Power Grid Surveillance and Control Based on Wireless Sensor Network Technologies: Review and Future Directions

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Abstract. In this paper, the concept of the smart grid and the emerging challenges of wireless communication technology for use on the smart grid (SG) is reviewed. One modern-day technology of great significance is wireless sensor networks (WSNs), which has the potential to ensure the smooth operation of smart grid management and increase its energy efficiency, reliability and cost-effectiveness. The advanced electric power grid infrastructure known as smart grid takes advantage of automated control and cutting-edge communication strategies to achieve greater efficiency, reliability and safety, whilst seamlessly combining renewable and alternative sources of energy. Unlike conventional communication technologies, WSNs are more beneficial to modern electric power systems because they are affordable and operate on a cooperative basis. For this reason, WSNs are considered to have good potential for improving the way electric power is produced, distributed and used. Therefore, they are a key element of the smart grid. Nevertheless, the implementation of WSNs in smart grid settings may be inadequately reliable due to the complexity and unfavourable aspects of electric power system environments. The purpose of the current work is to review WSN uses in electric power systems and the opportunities and difficulties offered by this technology, as well as to delineate possible facets of smart grid applications and wireless technologies that future research could explore. Therefore, this work is significant.

Keywords—smart grid, communication technologies, wireless sensor networks (WSNs)

1. Introduction
Presently, a major consideration in relation to power systems is energy efficiency. To make power systems as energy efficient as possible, it is necessary to have infrastructure resistant to great disruptions, including transients, harmonics, decline or increase in voltage, and voltage fluctuations[1,3]. The standard approach to achieving energy efficiency focuses on enhancing the energy efficiency of technologies and improving the reliability of systems.
Throughout the world, widely accessible, sustainable and environmentally-friendly electric energy has been increasingly demanded in recent times owing to such phenomena as climate change and fast population growth. This demand translates into a greater strain on the already overloaded and outdated electric power infrastructure that can be found in the majority of countries [2-7]. For instance, the electric power infrastructure in Iraq lacks reliability and fails to supply electricity regularly. Meanwhile, significant problems of network bottleneck have arisen due to the growing demand for electric power, alongside the complexity and lack of linearity of the network of electricity distribution. In turn, the network bottlenecks, coupled with issues related to safety, have recently brought about a series of extensive blackouts[8-11]. Furthermore, the power grid is problematic not only because of the excessive
strain placed on it but also because of the suboptimal strategies of communication, monitoring, fault detection and automation. Consequently, one flaw is enough to trigger a chain reaction resulting in regional system collapse [12-15].

The existing network of electricity distribution has high complexity and is incompatible with modern-day requirements due to such issues as an absence of analysis automation, suboptimal visibility, poor response speed owing to mechanical switches and absence of situational awareness [16]. These issues have been among the causes of the blackouts that have occurred in the recent decade and they have been further compounded by population growth, increasing energy demand, climate change, equipment malfunction, issues of energy storage, the capacity restrictions of electric power production, one-way communication, depletion of non-renewable energy sources, and issues of resilience [17-20].

The next-generation electric power system known as a smart grid has been introduced as a potential solution to the above-mentioned issues [21]. The smart grid takes advantage of automated control and cutting-edge communication strategies to achieve greater efficiency, reliability and safety, whilst seamlessly combining renewable and alternative sources of energy [5,6]. The vital smart grid element for ensuring the reliability of power distribution is dependable and online information [22]. Power disruptions result from equipment malfunction, capacity restrictions and natural phenomena. Prevention of such disruptions can be achieved through online monitoring of system status, diagnostics and protection [23]. From this perspective, online sensing technologies afford smart and inexpensive monitoring and control tools that are now crucial for ensuring that the smart grid is safe, reliable and efficient [7-9]. The present grid does not have adequate monitoring, diagnostics and communication strategies. By contrast, the smart grid has better sensing and sophisticated tools of communication and computing (Figure 1). Its constituent elements (e.g. distribution, transmission and residential, commercial and industrial substations) are interoperably owing to the connections ensured by communication channels and sensor nodes [24].

The element of the smart grid that is critical for a dependable supply of electric power is reliable and real-time data. Online power system status monitoring, diagnostics and safeguarding can help to prevent power disruptions that result from equipment malfunction, capacity restrictions and natural phenomena. From this perspective, the development of a smart grid depends on cutting-edge information and communication technologies that can facilitate smart monitoring and control [25]. The existing situation calls for changes to the transmission lines with an efficient communication system to enable monitoring of various parameters and rapid fault detection in real-time. A smart grid demonstrating reliability, flexibility, improved resilience and self-repair ability can be achieved through the incorporation of two-way communication strategies, distributed energy resources and production, intelligent technologies and sophisticated power storage systems into the traditional grid [26].

The present work has as a primary aim a review of the opportunities and difficulties associated with the use of wireless sensor networks (WSNs) within a smart grid to pave the way for future research in related fields that have not been investigated so far. Unlike standard communication technologies, WSNs are more advantageous because they function on a cooperative basis, can be deployed quickly, are inexpensive and flexible, and enable accumulation of intelligence through parallel processing [27-29]. The parameters of crucial importance to equipment status are monitored by wireless multifunctional sensor nodes that are implemented on that equipment. The generated data are used by the smart grid to rapidly and effectively react to alterations in conditions. Hence, the ability of a highly dependable and self-repairing intelligent electric power grid to adjust to changes is critically reliant on WSNs [30].

The structure of the rest of this work is as follows. The opportunities associated with the implementation of WSNs in a smart grid are presented in the second part, while the difficulties of such implementation are addressed in the third part. The communication technologies that can be used in a smart grid are discussed in the fourth part, while several smart grid standards are outlined in the fifth part. Last but not least, concluding remarks are provided in the sixth part [31].
2. The Opportunities Provided by WSN use in Smart Grid

An electric power system has three main substations, namely, production, distribution and use of power. The performance of these substations can be improved via WSNs, which are therefore considered a key element of the smart grid as the next-generation electric power system. The present part addresses the opportunities that implementation of WSNs in a smart grid can offer [32]. It must be highlighted that certain smart grid applications are compatible not only with WSNs but with other wireless technologies (e.g. Wi-Fi, WiMAX) and power line communication technologies as well. For example, sophisticated metering applications could make use of long-range backhaul communication technologies [33].

2.1. Wireless Automatic Meter Reading (WAMR)

The use of WAMR systems in conjunction with electric utilities has become economically viable due to WSNs. Electric utilities can benefit from WAMR systems because these systems remove the necessity of having human readers, thus improving operational cost-effectiveness, use customers’ energy consumption to create online pricing models [34] and afford sophisticated remote monitoring, thus safeguarding assets. Nevertheless, dependable two-way communication between the electric utilities and end-users’ metering devices is essential for WAMR systems to work. To this end, inexpensive wireless communication technology with reduced power consumption is supplied by WSNs. The wide availability of such technology has led to a consensus that wireless communication is a highly cost-effective approach for gathering utility meter data [12].

2.2. Remote System Monitoring and Equipment Failure Diagnosis

Above all else, electric power systems are required to be safe and reliable because system malfunction due to equipment failure, environmental factors or operational errors can have massive economic and public safety implications. To give an example, numerous blackouts have occurred in Argentina, affecting a large proportion of the population and raising questions about the suitability of the grid infrastructure not only in Argentina but in the neighbouring countries of Uruguay and Paraguay as well. The blackout did not affect Brazil, although the country did suffer an extensive blackout in 2009 when over 60 million people were left without power. Countries in other regions of the world have not been spared blackouts either. In 2003, a blackout occurred in the US and some areas of Canada, affecting...
around 50 million people, while another blackout with similarly widespread impact happened in Italy in the same year. In 2012, India suffered a blackout that spanned 22 states and affected 50% of the population. In terms of facilities, the average hourly cost of unplanned system downtime due to unforeseen equipment malfunction is USD 70000-200,000 [10]. Improved monitoring of key system elements and more efficient coordination of protection devices could either minimise or prevent a large number of system breakdowns. Despite this, the existing electric power infrastructure is largely lacking in terms of proper monitoring and automation, with important equipment (e.g. motors < 200 hp) lacking monitoring completely in most industries. This situation is primarily due to the high costs involved in implementing remote sensing, monitoring and fault diagnostics on a broad scale [35].

WSNs are advantageous chiefly because they are affordable and therefore they have the potential for use as sensing and communication tools in remote system monitoring and diagnostics. Rich data about the status of system elements (e.g. generation units, transformers, transmission lines, motors, etc.) can be remotely obtained via the Internet through effective monitoring systems consisting of a multitude of intelligent sensor nodes [36]. Online system monitoring and coordination of controls and protections at system level can enable identification and isolation of individual system faults in the power grid/facility, preventing it from degenerating into a chain-reaction response and leading to major system disruption [37].

3. Difficulties of WSN Implementation in Smart Grids

Several factors can make the implementation of WSNs in smart grids difficult as detailed below.

3.1. Unfavourable environmental conditions

Link faults may cause fluctuations in network topology and wireless connectivity within electric power system environments. Moreover, the performance of sensors may be affected by various factors, including RF interference, media that are greatly caustic or corrosive, high levels of humidity, vibrations, dirt and dust. Some sensor nodes may fail or else the data they capture may be irrelevant as a result of such unfavourable environmental conditions and variability in network topology [38,12].

3.2. Packet faults and fluctuations in link capacity

The degree of interference on the receiver side determines the wireless link bandwidth in WSNs, with communication exhibiting high bit error rates (BER=10^{-2}-10^{-6}). Furthermore, obstructions and noise within electric power system environments cause significant temporal and spatial variability in the features of wireless links. Therefore, the location dictates the bandwidth and communication latency at every wireless link. The ongoing fluctuations experienced by these elements pose marked difficulties to the fulfilment of the QoS specifications [39,11].

3.3. Resource limitations

Energy, memory and processing resources all have an impact on how WSNs are created and installed. WSN communication protocols are usually customised to afford high energy efficiency because the battery energy supply of sensor nodes is often restricted [11].

3.4. Security

Power utilities cannot operate without secure storage and transport of data, particularly when it comes to billing and grid management [40,14]. Therefore, effective security measures must be adopted to prevent intrusions and the power grid security should be standardised.

A highly important specification for power utilities is ensuring that the system is reliable. The reliability of a power grid is compromised by outdated infrastructure and growing energy use and peak demand [15]. However, a system can be made more reliable and robust by adopting advanced and secure communication protocols, communication and information technologies, control devices of greater speed and robustness, as well as embedded intelligent devices (IEDs) throughout the grid [16]. The
chosen communication technology determines communication configuration availability. In the case of
an expansive smart grid, it is advisable to employ cost-effective wireless technologies with restricted
bandwidth and security [14]. By contrast, wired technologies are usually more expensive because they
have greater capacity and are more secure and reliable [14]. Therefore, a combination of wired and
wireless communication technologies could be used to guarantee that a system is reliable, robust and
accessible whilst also keeping the costs of implementation down to a minimum.

3.5. Scalability
For a smart grid to be operational, it must demonstrate scalability [3, 41]. As communication networks
become increasingly complex with the introduction of a wide range of smart meters, sensor nodes and
data collectors, as well as renewable energy resources, smart grids must be capable of managing
scalability. This can be achieved by implementing cutting-edge web services and dependable protocols
with sophisticated features (e.g. self-configuration, security).

4. Existing Communication Technologies for Smart Grids
A smart grid infrastructure cannot operate without a communication system [12]. The development of
such an infrastructure requires cutting-edge technologies and applications to be integrated, which will
produce massive volumes of data that need to be analysed, managed and subjected to real-time pricing.
Therefore, electric utilities must outline the specifications of communication and establish the ideal
approach for managing output data and provide an overall service demonstrating reliability, security and
affordability. Furthermore, to achieve better services and performance, electric utilities must try to
encourage end-users to become involved in the smart grid system. There is great awareness about the
importance of managing demand and end-user involvement to ensure the efficiency of electric power
use, and the correlation between electric grids and communication systems has been thrown into sharp
relief by the system breakdowns that have occurred [42,11].

Within a smart grid system, the flow of information depends on two kinds of information infrastructure.
One information flow occurs between the sensor and electrical appliances and the utility data centres,
which can be achieved via powerline or wireless communication channels [13], while the other flow
occurs between smart meters and the utility data centres, which can be achieved via cellular technologies
or the Internet. However, the introduction of smart metering must consider a number of limitations,
which are outlined in Table I together with the corresponding technologies.

4.1. ZigBee
The wireless communication technology known as ZigBee is characterised by reduced power
consumption and data rate, simplicity and affordability. These characteristics make it appropriate for
applications such as intelligent lighting, energy monitoring, home automation and automatic meter
reading. According to the US National Institute for Standards and Technology (NIST), ZigBee and
ZigBee Smart Energy Profile (SEP) are the best communication technologies for the smart grid
residential network [15]. It is critical for smart meters, smart home appliances and home displays to
communicate with each other. Smart meters are prioritised by numerous AMI merchants (e.g. Itron,
Elster, LandisGyr) because they are compatible with ZigBee [16]. Besides communication with ZigBee
integrated devices, ZigBee integrated smart meters are also capable of controlling those devices.
Table 1. Technology

| Technology | Applications          | Coverage Range | Spectrum                       | Data Rate           | Limitations                  |
|------------|-----------------------|----------------|-------------------------------|---------------------|-----------------------------|
| GSM        | AMI, Demand Response, HAN | 1-10 Km       | 900-1800 MHz                  | Up to 14.4 Kbps     | Poor rates of data          |
| GPRS       | AMI, Demand Response, HAN | 1-10 Km       | 900-1800 MHz                  | Up to 170 Kbps      | Poor rates of data          |
| 3G         | AMI, Demand Response, HAN | 1-10 Km       | 1.92-1.98 GHz, 2.11-2.17 GHz (Licensed) | 384Kbps-2Mbps       | Limited coverage            |
| WiMAX      | AMI, Demand Response | 10-50Km (LOS) | 2.5 GHz, 3.5 GHz, 5.8 GHz (Licensed) | Upto 75 Mbps        | High fees related to spectrum |
| PLC        | AMI Fraud Detection    | 1-3 Km         | 1-30 MHz                      | 2-3 Mbps            | Unfavourable environment with noise |
| ZigBee     | AMI, HAN              | 30-50 m        | 2.4 GHz-868-916MHz            | 250 Kbps            | Poor rate of data, limited coverage |

- **Strong points**
  Every one of the 16 channels that ZigBee has in the 2.4-GHz band possesses a bandwidth of 5 MHz. Radios with 1-100 m transmission range, a data rate of 250 Kb/s and OQPSK modulation have a maximum output power of 0 dBm (1 mW) [16]. As a standardised protocol underpinned by IEEE 802.15.4, ZigBee is advantageous because it is uncomplicated, mobile, robust, does not have many bandwidth specifications, it is inexpensive to implement, operates in an unlicensed spectrum, can be inserted in a network without difficulty [4]. Therefore, it is suitable for metering and energy control and it is the best option for smart meter applications. The benefits of ZigBee SEP include load management and decrease, demand response, real-time pricing models and system monitoring, as well as sophisticated metering assistance [16].

- **Weak points**
  Concerning practical applications, ZigBee presents a few limitations, including poor processing, insufficient memory, slight delay specifications, and susceptibility to interference from other appliances with a common transmission medium and unlicensed, industrial, scientific and medical (ISM) frequency band, including IEEE 802.11 wireless local area networks (WLANs), Wi-Fi, Bluetooth and Microwave [16]. Therefore, it is doubtful how robust ZigBee is in noisy environments, as 802.11/b/g interference could compromise the whole communication channel [12]. However, network lifespan can be increased and the reliability and energy efficiency of network performance can be ensured by using measures for detecting and preventing interferences as well as routing protocols that possess energy efficiency.

### 4.2. Wireless Mesh

Characterised by flexibility, a mesh network comprises a cluster of nodes that can expand with new nodes and every node can play the role of a separate router. The network is capable of repairing itself, so if it loses a node, the communication signals will establish a different channel through the remaining nodes. A radio module is incorporated in all intelligent devices within the Smart-Meter system of PG&E, with the metering data being directing via meters that are close by. Furthermore, the signal is repeated by every meter until the accumulated data arrive at the electric network access point, from where the data are transmitted to the utility through a communication network.
• **Strong points**
Mesh networking is affordable, capable of repairing and configuring itself and demonstrates dynamic self-organisation and high scalability. It can help networks perform better, ensure network load equilibrium and expand the area that networks can cover [15]. The option of multi-hop routing can provide satisfactory coverage in urban and suburban zones. Moreover, owing to the character of mesh networking, meters can play the role of signal repeaters and network coverage and capacity can be increased through network supplementation with a large number of repeaters.

• **Weak points**
The main difficulties confronting wireless networking include network capacity, fading and interference. Coverage is particularly problematic in urban zones because the communication network is not fully covered by the meter density. Mesh networking depends to a great extent on adequate balancing between routing reliability and flexibility, a suitable supply of intelligent nodes and consideration of node costs. Additionally, network management must be undertaken by a third-party agency and data must be encrypted for security reasons as the metering information goes through all access points. What is more, the existing bandwidth can be restricted due to extra overheads in the communication channel engendered by loop issues associated with the travelling of the data packets around a large number of neighbours [16].

4.3. **Cellular Network Communication**
Communication between smart meters and utilities and between remote nodes can be effectively achieved through cellular networks that are already available. The use of such networks can help utilities to avoid operational expenditure and time-wasting, whilst also permitting expansion of the area where smart meters can be introduced. Among the existing cellular communication technologies compatible with smart metering are 2G, 2.5G, 3G, WiMAX and LTE. The volume of data produced is massive when the duration of data transmission between meters and utilities is around a quarter of an hour, so data transmission to utilities would necessitate a high data rate connection.

• **Strong points**
Utilities can employ the available cellular networks instead of wasting financial resources to develop the communication infrastructure that a smart grid necessitates. Indeed, cellular communication is among the foremost communication technologies due to its broad availability and affordability. Cellular networks offer enough bandwidth for the massive volumes of data produced owing to the smaller intervals of data collection. Furthermore, cellular networks effectively ensure the security of data transfers. AMI, Demand Response and Home Area Network (HAN) applications are supported by both GSM technology and GPRS, which have a performance of up to 14.4 Kb/s and 170 Kb/s, respectively. GSM technology is especially robust in terms of anonymity, authentication, signalling protection and user data protection security services [16]. The potential of cellular networks as a communication technology for smart grids is reinforced by their affordability, satisfactory coverage, reduced maintenance expenses and rapid implementation.

• **Weak points**
Communications must be available without interruption for certain power grid applications of vital importance to operate properly. However, networks may become congested or perform poorly in crises because the customer market shares cellular network services. Therefore, utilities may be compelled to establish their independent network of communications. Public cellular network providers may be unable to offer their services in unusual circumstances (e.g. wind storms), but private networks may be able to cope with such circumstances more effectively because they employ diverse technologies and spectrum bands.
4.4. Powerline Communication

Extremely fast (2-3 Mb/s) inter-device transmission of data signals can be achieved through powerline communication (PLC) based on the use of available powerlines. PLC has been the preferred communication channel with electricity meters because it links directly to the meters [10] and AMI has been successfully installed in urban zones where other options have proven to be substandard. The potential of PLC systems with LV distribution network for smart grid applications has been investigated in the context of China [12]. A basic PLC network consists of smart meters linked to the data concentrator via powerlines based on PLC technology, with cellular network technologies mediating the transmission of data to the data centre on the basis of GPRS technology [16].

- **Strong points**
  The existing infrastructure reduces the expenditure associated with the implementation of the communication infrastructure, so smart grid applications could benefit significantly from PLC. In addition to its cost-effectiveness, PLC is also broadly available and standardised, which explains why it is so widely preferred. Moreover, the PLC infrastructure already has coverage in areas within the range serviced by utilities and therefore it is appropriate for various smart grid applications (e.g. smart metering, monitoring, and control) in urban areas.

- **Weak points**
  The properties of powerline networks pose a few technical difficulties. For instance, channel modelling is challenging because of the unfavourable and noisy environment that is the powerline transmission medium. Furthermore, PLC is incompatible with applications requiring a high bandwidth as its bandwidth does not exceed 20 kb/s [16]. Moreover, the quality of the signal relayed across the powerlines is negatively impacted by several factors, including network topology, the number and types of devices linked to the powerlines, and the transmitter-receiver wiring distance [16]. PLC is inappropriate for transfer of data because it is susceptible to disruptions and depends on signal quality. Nevertheless, the complete connectivity that PLC cannot achieve on its own is still possible if this technology is integrated with other technologies, such as GPRS or GSM.

5. Smart Grid Standards

A wide range of applications and approaches for smart grid systems have either been designed or are under design. Despite this, there is a major problem in that sophisticated applications, smart meters and devices and renewable energy sources cannot be integrated and so they are poorly interoperable because no universal standards have been formulated for the general smart grid system. Therefore, the smart grid system will remain only a theoretical construct if interoperability standards are not drawn for the general system. Endeavours to standardise the smart grid system can enable smooth interoperability, strong information security, safer products and systems, and compactness of protocols and communication exchange [43,16].

Standardisation endeavours have been made in various regions and countries. For instance, the creation of a smart electricity system in the following three decades is the aim of the strategic energy technology plan devised by the European Union Technology Platform. Meanwhile, the introduction of smart meters has been pledged by the Canadian Ontario Energy Board [16]. Other institutions and organisations with similar aims include NIST, the American National Standards Institute (ANSI), the International Electro-Technical Commission (IEC), the Institute of Electrical and Electronics Engineers (IEEE), and the International Organisation for Standardisation (ISO) (Table II).
Table 2. Table Type Styles

| Name/Type of Standard | Application | Details |
|-----------------------|-------------|---------|
| ICE 61970 & ICE 61969 | Energy Management Systems. | Provision of Common Information Model (CIM). ICE 61970 and ICE 61969 are respectively applied in the transmission domain and distribution domain. |
| ICE 61850 | Substation Automation | Characterised by flexibility, future-proofing and open standard, and is capable of communication between transmission, distribution and substation automation. |
| IEEE P2030 | Customer side application | Assistance for smart grid interoperability of energy technology and IT operation with electric power systems. |
| ISA 100.11a | Industrial Automation | Wireless system open standard. |
| IEEE P1901 | In home-media, utility & Smart Grid applications | Fast PLC. |
| ANSI 12.18, ANSI12.19, ANSI12.22 | Automatic Metering Instruments (AMI) | Transmission of data through optical media, metering models demonstrating flexibility. |

6. Key Features/ Advantages

Smart Grid main features are as follows:

6.1. Self-Healing

The smart grid uses real-time sensors such as PMU to detect power supply operating conditions [39]. With self-healing capabilities, smart grids can use PMUs and automatic control centers to predict, detect or respond to failures or faults.

6.2. Interactive

Bidirectional power flow is one of the key features of the Smart Grid [44]. One may simultaneously be a customer and a manufacturer. Dynamic pricing allows consumers to use less electricity during peak hours, thereby reducing high demand. Ultimately, this action contributes to the desired unity Load-Factor.

6.3. Security

The design of the smart grid network and control system makes it highly resistant to cyber-attacks. The use of PMU for real-time monitoring enables operators to anticipate possible problems and take preventive measures [45]. Distributed power generation and microgrid also ensure power supply safety.

6.4. Asset Optimization

The use of Geographic Information System (GIS) will establish an effective network with the least transmission network and equipment [46,47]. It makes maintenance based on condition and performance. A smart grid can also improve performance by reducing line losses.

6.5. Decentralized generation

Decentralized Distributed Generation (DG) refers to decentralized generating units. This leads provides energy support, thereby reducing interruptions that may cause system outages. It also reduces investment risks because of its ability and flexibility in the installation location [48]. The use of renewable energy
(RES) will help reduce dependence on fossil fuels and increase energy prices. When the DG system is installed close to the customer's loads, it can prevent the creation of new transmission and distribution networks, thereby reducing operating costs, thereby saving costs.

6.6. Market Empowerment

Smart grids allow consumers to be a part of the electricity market. This offers more flexibility in energy procurement and reduces energy supply costs and environmental impacts [48]. And will help the utility sector meet rising customer demands.

6.7. Environment Friendly

The smart grid system optimizes the use of existing power generation, transmission and distribution, by providing continuous feedback on the use of electricity, enabling consumers to adjust usage patterns based on price and consumption [49]. Guarantee greater efficiency in rural areas and improve reliability and supply quality in urban areas. And the improvement of end-use efficiency can significantly reduce carbon dioxide emissions.

7. Key Challenges for Smart Grid

Smart grid development faces several challenges

7.1. Financial Resources

A significant amount of capital investment is required to start the Smart Grid project. Therefore, the build a necessary decentralized network and other institutions we need substantial financial resources/investments.

7.2. Government Support

The only barrier to the implementation of SG is not only financial resources [50]. Even more important are political bodies in the region. For the successful implementation of the Smart Grid, we need a supportive government and an efficient energy policy.

7.3. Compatible Equipment

Many existing appliances must be updated because they are incompatible with smart grid systems. For utilities, regulators, and customers, this may pose a challenge.

7.4. Consumer Education

The successful implementation of the Smart Grid requires customer awareness and engagement. A large portion of the advantages of the Smart Meter depends on customer engagement. Consumers must also be prepared to make the most of it [51].

7.5. Cost Assessment

The cost may be higher than expected because the standards and protocols required to design and operate smart grid infrastructure are still in a state of constant change.

7.6. Cyber Security and Data Privacy

The potential to raise concerns in cyber-insecure networks and abuse of private data are raised by digital communication networks and more elaborate and frequent knowledge about consumption patterns.
7.7. Ability to absorb advanced technology

The smart grid must be able to absorb modern and advanced technologies. Since the smart grid uses high-tech equipment throughout the network [52]. Currently, technology has never stopped and is advancing at a pace never before seen.

7.8. Strengthening the Grid

While the smart grid is revolutionary, it also has some drawbacks, which great concern to us. The company and staff in the power grid must overcome emergencies and some unexpected events and hazards [53] such as :

- Attacks of cyber thieves
- Weak Base
- Inefficient Control System
- Corrosion
- Smart Meter Authentication
- Blackouts

7.9. Compatible types of equipment

The smart grid is a very complicated system. A significant amount of equipment which is bidirectional with the grid is required to cover the control program of the entire power grid [54].

8. Conclusions

The entire energy industry is quite busy researching and developing smart grid systems, which is a topic of the future. The introduction of SG technology has changed the conventional grid system. Characterised by complexity, non-uniformity and hierarchical structuring, the smart grid can benefit from the use of WSNs for different related applications. Consisting of a series of distributed sensor nodes, WSNs can be used to remotely monitor and control the various smart grid elements because they can capture and transmit data about different aspects. Therefore, WSNs are particularly useful for managing energy systems at the residential, industrial and organisational level. However, due to their location in unfavourable environments, the sensor nodes of these networks are susceptible to disruptions and interferences. Communication between sensor nodes can be safeguarded through cryptographic security, which can also determine when a sensor has been compromised and annul the breached security keys. However, WSN nodes have restricted memory and computation capacity, so ensuring that these nodes are secure poses technical difficulties.

All smart grid IoT applications are based on WSN, in which security issues will be extensively and thoroughly investigated. Furthermore, advances in Internet technology have already made it possible to devise different solutions for local and wide area networks. In terms of the reliability of a smart grid system, the most problematic aspect is ensuring the security of a vast network comprising small WSNs. The restrictions enforced by communication standards and sensor nodes afford a multiplicity of dimensions to WSN security as a research subject. An in-depth examination and implementation of a compromise between costs and security must be undertaken for future uses of WSNs in smart grid applications[54-56].

New technologies for smart grids will also bring new challenges. However, these new challenges should not be a reason to oppose the creation of a smart grid, because smart grids play an important role in transforming traditional power systems into modern grids and will lead us to improve energy quality and reliability.

The present work has provided an overview of the opportunities, difficulties, communication technologies and standards on smart grid systems, in parallel, this work has also explored different wireless communication standards.
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