IJAREEIE

e-ISSN: 2278-8875
p-ISSN: 2320-3765

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

Volume 11, Issue 4, April 2022

INTERNATIONAL STANDARD SERIAL NUMBER INDIA

Impact Factor: 8.18

| e-ISSN: 2278 – 8875, p-ISSN: 2320 – 3765| www.ijareeie.com | Impact Factor: 8.18|

||Volume 11, Issue 4, April 2022||

|DOI:10.15662/IJAREEIE.2022.1104003 |

Challenges and Opportunities of Smart Grids

D. Musongya Bisimwa

Assistant Lecturer, Dept. of Electrical Engineering, Faculty of Applied Sciences and Technologies, Université Libre des Pays des Grands-Lacs, Goma, DRC

Student in Master, Electrical Power Systems Engineering, African Centre of Excellence in Energy for Sustainable Development, College of Science and Technology, University of Rwanda, Kigali, Rwanda

ABSTRACT: The efficiency of power system is increasing when smart grids are being developed and this is becoming true step by step by the application of renewable energy resources optimization, electric vehicles management, two-way communication, load curtailment, consumer engagement in production, demand management, grid selfoptimization, etc. In this paper, we are presenting different challenges and opportunities of smart grids. To start the way to smart grids, the traditional grid is acquiring a kind of intelligence with advanced metering, production diversification, in energy pricing, in power quality and reliability, in providing the way towards an environmentally friendly, etc. An overview on published papers related to various challenges of smart grid including interoperability, network communications, demand response, energy storage and distribution grid management is done here. Local, regional, national and global opportunities of smart grid are also done.

KEYWORDS: Smart grid, Distributed Systems, Challenges, Opportunities, Demand Response, Interoperability.

I. INTRODUCTION

To pass from today's power grid to a smart grid is a big challenge. The electrical energy system's redesign is being done in many countries in the world, to transform a conventional unidirectional structure to the one which is more open, configurable and in which others stakeholders in the sector as consumers will participate. This change is motivated by different raisons, according to one or another country. From 2010, important changes about the new technologies use's and implementation's are being undertaken by the industry of electricity with the goal of increasing efficiency of generating electricity as well in transmission and distribution [1].

Smart grid technologies are essential to positively respond to world's big and increasing electricity demand. To start the way to smart grids, the traditional grid is acquiring a kind of digital intelligence with advanced metering, production diversification, in power pricing, in power quality and reliability, in providing the way towards an environmentally friendly, etc. Smart Grid is protected against the cyber attacks; the price is fixed in real-time [2].

Micro grids work at the distribution stage, and they are logically ingenious areas for the Smart Grid because they are characterized by their expandability and adjustability, and provide power in a local zone. Micro Grids can work as a grid-connected or as a standalone system. Micro grid technology has neither automation nor communication support. Further work is needed to enhance predictive capability, flexible, reconfigurable and self-healing. Micro Grid includes special purpose inverters enabling it to link to the main grid and contains special purpose filters build to manage with harmonics issues, while improving efficiency and power quality [2].

Renewable energy sources are environment friendly sources of energy and facilitate with innovative and cheap energy sources using natural sources. These natural renewable sources for instance wind power and solar energy will come up definitely with the present and future energy generation and consumption demand. Nonetheless, these renewable energy sources have challenges while dealing with long-distance transmission of energy. Another thing is about their dependence to the weather which causes wind and solar power to be irregular. The first energy grid duty's is to deliver a stable and efficient energy to the consumers. The exact solution of maintaining the distributed energy sources and supplying energy with enhanced security of the electricity grid in long-distant zones more effectively is provided by Smart Grids. The main purpose of a smart grid is providing local production and energy consumption by producers to consumers [3].

| e-ISSN: 2278 – 8875, p-ISSN: 2320 – 3765| www.ijareeie.com | Impact Factor: 8.18|

||Volume 11, Issue 4, April 2022||

|DOI:10.15662/IJAREEIE.2022.1104003 |

Smart Grid has changed fossil fuel based and the centralized power generation to the fix of distributed and centralized power generation. Smart grid integrates renewable power to the system. Also, it progressed from one-way flow of information and electrical power to the two-way flow of information and electrical power as well, and from the supplier-driven operation of facilities to the operation of facilities involving the customers (i.e., demand-side) [2]. In the energy trading process, prosumers and consumers should be able to trade the local energy in peer-to-peer fashion without any distortion. It is not good idea to smart grid to deal with transaction of energy between prosumers and consumers by using centralized infrastructure because it needs expansive and complex communication infrastructure. Decentralized technologies are the best to face and to adapt these challenges [3].

Smart grid consists of latest innovations of communication, power electronics, advanced controls, sensors, renewable energy resources integration as a centrally connected energy source or distributed, and many more. Latest components and devices are also required for these elements to be incorporated in the system, whose performance still need to be determined under different eventualities and improvements are required suitably [2]. Full-fledged working Smart Grid will imply end users as well, so then it catches single person attention. Diverse gains that are obtained from the power system sustainability through Smart Grid include decrease in price and peak demand, improved quality of power supply and network capacity, climate change mitigation and job creation [2].

Smart Grid is one of the prime applications of Internet of Things. Smart Grid can be defined as a data communications network which is working with the electrical grid to collect and analyze data that are acquired from the transmission of power, distribution stations, and end-users. Smart Grid uses these data to provide predictive information on how to best manage power, to the suppliers and customers [4].

II. SHORT PRESENTATION ON SMART GRID TECHNOLOGY

Generally, the grid is an unintelligent system that just executes the power operations of distribution and control of transmission lines from generation to the consumer. Present-day energy requirement asks for an ingenious grid. Fig. 1 shows the expected worldwide grow in consumption of energy. With this increase in demand, failure rate of the present grid system is supposed to increase greatly in peak demand hours hence leading to a surplus expenditure of 25–180 million USD. The current power grid systems are unsuited to satisfy next generation power systems concerns firstly as a consequence of high energy demands, power grid management complexity, non-integration with renewable energy sources, and other limitations linked with capacity and generation. For that reason, development of self-regulating grid which is reliable and efficient is imperative. This kind of system will be capable to integrate practically distributed renewable energy generators which will finally reduce the dependency over fossil fuels finally resulting in an environment friendly solution [5].

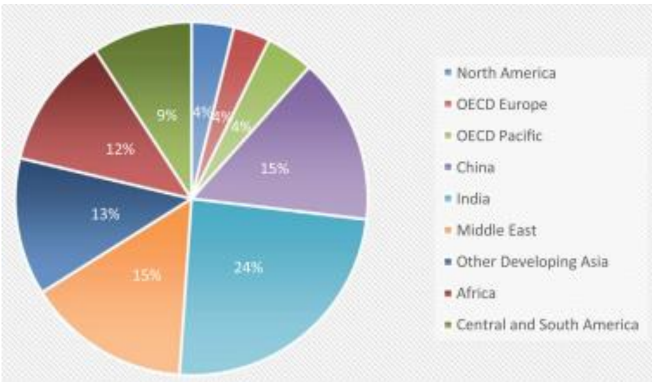


Fig.1 Global Energy Consumption Growth Percentage [5]

As a simple definition, the smart grid is an intelligent network that is automated and capable to store data, to communicate, and to make decisions. Another definition of smart grids is given by the US Energy Independence and Security Act 2007 [6]. It describes the smart grid to be a modernization to the electrical network such that it monitors, raises grid flexibility to disturbances, and automatically optimizes grid operation of interconnected system components starting from central generating units and distributed generation through transmission networks up to load centers. In addition, the US National Institute of Standards and Technologies defines the smart grid to be "a modern grid that adapts bi-directional flows of energy" and uses two-way communication and control abilities that guide to a lager range

| e-ISSN: 2278 – 8875, p-ISSN: 2320 – 3765| www.ijareeie.com | Impact Factor: 8.18|

||Volume 11, Issue 4, April 2022||

|DOI:10.15662/IJAREEIE.2022.1104003 |

of newly applications and functionalities. It adds, unlike today's grid in which the energy is supplied from centers of generation to centers of demand, Smart grids involve a two-way flow of data and energy [6].

Smart Grid offers several benefits to the existing traditional grid, which incorporates optional energy saving, incorporates the energy efficiency optimization, constructs infrastructure for network of electric power, saves facility investment cost, encourages green and renewable energy and electric vehicles to gain economic and environmental profits, and increases the reliability and quality of electric power [2]. Activities that are needed in sustainable Smart Grid technology are the smart planning, smart policies, smart operations and systems, smart technologies and smart people. Smart meters are among microprocessor based devices which can work with two-way communication. They help the consumers to control both the energy supply and the energy usage efficiently according to the cost. The power supply companies also use different information given by smart meters to set up real-time pricing for electricity [2]. The configuration of smart grids continues to evolve, as shown in fig 2 [7].

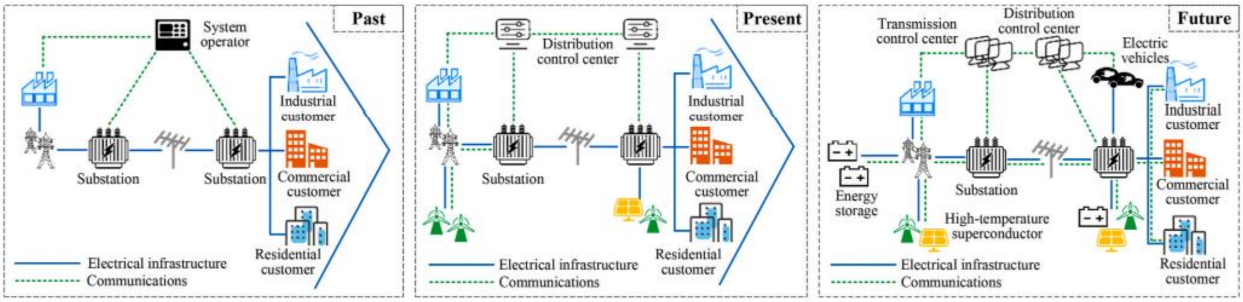


Fig.2 Evolution of Smart Grid [7]

In smart grid, many Network Topologies can be applied as Neighborhood Area Networks, Software-Defined Networks, Interdependent Networks, Field Area Networks, and Wireless Sensor Networks. The can be make from these technologies : Blockchain, Reinforcement Learning, Industrial Internet of Things, Internet of Things, Machine learning, Data mining, Machine learning and neural training, Short-term memory network, Power Line Communication Technology, Power electronics, Big data, Fog Cloud computing and Energy Storage and Power Electronics Technologies. Encryptions used in Smart Grids are Multidimensional Data aggregation and Cognitive Risk Control [1].

Both direct and alternating current can be transmitted by the Smart Grid and Data Transmission over a Smart Grids is possible. Applications that we can found in Smart Grids are Advanced Metering Infrastructure, Substation Automation, Distributed Automation, Distributed Energy Resources, Teleprotection, Anomaly Detection and Privacy Preserving. Connectivity used in the Smart Grid can be Ethernet, PDH/SDH, WDM/DWDM, Fi-Wi/RoF/C-RAN, 2G/3G/4G, MPLS, QoS, WSN [1].

Many tools can be used for the analysis of Smart Grids as Time series Analysis and Regression Model. And Protocols that can be applied in Smart Grid Algorithms are Green-RPL, Local positive degree coupling, IEEE 802.11s, Web Of Energy, Dynamic Barrier Coverage, IEC61850, Wind-driven bacterian foraging algorithm, Data Slicing, TSUBE energy trading algorithm, Stochastic Geometry, Rectangular quadrature amplitude modulation, Policy-based group authentication algorithm, Mapping interface integration COIIoT, the Bayesian NE and Nash Equilibrium, Algorithmic Approach and Wireless sensor network protocol [1]. The concepts given in fig 3 are the main keys of power systems that smart grids are going to deal with [8].

| e-ISSN: 2278 – 8875, p-ISSN: 2320 – 3765| www.ijareeie.com | Impact Factor: 8.18|

||Volume 11, Issue 4, April 2022||

|DOI:10.15662/IJAREEIE.2022.1104003 |

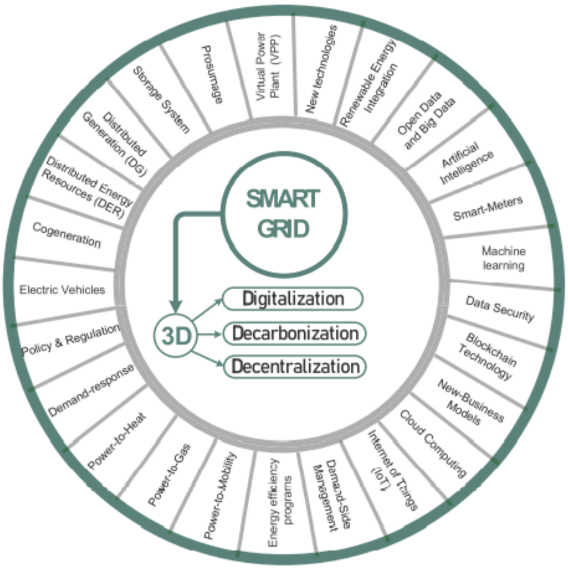


Fig. 3 Main Keys of Power Systems in Smart Grids [8]

The smart grid network potential demand has become excessive than before due to overloaded power grids which are not easy to manage in the traditional way because this infrastructure is incompatible with present energy demands and requirements. Demand for energy in peak hours generally exceeds the supply from power grids. Several problems may appear at different levels in energy generation, distribution or consumption. As the fossil fuels are used for generation of electricity in traditional power, environmental and health issues are created by grids. A smart grid solution delivers economic and environmental benefits with effective costs. A smart grid enhances the 5 use of natural renewable energy sources and gives the answer to the issues created by traditional electric power plants [3].

III. CHALLENGES OF SMART GRIDS

The principal characteristics of smart grid improvement involve enhancement of power systems, communication and standards, computational intelligence, environmental and economic factors, and test bed. The sustainable development faces some challenges such as electrical problems, human capacity, technology and political policies. These characteristics facilitate the development of energy efficient system which meets present need by including enhancements techniques of the power system, ameliorating standards and communication, developing computational intelligence technology which supports the development, economic, and environmental in sustainable energy, and demonstrating a suitable test bed which shows the advantages of Smart Grid [2]. The characteristic of computational intelligence includes all advanced analytical tools which use evolution programming, heuristic adaptive optimization methods and decision support tools for the optimization of the bulk power network. Those tools are very important and needed by smart grid for computation and designing. The development of Renewable energy is possible economically and technically and it will help increase the reliability of the system, reduce the carbon foot print of companies, decrease losses and to meet shortage in demand uncertainty. Fast decision making requires the development of automation, communication and standards hence to increase efficiency of operation. Utility and end users are those who made these decisions. The interoperability and security problems are indeed guaranteed by enforcing and designing the rules and procedures for marketing, operating and managing the Smart Grid networks [2]. Gates for the sustainable growth of Smart Grid are the development of people, home technology, government and scholar's function, challenges of the interconnection, growth technology in design, plant's maintenance and operation, Smart Grid development with varied architecture for helping demand supply management and energy efficiency. In general, the increase of power transfer capability of existing transmission systems to avoid congestion in the system is the principal technical challenge in the power system operation in a competitive and deregulated environment [2]. Among approaches which have been proposed to face this problem, we have the use of advanced technologies such as FACTS and distributed generations include optimal power flow based generation scheduling, and they can help to mitigate conditions of congestive network on the constrained transmission way. Difficulties for consideration in computational dares for the improvement of Smart Grid contain the factors here below [2]:

| e-ISSN: 2278 – 8875, p-ISSN: 2320 – 3765| www.ijareeie.com | Impact Factor: 8.18|

||Volume 11, Issue 4, April 2022||

|DOI:10.15662/IJAREEIE.2022.1104003 |

- Penetration of renewable energy resources; bidding strategies of participants prevent enterprises from giving answers with environmental objectives.
- Power system models are greatly dependent on control and operation which are intelligent; control and planning in power system help enterprises to get solutions with technical objectives.
- Absence of extensive knowledge by operators and/or engineers of computational tools that are user readily and friendly interpretable.
- Intricacy in control and operation of power system because of the Intricacy in computational tools used for uncertainties and modeling.
- Load demand forecasting, ancillary services and price prevent the enterprises from providing answers with economic objectives.
- Increase in distributed generations and tuning of controller parameters in varying operating conditions and demand response in electric market prevent the electric utility enterprises from providing smart answers with technical, environmental, and economic objectives.
- Risk minimization in electric power sector while investing in computational tools searches to set trade-off between maximizing the expected returns.

Interoperability, network communications, demand response, energy storage and distribution grid management constitute the Smart Grid principal technical challenges [2]. The analysis of these challenges is presented next, in short:

A. Interoperability

Smart Grid is sound to be a sophisticate and disparate environment that includes various types of devices, systems, networks and data. For instance, we can have devices without/with energy constraints, communication networks with fast/low processing, interactive/non-interactive systems and continuous/non-continuous big data. Considering the availability of all those communication tools operation with different protocols, all these technologies will lead to a challenge of interoperability within the smart grid while trying to communicate with each other. [9].

Interoperability describes the interaction between all existing architectures and software systems in fulfilling the objectives of smart grid. Because to reach the high capability of Smart Grid technology deployments, many smart devices with various so software and hardware must be connected together [2]. Interoperability is a prime element to be taken into account for Internet of Things systems and devices as well. The Internet of Things is formed of data acquisition, processing, transmission, and storage stages to produce a more efficient and robust communication system and it is among the latest rising communication technologies [10].

The interoperability of Plug in Electric Vehicles with Smart Grid requires to be verified specifically to optimize all the assets because those Electric vehicles have an important role to play in the future Smart Grid. The challenges involve progress and seeking smart energy management, utilization of power and energy stored sharing in batteries. The interoperability of advanced power electronics in Smart Grid should be studied as they will be part of each stage of Smart Grid; more specifically, about their complexity and disturbances that they will bring in the system [2]. Even if we can found a few information about standard models for interoperability of smart grid (e.g. IEC 61850, IEC 61850-90-7, IEC 61970/61968, IEEE 1815, and IEEE 2030.5), there is any specific standard information models about interoperability in several analytics platforms of big data, architecture, or about operational integrations of those architectures with utility decision frameworks. Otherwise, there will be a problem while uniting different parts as one system like usage and storage or while sharing data with utility operational frameworks. Interoperability between different vendors of cloud computing service is important. Thus, if interoperability standards are not outlined for the whole system, smart grid system will stay just a conceptual idea [11, 12, 13].

B. Network communications

One-way power flow systems allow simple interactions but two-way power flow systems come with smart grids; in these systems allow interactions between stakeholders. That is why Smart Grid is facing challenges of reliability and security either in wired communications or in wireless environments [2].

In this system, the date generated by utilities is growing exponentially which bring other challenges of big data, as well data mining, data storage, data querying, data processing, and data indexing will augment in an unprecedented manner in coming days. The data management is extended to the consumer level because the deployment of intelligent devices will be real in that level and their engagement in many grid services is growing. We can notice than, as the end users

| e-ISSN: 2278 – 8875, p-ISSN: 2320 – 3765| www.ijareeie.com | Impact Factor: 8.18|

||Volume 11, Issue 4, April 2022||

|DOI:10.15662/IJAREEIE.2022.1104003 |

will be deal with different devices like inverters, electric vehicles and smart meter, these will produce a big volume of data around hundreds of TB. Thus, utilities are challenged by the management of this growing amount of data [11].

All kind of communication networks are need for successful real deployments of smart grid. They can be private and public, either wireless or wired. The SG domains and sub-domains will use a variety of networks and the heart of power utility communications strategy is the substation [2]. The important of using many kind of networking environments is remarkable in the identification of performance metrics, the maintaining of access controls and appropriate security, and the validation of core operational requirements of different domains, users, and applications. Modern innovative answers, like scalable computing and distributed architecture are important [2, 11].

C. Demand response

Searching to improve the system reliability and reduce peak load demand in a system, the demand response allows the consumers to modify consumption as they are able to see the variations in price. Demand response is used in several sectors like commercial and industrial for good health of the grid and to improve his stability. But in smart grid, the Demand response will be extended in residential electricity markets on a large scale. The Smart Grid works with bidirectional and intelligence communication abilities, which allows end users to access to real-time pricing information from the utilities. Demand response mechanisms and incentives characterize fundamental Smart Grid objectives for residential customers, utilities, business and industrial to optimize the power supply balance and load demand without considering the size of the system. The reactivity and interaction of consumers are promoted by the demand response. It promotes the customers' interaction and responsiveness, and may offer a broad range of potential benefits on system expansion and operation, and on the market efficiency. When end users participate in Demand response, they can change their electricity use in three possible ways. The demand response programs can be globally classified in three groups according to the party that initiates the demand reduction action, incentive or event-based Demand response programs, rate-based or price Demand response programs, and demand reduction bids. Participants and customers benefit in saving bill, improving market performance, choice, system security and reliability [2].

The Smart Grid's energy efficiency and load control system can be more improved when the relationship between demand side management and smart metering infrastructure is increased. Advanced metering systems deliver two-ways communication which can be used by service providers to manage demand side management using smart invoicing and instantaneous pricing software program. When we combine smart metering and demand side management systems, it allows service providers to regulate tariff and energy pricing conforming to demands and load data because they are able to get the real-time load demand [10].

D. Energy storage

The storage of energy is important while dealing with smart grid, either directly or indirectly. This challenge of finding an economical way or technology of storing energy is among the greatest one for electrical power systems nowadays. Certainly, many storage technologies exist however they are not efficient or they are not economical. In addition, the integration of storage technologies is object of many researches and researchers have covered many applications of energy storage with respect to peak shaving, frequency stability, transmission upgrade deferral, voltage support, renewable firming, and many other usages. Thermal and hydro generations are the only one that can accommodate a quick bigger change in production. The output of renewable energy resources vary with the climate changes and nuclear power generation produce a changeless power. This demonstrates the necessity of an effective storage technology in electric power system as a part to ensure the reliability. Among the storage systems which exist, we can name: pumped hydro, superconducting magnet energy storage, Hydrogen storage, flywheel, compressed air, batteries etc. As they have exclusive disadvantages and advantages, these storage technologies can be selected for particular application [2]. To use one or more technology altogether as hybrid approach is being suggested by several researchers. The penetration of renewable energy resources in smart grid requires energy storage technologies such as batteries and others. In the past, although storing energy was considerably expensive and inefficient, market demand was high. But, now, as there is progress of technologies in nano-technologies, converter technologies and in chemical, energy storage systems are improving its efficiency and cost. Generally battery systems work with electrochemical processes and DC-DC/DC-AC converters. Electrochemical process is composed by anode, cathode and electrolyte in which cations and anions interact and it consists of system of power conditioning with converters. A number of battery cell technologies, contain lead-acid, nickel-cadmium, zinc air, lithium-ion, etc. In last few decades, Lead acid batteries have been appreciated for diverse on-grid applications. They are cheaper per kWh, less sensitive and robust to application conditions [2]. The cost of Lithium-ion battery is around $ 1/Wh and this makes it to be one of battery technologies

| e-ISSN: 2278 – 8875, p-ISSN: 2320 – 3765| www.ijareeie.com | Impact Factor: 8.18|

||Volume 11, Issue 4, April 2022||

|DOI:10.15662/IJAREEIE.2022.1104003 |

which are the most expensive, however Lithium-ion battery is among the most largely used battery technologies for Storage Systems. Flywheels and dynamos are mechanical energy storages. The process of water to be pumped from a lower reservoir uphill to store energy is the principle of pumped hydroelectric storage technology. This technology has advantage of long life and large energy storage. They can be promptly used reserve provision, frequency control and the energy management. The choice of Energy Storage System is done based on some parameters [2, 5].

- Thermal Energy Storage System: During the off-peak hours, the thermal energy converted from electric energy is stored in this system. This system is composed by heating/cooling setup, storage heat exchanger, air handling unit. The load shifting is available in this storage system, and the charging can be done centrally or locally. Three advantages of this Energy Storage System are the frequency regulation, rapid response rate and large storage capacity. And, its efficiency is around 100%. Hence, according to the various factors related to economic, technical and functional different load demand can be satisfied. Super conductors, super capacitors and magnetic coils are not largely used in Energy Storage System and are very expensive.
- Hydrogen-Based Energy Storage Systems consist of an electrolyser, hydrogen storage and a fuel cell. The electricity is produced through reverse electro-chemical reaction within fuel cell which has the life cycle of 20,000 cycles. Hydrogen has no emissions and can be stored for a long time. Also, it has adequate dynamic response and low efficiency of around 50%.
- Fly-wheel Based Energy Storage System: In this Energy Storage System, a cylinder that spins at a very high speed, storing kinetic energy. With a Life cycle of 10,000 cycles, Fly-wheels have almost low energy density of around 20Wh/I. This system is employed for static application and it uses induction machine or the permanent magnet electric machine. It has high energy conversion efficiency and others characteristics like : high cycling rate, fast dynamic response, long life span, high self discharge rate, energy density, high power. As one of the large scale Energy Storage System, flywheel technology has the efficiency around 99%. This technology is preferred for primary regulation goals [2].

E. Distribution grid management

Distribution Automation devices are reliable and robust. They provide higher computing power and are used as planning data source. Distribution Automation is the atomization of all the distribution system. Hence, the devices like Remote Telemetry Units (RTUs), Phasor Measurement Units (PMUs), Energy management system (EMS), Supervisory Control and Data Acquisition (SCADA), Distribution management system (DMS) and smart meters are used in distribution system [5]. Here down in fig 4 is presented the diagram of the Distribution Automation for electrical power distribution systems.

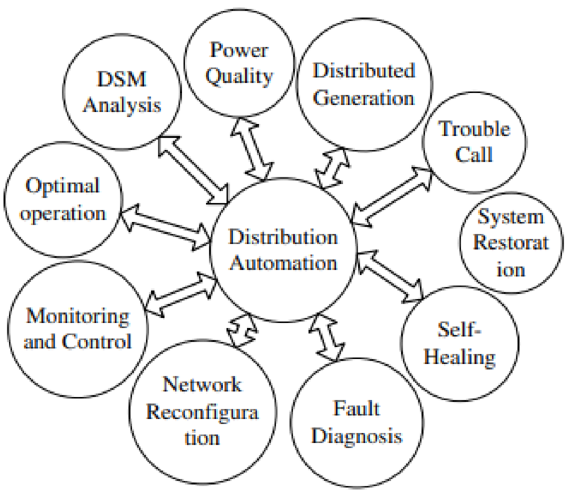


Fig. 4 Distribution automation forms in distribution systems of electrical power [5].

Some advantages of automation of intelligent grid are: optimal operation, network restoration/switching, device management and intelligent control schemes, distribution system management (DSM), self-healing, stability and fault diagnosis, control and network switching, reactive power control by handing the control coordination i.e., Other

| e-ISSN: 2278 – 8875, p-ISSN: 2320 – 3765| www.ijareeie.com | Impact Factor: 8.18|

||Volume 11, Issue 4, April 2022||

|DOI:10.15662/IJAREEIE.2022.1104003 |

advantage is that distributed generation can be used in emergency through demand reduction and intelligent controls. The part of electrical power system implies the delivery of energy to consumers and the associated features. A number of continuing dares for grid upgrade are underlined by Distribution Automation [2, 5]:

- Powerful control methods and speedy simulation approaches in the operation of recent grid systems which are facing large numbers of variable generation.
- Ameliorated interoperability and cyber security techniques, protocols, standards, and tools for cost-effective, rapid, and safe Distribution Automation implementation.
- Penetration of Distributed Energy Resources Management System (DERMS) along with smart grid Distribution management system.
- High-resolution, cheaper sensors which report real-time conditions across feeders to optimize the visibility of the operator of distribution system onwards the substation assets.
- Power electronics and advanced grid devices, including solid-state distribution transformers, provide upgraded functionality and flexibility to manage microgrids and raise the overall efficiency of the system.
- Advanced Distributed Energy Resources Management System to integrate demand-response and distributed resources in a cost-effective and coordinated manner.
- Less expensive and trustier storage systems to manage distribution systems and improve the penetration of distributed energy resources (DERs).

F. Dynamic process of failure and restoration

A smart grid is either self-sufficient or greatly interdependent. In addition, smart grid can be set out as a conventional power grid which is controlled by a communication network and others functions. The development of integration of variable renewable energy and emerging techniques is done in smart grid to a classic cyber-physical system. In smart cities, as all multiplex systems are connected together, it can result in a catastrophic general blackout. Therefore, those multi-systems are more exposed because, considering each individual power system which forms these multi-systems, a chain of cascading failures could spread quickly and reaches the interdependent networks. Thus, the solution is the improvement of the modeling framework, and the development of adequate reconfiguration technologies to restore interdependent networks [7].

G. Penetration of renewable energy resources

Many challenges appear while integrating renewable energy resources to the grid because of their variability and limited predictability. Two challenges are discussed in [14], which are Low Voltage Ride-Through capability and inter-area oscillation. To stop system cascaded fault, these renewable resources should ride-through low voltage situations and failures. That ability of renewable systems is called the low-voltage ride-through capability. The stability of power system can be improved renewable sources like inter-area oscillation damping. The oscillation issue is that power transfer capabilities are limited, specifically in long transmission lines and additional instability is added to the system during abnormal events [14].

H. Others Smart grid’s challenges

Others Smart grid’s challenges can be listed below: Financial Resources, Government Support in efficient energy policy, Compatibility of Equipment which exist now, Consumer Education to use smart grid, Cost Assessment, Ability to absorb advanced technology, Cyber Security and Data Privacy[13].

IV. OPPORTUNITIES OF SMART GRIDS

In many developed countries, researches are being done by institute of Research to develop smart grids technologies. Among them we have the Electric Power Research Institute (EPRI) in United States of America (USA), the Electric Power Research Institute (CEPRI) in China, the European Energy Research Alliance (EERA) in Europe and POWERGRID in India. There are focused in smart grid activities like electricity generation, wind turbine blade inspection, advanced hydro turbine demonstration, power plant water consumption reduction with nano-particles, transmission line robot, smart meters, environmental considerations and social impacts, radio frequency, toxicology study of power plant emission, electrical measurement, renewable energy, new materials technologies , communication technologies, superconducting magnetic energy storage, regulatory framework and policy advocacy for tariff design and net metering, etc [2].

| e-ISSN: 2278 – 8875, p-ISSN: 2320 – 3765| www.ijareeie.com | Impact Factor: 8.18|

||Volume 11, Issue 4, April 2022||

|DOI:10.15662/IJAREEIE.2022.1104003 |

A. Local opportunities for Smart Grid

Some of the essential new technologies and the principal research and improvement that will develop the Smart Grid systems are listed below [2]:

- Integrated Communications: To link the units to open architecture to handle the real-time control and data allowing one and all part of electrical grid like talking and listening at the same moment.
- Advanced Control Methods: To monitor principal components that precise suitable solutions for any situation and allows quick diagnostics.
- Measurement and Sensing Technologies: To support very fast and more precise responses, such as demand-side management, remote monitoring, and time-of-use pricing.
- Advanced Components: To apply current research in power electronics, diagnostics, superconductivity, and storage.

B. Regional and national opportunities for Smart Grid

Before focusing on specified technologies for moving ahead, utilities and the government have shared input about primary functions they need in smart grid. The opportunities for regional and national level involve the characteristics, like self-healing and resist attack, provide higher quality power that will save money lost on outages, motivate end users to participate actively in operations of the grid, and accommodate energy storage options and all generation [2].

The architecture and concepts of blockchain technology have opportunities when this technology is integrated in smart grid. Blockchain is defined as a ledger-based on distributed database in the shape of connected blocks forming a chain. By a linked part each block is linked with the previous and next blocks in the connected chain and it consists of information. The maintenance of all the variations in the blocks is the principal advantage of this technology since no block can be changed or eliminated and all blocks are linked in the chain. This feature makes blockchain more secure and changeless during the transfer of safety-critical items like money and contracts without any intervention of a third party as banks [3].

Power-line communications is known to be a cabled technology that utilizes existing electrical power lines for transmission at no more than 3 Mpbs [15]. As an opportunity, this technology is a possible substitute for the development of end-to-end communications, from the stage of home electric appliances, controlling/monitoring applications to distributed generation level based, control/management applications with a free existing network. It is exclusively the IEC 61334 series standards and reachable proven technology, which is playing a importance role to make our energy practices/ requirements ‘smart’ and constitutes the key of a comprehensive smart metering M/441 architecture according to international standards [16].

The three principal parts of an electric power system are production, distribution and power consumption. To increase the performance of these parts, many technologies can be involved via wireless sensor networks (WSNs), which are growing to be an essential key in the smart grid system as the next-generation electric power system. The current part addresses the opportunities that WSNs implementation can bring in a smart grid. It must be underlined that various smart grid applications can work together not only with WSNs even so with other different wireless technologies (e.g. Wi-Fi, WiMAX) and also with the power line communication technologies. For example, long-range backhaul communication technologies can be used by sophisticated metering applications [13].

C. Global opportunities for Smart Grid

The global energy challenges that are policy and technical will allow higher integration of Renewable Energy Resources and permit markets of electricity to prosper but they necessitate efficient analysis for the Smart Grid to operate the grid more effectively [2].

In coming days, digital twin technology can be surely adopted for smart grids. In addition, edge computing, 5G communication technology, fast-developing IAI technologies, and sensor technology as well provide numerous opportunities to improve the restoration of smart grid [7].

Worries about climate change have been considered as a keystone by the international energy policy. Smart Grids are capable to participate in the adaptation and moderation of the climate change. They are done by ameliorating system

| e-ISSN: 2278 – 8875, p-ISSN: 2320 – 3765| www.ijareeie.com | Impact Factor: 8.18|

||Volume 11, Issue 4, April 2022||

|DOI:10.15662/IJAREEIE.2022.1104003 |

reliability and resilience and by diminishing low-carbon electricity production. This is possible by the deployment of large scale wind and solar plants in Smart Grid to supply electricity to the transmission lines. And this will afford the expansion of favourable conditions for the renewable energy sector development [17].

V. CONCLUSION

This paper has developed in detail a review about different challenges and opportunities of smart grid. While designing the Smart Grid systems, the principal problem which is faced by involved people is the adoption and absence of awareness of standards. One more challenge is to incorporate the replaceable parts from a diversity of various providers all over the world, i.e., interoperability and standards. Several challenges for smart grid comprise the capturing the benefits of storage, plug-in hybrid electric vehicles and distributed generation, enhanced communications and intelligence, integrating intermittent renewable energy resources, and give the strength to the grid. Therefore, this paper concludes that the smart grid has many problems and challenges that must be to be taken into account; however we enumerate also many opportunities to handle some of challenges. When Smart grid technology will be implemented, it will help for saving money, reducing demand, and improving efficiency and reliability.

REFERENCES

[1] J. J. M. Escobar, O. M. Matamoros, R. T. Padilla, I. L. Reyes and H. Q. Espinosa, “A Comprehensive Review on Smart Grids: Challenges and Opportunities” in sensors, 21, 6978, Oct 2021

[2] S. R. Salkuti, “Challenges, issues and opportunities for the development of smart grid” in International Journal of Electrical and Computer Engineering, vol. 10, pp 1179-1186, Apr 2020.

[3] N. Arjomand H. Sami Ullah S. Aslam, “A Review of Blockchain-based Smart Grid: Applications, Opportunities, and Future Direction” Jan 2020.

[4] A. Ghasempour, “Internet of Things in Smart Grid: Architecture, Applications, Services, Key Technologies, and Challenges,” *Inventions*, vol. 4, no. 1, p. 22, Mar. 2019.

[5] M. Irfan, J. Iqbal, A. Iqbal, Z. Iqbal, R. A. Riaz and A. Mehmood, “Opportunities and challenges in control of smart grids – Pakistani perspective”, *in Renewable and Sustainable Energy Reviews*, vol. 71, pp 652-674, May 2017.

[6] I. Alotaibi, M. A. Abido, M. Khalid, and A. V. Savkin, “A Comprehensive Review of Recent Advances in Smart Grids: A Sustainable Future with Renewable Energy Resources,” *Energies*, vol. 13, no. 23, p. 6269, Nov. 2020.

[7] D. Fan, Y. Ren, Q. Feng, Y. Liu, Z. Wang and J. Lin, “Restoration of smart grids: Current status, challenges, and opportunities” *in Renewable and Sustainable Energy Reviews*, vol. 143, 110909, Feb 2021.

[8] G. G. Dranka, P. Ferreira, “Towards a smart grid power system in Brazil: Challenges and opportunities” *Energy Policy*, vol. 136, 111033, 2020.

[9] A. Kumari, S. Tanwar, “Secure data analytics for smart grid systems in a sustainable smart city: Challenges, solutions, and future directions” *Sustainable Computing: Informatics and Systems*, vol. 28, 100427, Aug 2020.

[10] Y. Kabalci, E. Kabalci, S. Padmanaban, J. B. Holm-Nielsen, and F. Blaabjerg, “Internet of Things Applications as Energy Internet in Smart Grids and Smart Environments,” *Electronics*, vol. 8, no. 9, p. 972, Aug. 2019.

[11] B. Bhattarai, S. Paudyal, Y. Luo, M. Mohanpurkar, K. Cheung, R. Tonkoski, R. Hovsapian, K. Myers, R. Zhang, P. Zhao, M. Manic, S. Zhang, X. Zhang, “Big Data Analytics in Smart Grids: State-of-the-Art, Challenges, Opportunities, and Future Directions” *IET Smart Grid,* vol. 2, 0261, May 2019.

[12] G. De La Torre, P. Rad and K. R. Choo, “Implementation of deep packet inspection in smart grids and industrial Internet of Things: Challenges and opportunities” *Journal of Network and Computer Applications*, 2326, Feb 2019

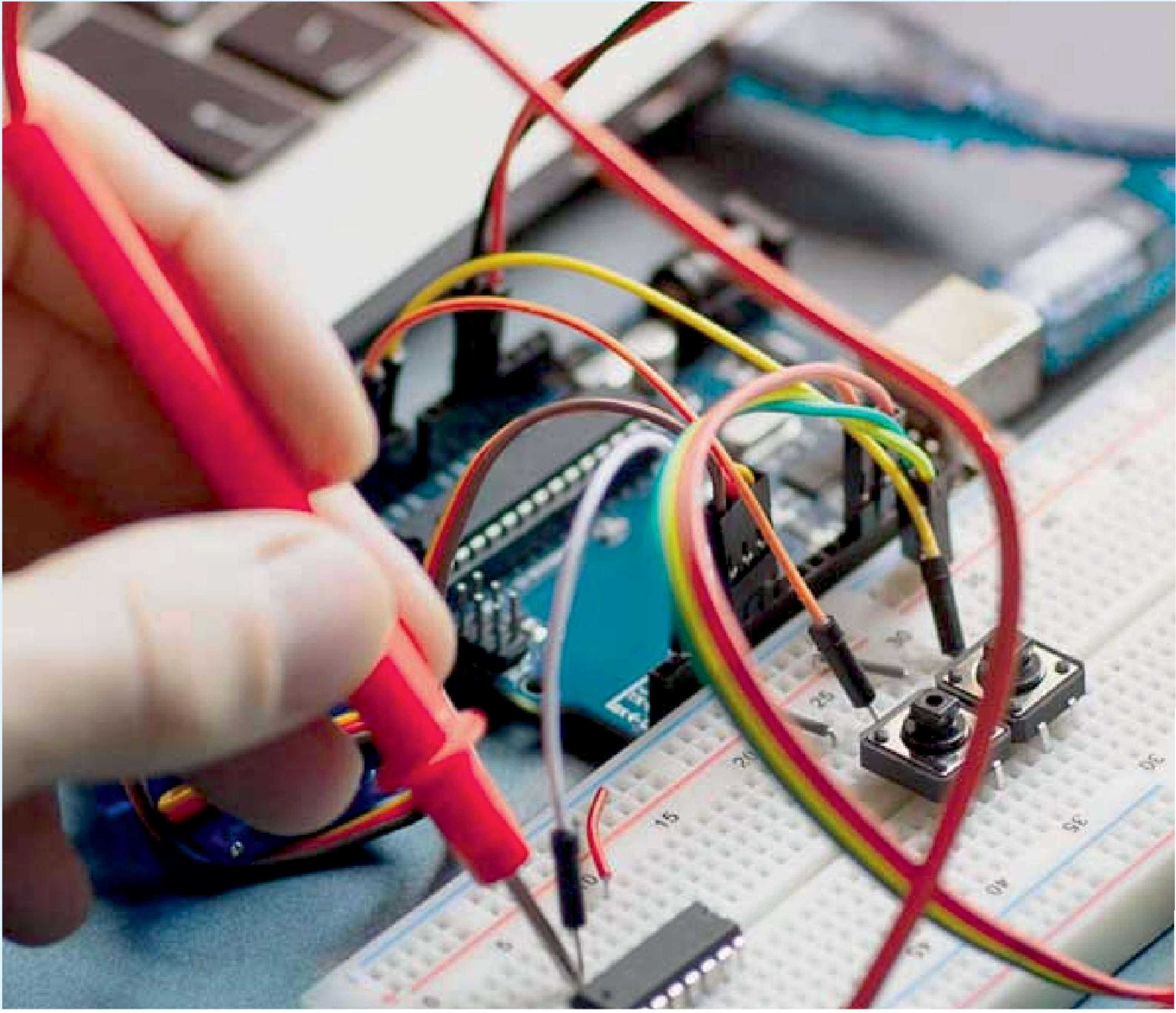
[13] Ali Hadi Abdulwahid “Power Grid Surveillance and Control Based on Wireless Sensor Network Technologies: Review and Future Directions” *J. Phys.: Conf. Ser.*, 1773 012004, 2021.

[14] D. Eltigani, S. Masri, “Challenges of integrating renewable energy sources to smart grids: A review” *Renewable and Sustainable Energy Reviews*, vol. 52, pp 770–7 80, Jul 2015.

[15] D. B. Avancini, J. J.P.C. Rodrigues, S. G.B. Martins, R. A.L. Rabêlo, J. Al-Muhtadi and P. Solic, “Energy meters evolution in smart grids: A review”, *Journal of Cleaner Production*, vol. 217, pp 702-715, Apr 2019.

[16] K. Sharma, L. M. Saini, “Power-line communications for smart grid: Progress, challenges, opportunities and status” *Renewable and Sustainable Energy Reviews*, vol. 67, pp 704-751, Jan 2017.

[17] M.A. Ponce-Jara, E. Ruiz, R. Gil, E. Sancristobal, C. Perez-Molina and M. Castro, “Smart Grid: Assessment of the past and present in developed and developing countries” *Energy Strategy Reviews*, vol. 18, pp 38-52, 2017.



INNO SPACE
SJIF Scientific Journal Impact Factor
Impact Factor: 8.18

INTERNATIONAL STANDARD SERIAL NUMBER INDIA

निस्केयर
NISCAIR

International Journal of Advanced Research

in Electrical, Electronics and Instrumentation Engineering

9940 572 462 6381 907 438 ijareeie@gmail.com

www.ijareeie.com

Scan to save the contact details