specific aspect, consolidated in the smart grid and evil the national economy, general security, Government conviction, and public protection with environmental reliability [27]. The hazard to the economy and confidence in the administration could increase from low to direct, where present is a reasonable conflict between drivers and public services and when the rates of private customers have expanded. As a result, the system security prerequisites must be proposed and distinguish which intelligent network security goals are planned to be expected [28].

B. Consumer Side coordination (CSC)

Consumer-side coordination is updated to monitor electrical power consumption at the user level, such as industrial, tertiary, and residential levels. Four points of views are committed to consumer side coordination's that are [29-30]:

• Energy Management Systems
• Energy storage devices
• Intelligent Electronic Devices
• Distributed Generations

The home monitor such as control cards, smart devices and cargo storage circulation could speed up the advantage of energy efficiency and minimize maximum demand [31]. The answer to the research is that end customers reduce their energy consumption in the cause to the needs of the power grid, the economic symbols of a substantial discount market or the extraordinary retail sales rates. Both the manual-to-customer reaction and the programmed and evaluated devices and the internal controllers are associated with the energy management technique or controlled by a utility program or system supervisor [32].

C. Electric Car Charging

The loading frame of the Electric motor vehicle can handle the demand for charging. There are four types of function for electric cars that charging. Those are great for cars, grid vehicles, storage for cars and vehicles to Storage [33]. With the input of the developing interest reaction and the dynamic value, the cars could fill as versatile structure storage parts. At the moment the system is under the most significant demand, and the status of electric cars wholly charged, Electrical cars charged to the network to substantial loads for home storage devices to help the domestic energy operation [34]. At the moment the system is under the most peak demand and the electric vehicles state is out of power, the home storage devices charge the Electrical vehicles for them on a daily basis utility. When the system is of low power demand, and the expenditure of energy is declining, the electric cars w charged by the electricity network [35].

D. Transmission line improvement appliance

Many technologies apply to transmission to improve controllability, the ability to exchange and the decrease in energy loss. Three critical applications have appeared here [36-37]:

• Flexible AC Transmission Systems (FACTS)
• High voltage DC systems (HVDC)
• High-temperature superconductors (HTS)

E. Distributed Management System

DMS ' function is through the processing of real-time information, the advanced sensor system and meters for [38]:

• Reduce interruption and repair time
• Keep the voltage level

• Detects faulty positions
• Improve energy management
• Reset the power supplies automatically
• Optimizes voltage and reactive power
• Distributed Generation control [39]

F. The combination of Renewable Energy

A few sizes of renewable power source assets spread at various levels of energy network: extensive scale renewable power source assets at the transmission level, medium scale appropriation and little scales in the Customer's parallel structures [40]. The capacity to control and dispatch remains the principal challenge for the reconciliation of renewable power sources and energy assets distributed in the activity of the electrical system. Both electrical and thermal energy storage plans can reduce the effect of variable renewable power sources especially wind as well as solar-based energy. Distributed generation combine can enhance the power quality of the power network and decrease the substantial load [41-42].

G. Communication Technology

Information and communication technology (ICT) is to assist the communication of data for the activities granted and continue and during interference.ICT is not to concentrate the communication networks they are using, privately (counting systems Radio, metric work systems), or public (Web count, mobile phone, link, and phone) [43]. Interested parties can use and productively process the system with the use of specialized devices, significant preparation, planning of system control and planning of the company's capital assembly in Two-way Communication Foundation [44].

H. Monitoring and Control system

A vast area of monitoring and control of all parts of the power framework and continuous execution through interconnection inside extensive geographic areas and enhances the segments of the power framework, exercises, and Execution through help to framework administrators to understand them [45]. The progressed working framework equipment, including the broad area of situational mindfulness, wide area monitoring frameworks and wide area versatile security, control and computerization, keep up a separation vital power outages and Encourage the mix of variable sustainable power source assets. Also, the information created by the monitoring, estimation and control frameworks of the expanded area could also encourage the activity of the structure together with [46]

• Reporting on the decision-making process;

• Attenuation is extended area dispersions;

• Improved transmission capability with reliability [47].

Table.2 indicates that hardware and software are together to every part of technology and concern over the intelligent network [48-49]. As should be evident in this table, the elements of the communication network are the essential parts to create sharp networks and implementation in many technology sectors of the intelligent network [50]. The communication system would be used to transfer information about the use and level of energy storage to the control center. Industry standard automated technique and Ethernet would be applied to the intelligent network to communicate between replacement and control section. The global control and control strategy installed within the control center entirely responsible for the generation, storage and use of energy [51]. It regulated the production of renewable energy, storage and use of power as indicated by the projections of fluctuating generation (in particular renewable energies) and the dynamic curve of energy load. Also, the new method includes in the control and monitoring device [52-53]. Such as the energy management structure of the micro-grid Framework should be smarter to address the uncertainty and demand and fluctuation of the generation. The estimation calculation (EC) is one of the rational predictions that can update the data in the middle of the system operation [54]

Table2.Equipment employed into the smart grid

Smart Grid Technology & Issues	**Equipment**	**Systems and Software**
Cyber Security	Communication Equipment routers, relays, switches, gateways, computers,	Monitoring and control of Data Acquisition(SCADA), Distribution Management System (DMS), firewall rules, vulnerability management
Protection	Fibre communication network, routers, relays, switches, computers (servers**)**	Wide area of adaptive protection, control, and Automation, situational awareness of a broad area, agent-based Distribution management system (DMS)
Wide area monitoring & Control	Phase measurement units (PMU)	SCADA, Control and Mechanization, Width Situational consciousness of the region
Information & Communication Technology	Communication equipment (Power Line Carrier, WiMAX, LTE, RF mesh network, mobile phone), routers, relays, switches, gateways, computers (servers)	Enterprise resource planning software (ERP), customer information system (CIS)
Renewable and DG Integration	Bulk-power and grid-support conditioning equipment, communication	Energy Management System (EMS), Distribution Management System (DMS), SCADA, Geographic Information System (GIS)
Transmission Enhancement	Superconductors, FACTS, HVDC	Network stability analysis, automatic recovery systems

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Distribution Grid Management	Automatic RECLOSRS, switches and capacitors, distributed generation and storage remote control, transformer sensors, wire and cable sensors	Geographic Information System (GIS), Distribution Management System (DMS), Interrupt management System (IMS), Workforce Management System (WMS)
AMI	Smart meter, home monitor, servers, relays	Meter data management system.
Electric Vehicle Charging	load infrastructure, batteries, Inverters	Power billing, intelligent load grid-to-vehicle (G2V) and methods of downloading from vehicle to Grid (V2G)
Customer Response Side	Intelligent devices, itineraries, home display, Building Automation systems, thermal accumulators, the smart thermostat	Power Board, Power management Systems, power applications for smartphones and tablets

6 Advantages of the Smart Grid

As indicated by NETL, the advantage of the intelligent network can improve the operation of the system and the use in six key areas, which shown in the accompanying mode:

1. Reliability: Decreasing the rate of interruptions and interrupting the quality Energy and reduce the possibility and the penalty of generalized blackouts [55].

2. Economy-keeps prices low in electricity costs reduces the total amount paid by the consumers on the network "production as normal" (PAN), creates new jobs, and stimulates total national production (gross domestic product) [56].

3. Efficiency-Minimizing the cost to generate, transport and consume electricity [57].

4. Environment — emission reduction compared to PAN, taking into relation the increased penetration of renewable energies with improving the efficiency of generation, supply and apply[58].

5. Security — decreases the probability and consequences of assaults caused by counterfeiting and catastrophic events [59].

6. Safety — Reducing damage and death toll from network-related events in general, the advantages of the smart grids are [60-61]:

– Better system performance counters
–Better customer realization
– A better capacity to provide data for tariff cases; Permeability of the Operation/Asset Management Utility [62].

–Information available for strategic planning and additionally better help for advanced synthesis [63].
–The most reliable and profitable power delivery improved by the data flow and ensures life-cycle management of communication, cost containment, and end-to-end power delivery improved in a Smart Grid design[64].

– Enhancing the delivery is correct data for rate-with capitalization-approaching permeability into the operation of asset Management utility [65].
– Effect on access to authentic information for strategic planning [66].
Several stakeholder meetings can benefit from the implementation and operation of the Smart Grid. NETL discriminate the stakeholder into four systems, which are a delivery organization, electricity provider, the largest residential and social consumer. Table- 3 [67]

Area	**Delivery Organization Benefits**	**Electricity provider Benefits**
Consistency	• compact operating costs •Improve the safety of employees • Increased revenue •.Superior customer satisfaction ratings and better relations with the controller, and so on. • the decrease in capital costs as a fewer strategy not in services	• Reduces downtime for some generators
Economical	•Many opportunities to exploit their resources and To introduce new energy markets formed by the Smart grid. •Increase in revenue as service theft reduced •Improving the cash flow of more efficient management of billing processes and revenue management.	•New Market Open doors for Disseminated Age • capacity Interest for bring down costs, new DER Business Alternatives • Increment the increments in Wind and sun based age • Decrease the task and Upkeep costs (O&M) in stackage plants
Efficiency	•Increase the consumption of high-quality	• More focused generators Greater to market

	•Reduction of line misfortunes •Reduction of transmission clog costs •Postponement of future capital ventures •Increasing resource information and insight by permitting •Better comprehension and control of the supervisor • Reduction of capital use •Extended lifetime of framework assets •Improve representative efficiency • More exact expectations about when the new capital •Necessary speculations	•Improves generation efficiency •Opportunities to grow the environmentally friendly power vitality portfolio •Less constrained interference
Environmental	• Expanded ability to incorporate discontinuous renewable assets • Emission Decreases •Opportunity to improve the image of environmental leadership Enlarged ability to help the integration of Electric vehicles •Diminished recurrence of transformers flames and oil spills	•New opportunities for generating and storing renewable information created by Smart network capability to support increasing levels of intermittent resources
Security and Safety	• Diminish the probability that a man has an intentionally cyber or physical attack • Enhanced reclamation times after the catastrophic event • The decrease of burglary and	•Reduced exposure of generation plants to potentially harmful and hazardous disturbances due to a safer transmission system

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	vandalism of products • The reduction in injuries and deaths of employees	

7 Motivations & Challenges

A. Motivations

As another generation intelligent power supply framework, smart Grid modernizes energy productivity by connecting with modern technologies on the current system and trading continuous data amongst providers and electrical consumers. Despite the benefits for each group of stakeholders on the smart grid, there are several driving forces in the smart-grid application [68-69].

First of all, the conventional grid system is aging an older technique with poor power quality an illustration is a power outage happening in numerous nations [70]. The most genuine power outages occasions have occurred in countries around the world are prepared as takes after [71-72]:

• Nov 9. 1965, upper east United States and Ontario power outage, more than 30 million individuals influenced
• March 11, 1999, south of Brazil Blackout, the vast majority of the third south of the nation concerned
• 28 September 2003, Italy, Switzerland Blackout, around 45 million individuals influenced.
• 14 – 15 August 2003, upper east Blackout, 50 million affected individuals.
• 18 Aug 2005, Indonesia Java – Bali Blackout, 100 million individuals affected.
• 10 – 11 Nov 2009, Brazil and Paraguay power outage, 190 million individuals influenced
•30 – 31 July 2012 July 2012 India Blackout, more than 700 million individuals influenced

Secondly, the transmission block is the most critical issues of the conventional system. It happens when the sending of trade causes the infringement in the context of the transmission [73]. Some reasons such as the transmission line and generator breaks, the demand for energy changes emphatically, and offensive production can induce obstruction in the transmission. As a result, the structure supervisor cannot send the sufficient power, regardless of whether the generators could give more power. It can also induce infeasibility in existing and future contracts [74].

Moreover, the environmental effect is additionally one of the principal motivations to drive smart grid. With an intense ecological change in the course of the most recent couple of decades, a lot of greenhouse gas depleting substances and some other pollutions gases contamination from the explosion of fossil fuel derivatives in conventional power plants are thought to be the fundamental motivations for the improvement of sustainable power sources [75]. A considerable measure of specialized solutions, (FACTS HVDC, UPS, STATCOM), and new thoughts have been connected in the framework to proceed transmission ability and energy conversion efficiency [76-77].

B. Challenges

As the new system and with a considerable measure of innovative automatic execution, the smart grid faces several challenges.

1. security and protection

With the communication merge fixes on the grid, the Smart grid also gets problems that never occur in conventional systems. Cybersecurity problems should be taken with excellent care to prevent the power network from interfering with an improper setting or adding messages [78]. Focuses on the apple of automatic energy Recovery network Technologies also must conscientiously consider the tragic event and physical attack [79, 80].

2. Reliability

Integrates of the communication system correspond reliability issues to the operations of electrical frameworks. It is almost sure that the communication framework could give a powerful message that can influence the overseer of the energy framework to react quicker even with a first circumstance [81-83]. In any case, wrong words created by programmers sent to the system can be joined by actual results and at last reason control blackouts. In additionally need to re-evaluate the dependability indicator. Although some common indexes such as SAIDI, CAIDI, SAIFI, CAIFI, new symbols created with the thought of the operation of the communication system to represent the reliable power quality [84] accurately.

3. Power Quality

Disturbance recognizable proof and harmonic control technology must be developed to provide control high quality to the consumer. The identification of the disturbances remains in the initial phase of the investigation. Non-dispatch able energy assets such as wind and solar based energy must be forecasted more precisely and decisively with their increasing access and in addition to the load spending [85,86].

4. The relation between Grid and consumers

The end goal to deliver more consistent power and enhance energy reliability. The consumer must take an interest in the grid operates as demand response, select the nature of power quality, the establishment of small distributed generation plans and consumer of electric vehicles, which additionally require the communication system to supply the safety condition to keep the individual data of purchasers lose intentionally [87-89].

C. Smart Grid recreation

1. Data accuracy

The smart grid system test system is an expansive quantity of data implicated with the development models and the condition of operation. The accuracy of the data is a vital issue to tend. Quality and accuracy data must be protected and ensured for applications on models [90]. Since the apparatus is supplanted and reset, the information in the smart grid systems also requires an update, which could be controlled to meet the reasonable circumstance. Also, as per the characterization of the clients, the security of the data must be legitimized by the specialist [91].

2. New model functions

As specified before, the market operation would be presented to discover the connection between partners and any group of individuals going to the market action [92,93]. Stochastic demonstrating is worked to research the active conduct of market movements. Speculation in sustainable power sources such as wind and solar oriented advertise cost ought to incorporate smart grid, test system to decide how to enhance optimize the power system, and the dispatch of power.

Furthermore, the appearance of a new energy market substance such as chargeable motor vehicles are prompting modernizes the charging models in the electrical system. AMI control client restores their electric motor the off-peak charging time to spare cash [93-95]. Therefore, client practices would also be displayed to accomplish a more precise load forecast. The coordination models with additional would provide an entire depiction of electrical power generation to control energy use [88-90].

3. Reproduction modernize

Aged grid model should be modernized to keep up consistency with this present reality. The fundamentals models restore the particular condition. For instance, the single-phase model of the ventilation system cannot be efficient similar to the three-phase model for reliability [96].

4. Interface integration

The interface between the test system and the current structure could help industries to evaluate and develop equipment to handle the demand for public services [94-97]. A complete reproduction might induce the advancement of the grid system. Instead of allowing the model event to be self-contained, the most comprehensive built-in models might perform the most reasonable event. The reference illustrates the communication and data ability to improve the activity of the energy transport operation [98,99].

Meanwhile, the author also is indecisive about the capacity in the grid response, as several conventional power stations attach to the grid and take more time to start up with the incorporation of the model, this type of problem indisputable [100-103]. Some modernization plants are designed to consolidate controls, exchanges and electro-mechanical flow. The Oak Ridge National Laboratory (ORNL) combines models of electrical panels with connection communication with separate possibilities [104-106].

8 Conclusions

This article is fundamentally assessment the smart grid definitions, features and technologies of the system. Furthermore, the contrasts between a conventional grid and an intelligent grid analyzed. Moreover, this paper compressed the smart grid technologies and their advantages in various regards. Energy management methodologies, challenges, and implementations are reviewed in this paper too. This work has tired the development of the smart grid from the need to modernize the electric grid.
At last, the conventional network was limited and required more capacities. The features and characteristics of intelligent grid systems have recognized. This paper displayed the intelligent operation of the key and related technologies and distinguished the assessment activities, challenges, and issues spinning around them. There is opportunity about circumstances in the regions of time arrangement expectation in smart grids, reliability, and power quality examinations, energy flow optimization, battery frameworks, cloud assembly, and energy integrating sustainable on an extensive scale. Indeed, even the issues and challenges recognized as information security, physical and Cybersecurity, test system barrier and the automation of the delivery system can be great beginning stages for future research.

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