ANALYSIS OF POWER SYSTEMS FOR SMART GRID USING AUTOMATION, COMMUNICATION AND INFORMATION TECHNOLOGIES

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Abstract
The smart grid (SG) has updated a tried-and-true power distribution system by introducing new data-information-and-communication technologies (ICT). With increased power flow and efficiency, SGs feature better power distribution and transmission from power generation to end consumers. Along with the aforementioned contemporary automation, traditional SG characteristics include two-way communication, sophisticated monitoring, and control to address power quality concerns. This protects all of the associated power system's components' effectiveness and dependability against potential threats and assures that they will last their entire life cycle. The utility firms' productivity increased as a result of SGs' integration of ICT into the power system. Improved asset management and energy management for end users are results of integrating ICT with SG. This article provides an overview of the many communication and information technology fields included in SG automation.
Keywords - Smart Grid (SG), Information and Communication Technologies (ICT), Distribution Automation (DA), Phasor Measurement Unit (PMU), Flexible AC Transmission Systems (FACTS).

1. Introduction

The focus of current energy research is increasingly on holistic approaches to delivering continuous and effective energy-based systems, as well as solutions for the rapid development of next generations energy demand at various points of usage [1]. Future power system innovations will include sophisticated methods to boost quality of the electrical power system's & dependability [2]. Renewable energy sources (RES) are the greener power sources, may be thought of as a method to fulfill the demand for electricity while reducing greenhouse gas emissions [3]. Due to its sporadic nature, RES, however, has drawbacks [4]. Utilizing effective energy storage systems with RES will eliminate the related power fluctuations [5]. It is not an easier or more straightforward effort to integrate various RES entities with traditional grid operations. Coordination of the smart grid (SG) depends on effective data exchange between power system entities [7]. The whole structure of the power system may be viewed as a logical information network made up of electronic devices that act as nodes (information sources) and transfer data to various sinks (data aggregators), which are interlinked through different communications protocols at differing levels. Information linkages that span several systems,

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such as utility companies, clients, and communication protocols, are used to send data from source nodes to sink (destination) nodes. A set of interoperability standards is necessary to provide the best possible communication between these nodes [8For the grid to perform its intended duties, it requires developed and trustworthy automation for effective monitoring and control using information and communication technologies (ICT) [9].

Because of technological advancements, the legacy grid has evolved into the SG. The incorporation of diverse entities into the SG network is the basic organizing principle. Based on SG's proactive scheduling of demands, generation of power, their transmission & distribution are handled appropriately & smartly [10].

The accessibility of real-time information is the main benefit of SG for utilities. This is because timely data delivery improves the monitoring and control capabilities of utilities [11]. Data servers receive enormous volumes of data, which may be analyzed with skill and effectiveness. Smart ideas must be made at the power system level to decrease power costs, maintenance expenses, output expenses, & improve the life span of overall power system [12]. In order to reduce power disturbances, isolate problems, and quickly restore power outages, data decisions are integrated with modern control technologies and data transmission technologies. Table 1 outlines several SG advanced technologies and provides information on how they are implemented. SG has to solve the following four significant issues:

- SG must act swiftly in response to shifts in power demand caused by consumer load utilization. In order to adapt to the changing economic situations, it should take efficient energy technology into account. It's important to consider how SGs are impacted by electric automobiles [13].
- The ecology should be protected from carbon dioxide emissions by SG, which should support hybrid generating alternatives with all RES possibilities [14].
- SG should take into account new technologies and approaches to handle the issues brought about by unpredictability and improbability in both supply and demand. The intermittent nature of RES and shifting client preferences are the main causes of this predicament [15].
- To provide safety from a variety of weather circumstances and cyber attacks, SG should take into account the dependability and security of electric assets.

Table 1. SG implementations through advanced technologies

Area Type	Hardware	System & Software
Wide-ranging Area Monitoring.	Phasor Measurement Unit (PMU).	SCADA, Wide-ranging Area Monitoring, Protection & Control (WAMPAC).
Information & communication Technology (ICT).	Communication equipment (Broadband wired & wireless access).	Customer Information system (CIS), Enterprise resources planning software (ERP).

RES-generation, distribution & integration.	Converters & Inverters, Battery storage, Smart control systems, communications equipments.	Distributed automation & management system (DAMS).
Power transmission standardization.	FACTS, PMU, Synchro-phasors linked through communication devices.	Automated recovery systems (ARS).
Advanced measuring infrastructures.	Smart meters, sensors, Actuators, smart displays, home gateways.	Meter Data Management Systems (MDMS).
Electric vehicle charging infrastructures.	Converters & Inverters, Battery storage, smart switches.	G2V & V2G Methodologies, Smart power billing.

The integration of a wide variety of physical power system resources & communication devices for sophisticated monitoring & controlling is what gives Smart grid its intelligence. The SG uses a variety of cutting-edge technologies to increase the intelligence of distribution infrastructure. SG provides for the exchange of real-time information for the scheduling of generation and transmission systems and permits power system for power distribution & generation development. For the seamless integration of multiple technologies, the best regulatory laws must be formulated. As a result, areas for SG services that are promising are: designing tariffs, managing end-user complaints, forecasting RES generation, setting up and commissioning services, & economic management. There are three key levels in the SG architecture:

1. Power system level,
2. Data communication level and
3. Information technology level

Power generation, transmission, and distribution networks, as well as end-user facilities, form the power system level. The data communications layer is in charge of communicating data on energy usage based on latency constraints established in accordance with SG regulations. All grid electrical components may send data in both directions—from utility centers to all other grid components—by using the communication layer. Data management, data analysis, and data gathering are the responsibilities of the information technology layer. Utility companies can use it primarily to schedule loads and manage their energy. The following two elements make up the transferred data between the end-user and the utility: i) energy consumption from the user side and tariffs from the utility side; and ii) assessment of different SG component circumstances allowing for their management, monitoring, and repair. Power grids are able to self-regulate thanks to contemporary practical approaches, tools, and cutting-edge technology in the fields of data analytics, control, and data communications. The parts that follow go into further detail on several elements that improve SG performance.

2. SG – Power System Automation Expansion

Generation assets, Transformers (of the step-up/step-down kind), & distribution system feeders are some of the components that make up the infrastructure of the power system. They are dispersed widely, which makes monitoring electricity firms more difficult. The existing power system was created as a centralized system that only allowed for the supply of power in one direction, from power generating plants to end-user locations. Because smart grid offers superior functions for power generation, transmission & distribution, it has grown to be a valuable resource for utilities. It transforms the aforementioned processes from a centrally managed system to a market-based operating system. The incorporation of RES aids in lowering carbon emissions but does not guarantee a constant supply. This issue can be solved by adjusting generation from RES; however, due to high penetration in environmental circumstances, this generation is unpredictable. Therefore, it is crucial to pay attention to security measures in order to maintain constant supply and demand. An intelligent power system's block diagram is shown in Figure 1. Electrical power networks now include complex two-way communication (information flows) thanks to the SG method.

High transmission and distribution losses are introduced by the generating plant's distance from the distribution region. Electrical components become intelligent as a result of the introduction of bidirectional communications in SGB. Through the use of IT and business strategies, advanced computing in Singapore (SG) enables the dispatching, planning, and management of contemporary time loads. Power systems operate better overall as a result of the use of cutting-edge information technologies such as effective data communication, intelligent electronics, and an IoT. Power system planning that is effective is crucial for determining supply and demand. The sophisticated, technology-focused SG will play an important role in next-generation Power systems. This is due to SG's introduction of enhanced monitoring & controlling systems for effective power managing in addition to the introduction of bi-directional connection among electrical equipments & users.

Smart Grid		
SCADA		**AMI**
Generation	**Transmissions**	**Distributions**
Independent Generators	Independent system operator management	Investor owned & Utility managed
Conventional & non-Conventional recourses-based generation	Operated by public utility companies	Operated by public or private utility companies

Figure 1. SG functions block diagram

2.1 Power systems SG's focus on the generating side

Power systems investigate has advanced, allowing the electrical industry to operate more wisely. Greater dependability for power generation systems has been ensured by the interconnection and mutual dependency among the various generation stations. Power system networks have grown increasingly sophisticated, and this has led to the emergence of "intelligence" in systems that have progressively advanced in sophistication through time. Unlike the previous approach, the current power dispatch guarantees increased flexibility from the current infrastructure.

To fulfill the demand for power, sophisticated energy management strategies are necessary. Tailored to the systematic allocation of load between RES and conventional resources. Although they provide a steady supply of electricity, traditional resources (coal and petroleum products) are continually used, which causes their depletion. Additionally, the environment is impacted by the release of carbon dioxide from traditional resources. As a result, RES, or sustainable energy resources, are becoming an alternate and important component of power generation, but it's important to guarantee the quality of the electricity. Solar and wind energy supplies are sporadic, which causes abrupt swings in power output. Therefore, it is necessary to create dynamic infrastructure and systems for better controlling power fluctuations. It necessitates introducing a fresh kind of intellect. The SG plans the generation of power according to the present need and operates based on market circumstances. As a result, the scheduling of the power plants is done using real-time demand monitoring. Additionally, it seeks to reduce operating expenses and anticipates maximizing profits from different tariff structures.

The SG offers a 2-stage planning for power generation management to the utility companies, first at the level of the production system and then at the level of the fleet. The key details taken into account in two steps are outlined as follows:

The following are the essential needs for plants:

- Generation Monitoring: The metering resources provide real-time data. The power generation is scheduled to plan, & the schedule is assigned to all energy sources appropriately based on the information gathered. In order to improve power dependability, key performance indicators (KPIs) on the generating side are also constantly checked. Net generation and gross generation are two of the KPIs with differing patterns.
- Merit order dispatch: Merit Order Distribution Reduced generating costs will be the primary objective for utilities. The load is properly divided over several generating units in order to save costs. SG has effectively planned this.
- Reporting: With the advent of SG, utilities are now able to provide extensive information on plant and unit operations, plant or unit scheduling, plant load factor, and unplanned interchanges to consumers and vice versa.

The following conditions are crucial for fleet management in utility control centers:

- Commercial generation: In general, electricity production is scheduled per day in advance. The development of smart grid makes it possible to support prompt decisions based on installed capacity, consumer location, equipment limits, and outages.
- Plant level Built-in monitoring: Aiming to create the appropriate demands, the utility control centre in Singapore receives information from all the power facilities regarding the generation capacity of each unit.
- Optimizing & reconciling revenues: A utility's income is based on an availability-based pricing structure. The information given by load dispatch centers can be used to confirm the tariff and the corresponding energy used.
- Scheduling the generation: This is the standard automation of a plant's activities as managed and operated by its management and operators. Given all the limitations in the system at that time, the solution should compute and deliver a generating capacity that would be optimal.
- Modeling the Tariff: If there are any contingency-based changes to the regulations controlling the SG, a dynamic solution should be able to manage updates to tariff models.

2.2 Power systems SG's transmission-side scope

The power transmission dependability factor must be at its highest for a given expanding demand for electricity consumption since it is the foundation of the complete power system networks. When the transmission infrastructure is sluggish, the expansion of the energy industry may be constrained. PMU, phasor data collector (PDC), FACTS, improved storage in addition to the constantly expanding transmission in the case of HVDC and HVAC, wide-area monitoring, and WAMPAC are some essential components of transmission systems that guarantee a trustworthy transmission system. Although the transmission system's capabilities can support the current load, SG adoption on a bigger power system scale would require upgrading the transmission system's capacity, necessitating a considerable infusion of funds.
The transmission system serves as a conduit between the power system's far-flung generation and consumption in a basic power system scenario. This includes the component of power system interconnections, which is a highly expected element in the SG scenario. Several significant factors may be listed, including: i) the facility of power transmission among 2and temporally diverse places, resulting in fewer outages at both said locations; and ii) the use of various fuels to achieve the ultimate goal of energy utilization. Therefore, in an SG situation, the sale of power would only be encouraged and promoted in the presence of a reliable transmission infrastructure. Synchro-phasor technology is crucial for the functioning of transmission networks in this respect, especially for enhancing dependability.

Following is a detailed explanation of several key concepts related to SG-based transmission systems:

PMUs' function in modern transmission networks. When an electrical component is time-synchronized, its sine waveform may be conceived of as having a certain size and phase angle, which is what synchro-phasors represent. PMUs, which are much quicker than SCADA, are used to measure synchronized phasors. Synchro-phasors have more knowledge about the stability of the power system due to their precision. This motivates the usage of synchronized phasors to reduce grid operation expenses. The usage of PMUs provides the following answers to issues encountered in monitoring a broad network of the power system because of their measuring capabilities: When viewed holistically, the use of PMUs in model-based analysis, real-time solution, and imbalance mitigation may be included in a larger framework for power system efficiency and reliability. PMUs may be included in the power system's overall control strategy as well as the production and analysis of models. Although PMUs naturally give more data about the grid, the data might still be utilized when combined with SCADA to monitor the extensive network.

Role of PDCs in advanced transmission systems:

The beginning of networks of PMUs employing the synchro-phasors technique is a sub-station, which serves as the backbone of the electrical network and expands by collecting real-time data from the CT and PT (current transformer and potential transformer). A PDC receives the data from the PMUs via a high-speed communication mechanism. The PDC would separate the flawed data after receiving it and time-stamp the remaining information into data sets. Additionally, this data is transmitted onto high-speed communication systems for analysis or use by a PDC with more processing power.

Role of advanced transmission applications:

It is much trickier to anticipate any network imbalances, failures, or similar eventualities due to the complexity of the power system. Under these circumstances, even mini power systems outages would increase the demand sensitivity to monitoring & control systems. The WAMPAC System is a state-of-the-art transmission protection system that depends on intelligent electronic devices (IEDs). In order to quickly communicate with the control centre and communicate with the PDC with high precision, IEDs are utilized to collect samples of input and output signals. WAMPACs have checked off several implementation-related boxes, from the power system's technical needs to the criteria for economic feasibility & ecological sustainability. This makes it clear that using the WAMPACs in the power system will only provide a consistent and satisfying demand for electricity. The WAMPAC would require phasor and frequency information obtained by a PMU based on sensors that would convey voltage, current phasor, and frequency information in order to actualize its technical aspects.

2.3 The scope of a SG for power systems towards distribution systems

Given their physical proximity and accessibility, distribution networks have not undergone considerable automation. The system became entirely local for the utilities after it was put on the feeders & connected to the transmission network, as opposed to the lengthy transmissions network or generation end. It would only need sporadic adjustments. Any automatic reactive power setups that need to be formed dependent on the load conditions using capacitor banks may be done on the basis of local signals and predetermined variables. Additionally, a fault situation would only be automatically handled a certain number of times. In the event of a current overload, specified lateral fuses would blow. The automation of the distribution networks is a result of the rising demand for power. A greater need for distribution automation

(DA) is mentioned in the smart grid policy criteria. The power system's user interfaces ought to serve as the foundation for DA, which ought to then go on to the transmission system and its interactions, leading to larger and more interconnected distributed energy resources (DER), as well as any other component requiring planning and technical effort.

Distribution automation functions:

DA performs isolated tasks like observing VARs on a feeder or locating system errors.

When compared to the bigger advantage of viewing them in accordance with such other functions, the productivity of these functions is negligible. The DA functions, in any event, depend on fundamental operations like SCADA.

Key advantages of distribution automation:

According to the five categories of advantages that result from using DA functions, they can be listed. Additionally, the following advantages are evaluated for the use-case scenarios:

The adoption of DA systems has clear advantages, including reduced implementation costs, avoided operational and implementation expenses, expected & steady prices, & a variety of pricing options for customers.

- Reduced frequency and duration of outages, cleaner electricity, and more dependable control of DG in combination through load management system are all benefits of reliability and quality.
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- This increased dependability quotient makes it possible to better position the system format, take into account cyber security and cyber threats, handle risky scenarios, boost plant security, and achieve energy independence.
- The effectiveness of the system's energy management has its own advantages. It comprises lower energy use and lower utility at the anticipated peak.
- The generation of greenhouse gases and other pollutants will be decreased, which will have a favorable environmental impact.

3. Smart Grid – Data Communication Systems Scenario

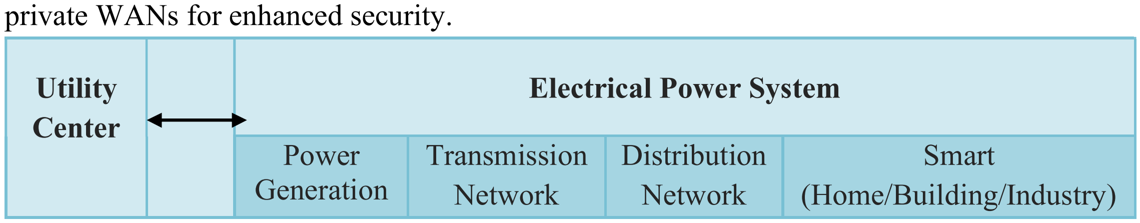
The utilities can now access real-time data to help them make informed decisions in both friendly and hostile circumstances because of SG technology. Increased monitoring will result in fewer failures, less maintenance, cheaper outages, and longer asset lives for the power system. The integration of new data communication and control technologies will decrease power disturbances, isolate faults, and speed up the restoration of outages. Coordination of the generating facilities, transmission system, utility firms, distribution system, and power market is greatly aided by the communication setup.

By lowering losses and voltage changes, using an information communication for transmission network may improve real-time monitoring, shield the system from possible disruptions, and ensure optimal usage of the transmission system. Substation automation and DA play key roles in enabling smart distribution networks. A potential strategy for future distribution networks is the greater use of DERs. By selecting and constructing various DERs from the available spinning reserve, SG shifts the peak loads. Information exchange between DA & monitoring systems & substations is greatly aided by the communication infrastructure in use. The customers & substation managements are intended to communicate information in the smart distribution system to increase stability. One aspect of enhanced data communications for advanced metering infrastructure is the two-way transfer of data from the utility to the end user and vice versa (AMI). All types of networks can be used for this, including fixed radio frequency networks, power line networks (PLC), fiber optic networks, and wireless networks. The utility can receive the data gathered by the smart meter over a wired or wireless link. In order to accept orders from the utility or update information for the end user, normal communication is required.

The smart meter is a delicate and intricate instrument that smoothly transfers enormous amounts of data between household appliances and utility centers. The data from smart meters is extremely reliable, and only a few people have access to it. The data movement inside the network is safeguarded by the communication standards and methods, which should be secured. To provide safe cryptographic encryption, each smart meter is given a distinct value, & all of the linked devices are given a comparable value. Even in the event of a power loss, the smart meter should be supported by the communication network. The communication technologies that are employed should be affordable, have increased transmission ranges, incorporated standard security measures, and provided the required bandwidth. Based on the different SG application kinds, the data communication network systems are generally divided into three groups: home area networks (HAN), neighborhood area networks (NAN), and wide area networks (WAN).

From a single utility centre, the three networks are in charge of administering all the appliances and apps. A network model containing several SG networks is shown in Figure 2. Demand response and AMI are mostly used in end-user locations made possible by HAN. Wi-Fi (IEEE 802.11) and ZigBee (IEEE 802.15.4) are only two examples of the wireless technologies that HAN uses to coordinate smart meters for its monitoring needs. The utilization of Ethernet and PLC are two examples of wired solutions. Wired connectivity, however, offers good data speeds and security. In comparison to wireless, Ethernet has higher wiring expenses and less flexibility. PLC use for HAN is still in its early phases.

WANs provide SG connectivity between the utility centre and NAN. WAN makes use of a high-bandwidth networks for backup communications among numerous substations, DA, & data aggregation points dispersed across great distances. The most crucial components of WANs are protecting power system security and dependability. Instead of relying on open networks, the majority of utility operators, including AT & T, Verizon, and Sprint, employ private WANs for enhanced security.



Internet Cable	WAN	NAN	HAN

Figure 2. System integration of SG with various networks

4. IT'S Impact on The IOT and Related Systems

4.1 IoT for SG applications

The IoT concept served as the foundation for the first automation-based enhancements to the conventional grid. The sophisticated utility system and increased DA were the names of the earliest IoT-based efforts. Given that utilities have more "things" than nearly any other industry, scattered across a larger region, they make up a big, complicated, linked machine.

New use cases are made possible by intelligent objects as the utility industry creates new energy-related services. Real-time application of production analytics to data gathered from smart meters & other instruments is essential to gaining insights for improved automation and business choices. A portion of the IoT tenets is represented by SG, and some of the more sophisticated applications included modern IoT ideas.

IoT may establish a sizable network and function independently. Important aspects of IoT include the maintenance and restoration of connectivity during outages and increasing traffic. It is therefore regarded as appropriate for a variety of wired and wireless communication mediums. IoT effectively gathers data from several different sensors. Among the most important IoT applications are the monitoring of network configuration, communication quality, and device configuration. That is difficult to do using conventional autonomous distribution networks. Parsing the statement also requires consideration of IoT. Internet does not always refer to the open Internet.

Think about the more upscale Internet2 regional systems that are recommended for offerings like the Eastern Interconnect Data Sharing Network. People count as "things," leading some to coin the phrase "internet of everything." In the broadest sense of the term, "things," they include technicians, trucks, poles, consumers, and wind turbines. Short IoT "to do" list for energy and utilities: Prioritize security, execute experimental projects for cloud computing, big data analytics, and end-user experiences (whether for customers or technicians), reinvent end-user planning, and then test, learn, and adapt. Research has been done on using IoT data for all analyses and creatively utilizing new data discovery methods that can offer a high return on investment as well as faster approaches to problem resolution and optimal operation.

4.2 SG's data analysis difficulties

Depending on the type of application, the SG systems produce enormous volumes of data at various times. To use data in a methodical manner, utilities must handle data management challenges. This is clear when one looks at how frequently these systems generate data. As shown, the production of enormous volumes of information in smart grid networks leads to 2 different problems: first, the storing of the data, & second, its utilization since the systems lacks the necessary infrastructure to fully utilize it. When used properly, this customer data can help prevent the peak load issue by lowering costs. All of this is based on the customers being aware that their data may be utilized to assist in managing their energy use. This would begin with customers becoming aware of how data is stored and generated when they interact with metros. An incentive to save money and energy can so change the effective consumer behavior.

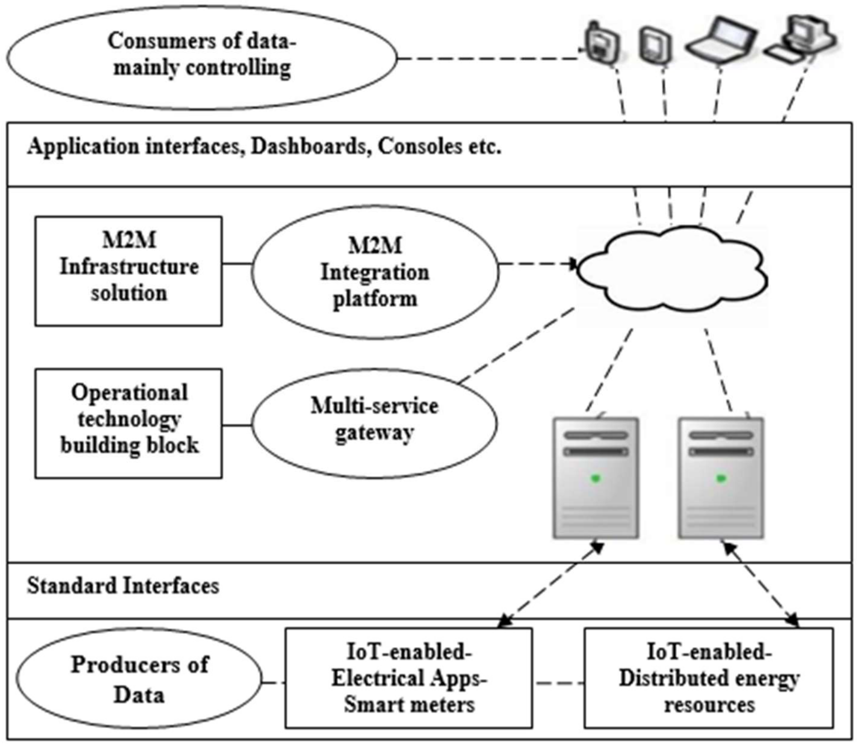


Figure 3. Intelligent power monitoring using IoT-related factors

4.3 Issues with cyber security for SG

The smart grid environment's dependability in terms of processing power to produce and manage such data is quite evident. The connectivity of numerous electronic devices that generate data also contributes to this reliability, heightening the concern of cyber security and making it a top priority. The definition of cyber security in the context of SG has been made clear and explicit. While some standards approach this from the perspective of an operator, others approach it from the perspective of performance. The string of issues in dec-2015 gave us a better understanding of the devastating potential of an SG environment lacking in cyber security. In the aforementioned instance, the hackers who committed the crime were successful in gaining outside access to the systems' human-machine interface, which caused a ten-hour blackout and had an impact on the lives of roughly 225,000 individuals. Authorities from the US FBI to the Ukrainian authorities conducted ex-post operations, which led to the conclusion that these problems had encounter the networks vulnerable software because they had discovered "Black Energy" malware across the internal networks of the systems, which led to an assault on the control system. Manually resetting the machine and restarting its processes were required to recover control.

It is crucial to concentrate on SG's information and communication network assaults.

The PHY layer or MAC layer is where signal-based detection takes place. Where a DoS attacker might identify an attack's presence using data from the RSSI (received signal strength indicator). The decoder at the receiving end logs mistakes in the data received if the RSSI of numerous data packets exceeds the threshold, indicating that the receiver node should correctly receive them. When an attacker is present, the assault detector can sound an alert.

The following long-term objectives of a protected smart grid environment must take into account the aforementioned factors: information secrecy, communication confirmation, repeated communication recognition, maintaining privacy, and assisting in action revocation. In order to ensure that the system as a whole is safe, the standard solutions created to function specifically with certain network applications would also need to do so. This makes cyber security a difficult area of research for SG in the future. At any tier of SG networking, packet-based detection systems may be used, and they can compare packet delivery ratio on a regular basis. Significant packet transmission errors might be used as a warning indication for assaults.

5. Conclusion & Future Work

The promise for meeting future energy demands is being realized through the application of contemporary technologies like ICT to turn traditional grids into SG with high levels of automation. The SG's effective energy management thanks to the implementation of DER is the most crucial consideration. Peak loads can be moved or delayed until other periods as part of the demand response, which is handled rationally. This method of controlling the power will improve system stability while reducing carbon emissions and safeguarding the environment. The most crucial infrastructure for Singapore is the introduction of AMI technology, which will enable bidirectional communication between utilities and end users to learn about each other's power use. Dynamic tariffs were recently established, and they entail end-user involvement. For communication purposes, AMI uses technologies including WAN, NAN, and HAN. Depending on the kinds of applications they are used for, different communication technologies perform different functions and operate at differing data speeds. Critical solutions still need to be found for interoperability problems including technologies like communication, information, and data management. Finding the gaps between various SG technologies is necessary, and there is a lot of room for future study in this area. One of the main issues that SG deals with is the maintenance of power quality. Smart metres at end user locations and IED at distribution systems will control voltage levels and power factor, respectively.

The smart meters must keep track of the voltage provided at end-user locations and report this information to the utility centre on a regular basis. As a result, data utility centres will optimise the voltage levels, raising the system's overall power quality. The end-user premises' appliances operate more effectively with greater voltage. Power system interventions that are situation-or event-based fall short of controlling and guaranteeing stability of the system. Remote supervision is one of the key advantages of SG technology. Equipment used for remote monitoring includes distribution transformers, capacitor banks, PMUs, and smart meters. The concepts of wide-area monitoring and remote monitoring have made it feasible for technologies like WAMPAC to help SG control power losses, faults, and disturbances more effectively. These monitoring systems will improve power delivery, reduce operating costs, and boost end-

user satisfaction while reducing power outages. The client will profit from the rising usage of RESs like solar and wind in dealing with real-time pricing for demand response invoicing.
With improved energy resource use, V2G & G2V charging become the main problem. Industry and academics need to concentrate their research efforts in this area due to its considerable influence on power systems. Efficiency in SG operations should be a top priority when it comes to utilities such effective data management, controlling, and communication. Future studies by SG on the privacy concerns associated with enormous data integrity and confidentiality may be crucial. As more SG appliances are connected to one another thanks to communication technology, cyber-security risks and related issues arise. Fine-grained technical approaches based on SG problems must be used to address these vulnerabilities.

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