Recent Advancement in Smart Grid Technology : Future Prospects in the Electrical Power Network

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ABSTRACT

The demand for electricity has increased dramatically as a result of technological advancements, creating difficulties for both its generation and distribution. when a result, when demand rises, power grid complexity increases due to the need for increased security, dependability, efficiency, and consideration of environmental and energy sustainability issues. These characteristics of a power grid lead to its eventual development into what is now known as a "smart grid."This is a conceptual technique that increases the efficiency, dependability, and sustainability of the electrical distribution system by implementing all smart characteristics. This article provides an overview of "smart grids," including their features and many applications in the electricity distribution sector.

The need for energy has increased as a result of urbanization, rising living standards, and technological innovation. This caused an increase in electricity use that, if ignored, would become unmanageable. This is concerning not just for the global environment's preservation but also for the provision of sustainable energy. Cities consume between 75 and 80 percent of the world's energy, accounting for 80 percent of greenhouse gas emissions .After a long day, the conventional, centrally-controlled method of distributing electricity is still in use. This is referred to as the power grid.

Global electric grids share a common structure, dynamics, and set of guiding principles since the invention of electricity, even with advances in technology. Only a few fundamental tasks, such as energy generation, distribution, and control, are the emphasis of these classic power grids. The current power grid is unstable, has large transmission losses, and is not very good. power quality that discourages the integration of distributed energy sources, is prone to brownouts and blackouts, and provides inadequate electricity. Traditional non-smart systems lack real-time control and monitoring. systems, which presents a difficult chance for smart grids to function as a real-time remedy.

Smart Grid technology holds promise as a means of improving electricity generation and providing an efficient means of distributing and transmitting power. Compared to typical grids, it requires less area and is easier to install because of its adaptability. The goal of the smart grid design concept is to make the grid observable, to make assets more controllable, to improve the power system's performance and security, and to focus in particular on the financial elements of operations, maintenance, and planning.

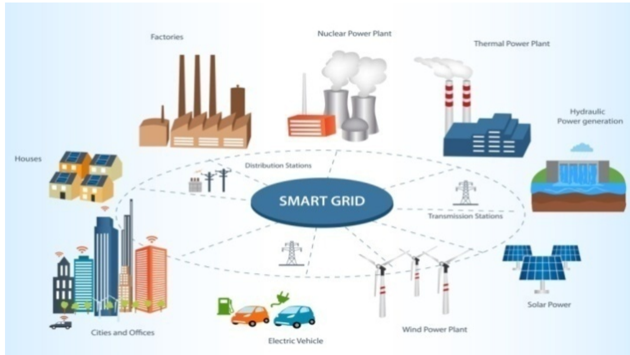
Because of this, it's also thought that smart grid technology can be used to micro-grids, which can then connect to one another and build a larger smart grid network. These smart grids offer a great deal of promise and may be able to help developing nations with poor infrastructure by ensuring the dependability of power distribution and transmission. Transportation accounts for only 20% of the total carbon dioxide emissions in the United States. The production of power accounts for 40% of carbon dioxide emission.

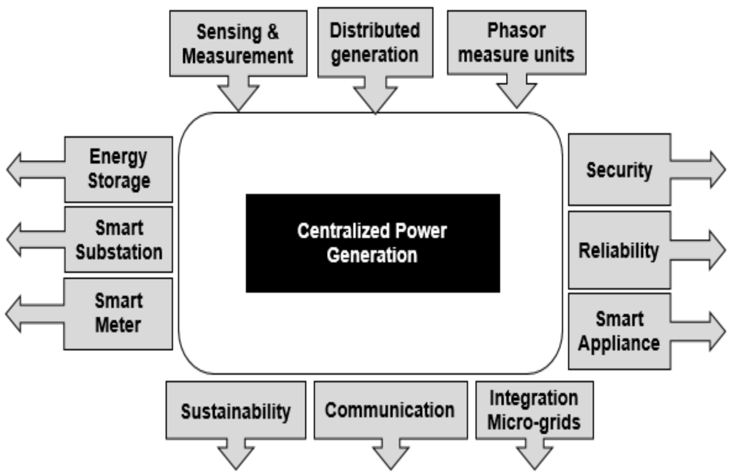
SMART GRID

The Smart Grid does not have a set beginning. This idea began to take shape as electrical networks began to distribute power. By then, other needs had emerged, such as those for pricing, services, control, and monitoring of the transmission and distribution of electrical power. Installing smart meters is typically linked to the deployment of smart grids. 1970s and 1980s saw them were employed to transmit customer data back to the grid. However, the most crucial and fundamental requirement that is still being thought about despite the most recent advancements is the efficiency and dependability of energy distribution and transmission via the electric power grid. However, the most recent cutting-edge research indicates that networks and grids should do more than only transmit and distribute information; they should also play a essential part in producing clean, renewable energy to lower greenhouse gas emissions and the carbon footprint.

A grid, or network of electrical conductors, is required for the distribution of electricity to consumers. This network may be referred to as a "smart grid" if it has automated control and monitoring systems. In theory, a smart grid is a idea for traditional grids that incorporates some of the newest, automated technologies to increase their sustainability and dependability. While conventional grids were just used to transfer and distribute electricity, the concept of a smart grid of today is capable of decision-making, communication, and storage depending on the circumstances.

Thus, in accordance with the Strategic Deployment Document for Europe's electrical. Networks of the Future, a smart grid is an electrical network that integrates the activities of all stakeholders, including producers, consumers, and one who combines the two in order to provide electricity in a sustainable, cost-effective, and safe manner. Therefore, the Smart Grid is not a single technology that needs to be used. Its stakeholders' growing reliance on it and its extent are demonstrated in. It provides its stakeholder an opportunity to maximize the efficiency, reliability, economic performance and security of their electrical network.





DESIGN

An overview of its architecture is shown in To understand the design and concept of smart grid one has to understand its difference with the traditional power grid. This comparison was done by Yu et al. in 2012 . This comparison is shown in Table 1. The design of the smart grid is flexible with its use and related objectives.

A conceptual model of smart grid was presented by National Institute of Standards and Technology (NIST) which elucidate the planning process, development requirements, related stakeholders, and necessary equipment. Table 2 illustrates how NIST categorizes these stakeholders into seven modeling area.

RELIABILITY

Reliability is a key component of consumer needs, which determines the grid system's success. This refers to a system that is error-free and flawless and has a steady supply of electricity. Intelligent Grid possesses the capacity to identify any malfunction and enable the system to heal itself. Demand response, microgrids and the interaction of renewable resources are problems for conventional networks. It becomes harder to assess these grids dependability as their size and complexity rise in response to demand. However, smart grids do a great job of addressing these problems. In order to do this, smart grids can track, store and estimate all of the data related to service reliability. Additionally, remote monitoring for hybrid generation and grid control might be feasible.

Security

one of the difficult problems facing the development of the smart grid is security. As automation rises, the grid becomes more susceptible to cyber attacks due to remote monitoring and control. The Electric Power Research Institute states that one of the main problems with the Smart Grid is system cyber security. Suleiman et al. provide a method by integrating the Systems Security Threat Model and Smart Grid Systems Treats Analysis to find the vulnerabilities in smart grids that are typically exploited by attackers Similarly, in 2014, Ashok et al. presented a strategy to tackle the problem of wide-area monitoring, protection, and control in cyber-physical security from the standpoint of coordinated cyber-attacks, which will ultimately improve security To evaluate the Smart. To ensure security, one must assess their methods. The National Institute of Standards and Technology (NIST), the IEEE Power & Energy Society (PES), the IEC Smart Grid Standardization, and other organizations are involved in and contribute to the standardization and regulation for the smart grid.

Promising current studies in several security-related fields for smart grids include: Multiple data consumers for privacy-preserving smart metering, with an orthocode privacy mechanism in the smart grid employing the Security Threat Model and ring communication architecture .Since security is thought to be one of the main obstacles to the adoption of Smart Grid technology, these continuing studies hold promise for removing this obstacle.

SYSTEM FOR DEMAND-SIDE MANAGEMENT

The demand side or user can communicate with the grid in two ways thanks to the smart grid. It offers an opportunity. For the user to make frugal use of the electric power. It will support boosting efficiency both at the distribution and demand sides. By lowering or switching to alternate sources of power during peak hours, it assists the grid in lowering demand and stress. This provides consumers with a financial incentive, which motivates them to do so. Demand side investment is among the many that are now being done in this area of smart grids.

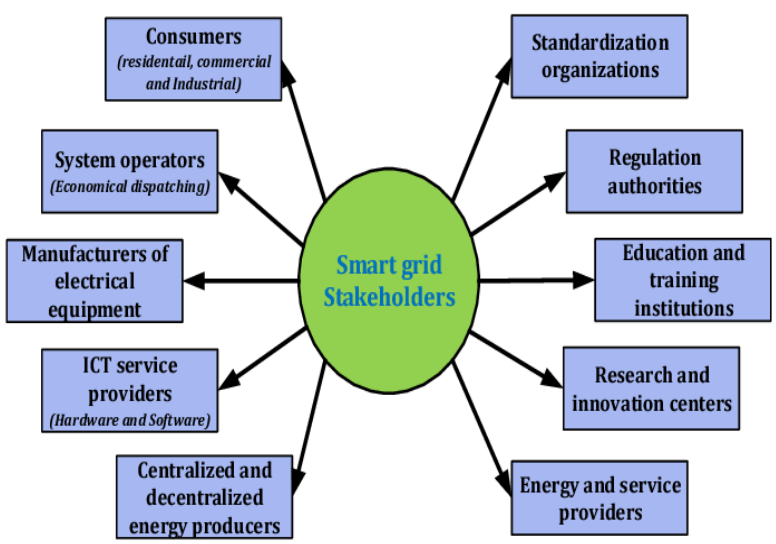
Resources, load control mechanisms, and energy-saving projects to tackle cost-effective, dependable, and financial viewpoints Demand side management solutions typically exclusively address customer-utility company communication. There will soon be a new consumption scheduling method available to address the grids of the future, where each customer can plan their own consumption. As peak loads for various consumers vary, this aids the distribution system in scheduling itself appropriately to meet demand. By arranging their demands, this also encourages the consumer to receive financial incentives. This concept of "smart" devices appliances and utilities has sparked a revolution alongside the development of the "smart grid." These are able to speak with the grid.

Which improve the home's independence and enable users to use electricity more effectively. The need for domestic electricity is changed by these appliances. The ability to wirelessly manage household appliances is made possible by several networking protocols, such as "ZigBee." These protocols provide the best possible outcomes by having the capacity to coordinate and communicate with all parties involved in the home energy management system.

TABLE - 1

Conventional Power Grid	Smart Grid
Electromechanical	Digital
One-way communication	Two-way communication
Centralized generation	Distributed generation
Few sensors	Sensors throughout
Manual monitoring	Self-monitoring
Manual restoration	Self-healing
Failures and blackouts	Adaptive and islanding
Limited control	Pervasive control
Few customer choices	Many customer choices

TABLE - 2



Micro-grids and integration of renewable resources

A lot of thought should go into producing power using renewable resources like solar, wind, and battery storage devices in order to meet the growing demand for electricity and minimize greenhouse gas emissions. They even assist in lessening the grid's electricity stress during peak hours. These resources are typically located far away or in isolated places. Even under certain situations, having a fully operational grid to transfer or distribute electricity is not feasible. In this case, a large distribution network is formed by the gathering of micro-grids. There will therefore be a significant volume of data to manage due to the vast number of micro-grids and sources. Thus, studies such as that conducted have provided a solution to this issue by utilizing a design that makes use of an intelligent system throughout the grid to efficiently distribute the power. Instead of being employed in a centralized manner, each intelligent node in the system will conduct tasks independently.

New technologies and research

A number of on-going research activities are being made for the advancement of the smart grid to make it more reliable and sustainable for the modern needs. These researches are focused on different technologies. It is difficult to cover all of these researches and advancement but this section includes some of the prominent and latest technologies and research activities associated with smart grid.

Internet of things (IoT)

The internet is evolving to a new level thanks to the Internet of Things (IoT). By condensing the complexity, it automates and simplifies life. Entire globe into one palm through communication and computing power. With the development of the smart grid and its constituent parts, a technology was required to facilitate the efficient, dependable and more intelligent interaction of these parts. The promise of IoT is complete all these requirements, ushering in a new age for smart grid technology.

However, a number of significant security issues, including as impersonation, data tampering, overkill, authorization, privacy concerns, and cyber attacks, have surfaced with this new Scholars are conducting investigations to address these concerns. To prevent any security risks, an IoT-based smart grid needs to incorporate services like authentication, confidentiality, user privacy, and data integrity. The connectivity that IoT offers to consumers improves their effectiveness and enjoyment. Customers can engage with the grid in a flexible and simple way thanks to it by using diagnostics and neighborhood-wide meter reading capacity, to cut. To put it succinctly, it enhances smart grid.

Smart grids with electric vehicles

As one of the biggest environmental issue is pollution due to vehicles. Use of electrical vehicles has the solution of this problem. There are several challenges for EVs to interact with the grid which include infrastructure, communication and control. Mostly it is seen that EVs are charged at home and even sometime charging take place at public or commercial Charging station. The dynamics of the electricity system can be predicted thanks to car to grid technology. A crucial component of car to grid technology is charging. There has been a great deal of research done on this charging and discharging.

Excellent connectivity between solar energy and electric vehicle charging suggested a method for taking the battery state and charging request into account for the subsequent drive in a different investigation. Seldom have reports of weak grids during Vehicle to Grid (V2G) usage been made. Similarly, this weak grid situation may be remedied by renewable energy sources like solar and wind Comprehending the electric grid's dynamic nature is crucial for forecasting.

Economical potential of smart grid in developing world

One of the main obstacles to the creation and application of the smart grid, particularly in poorer nations, is cost. There are substantial financial resources involved in the transmission as well as metering, distribution systems, and other associated technologies. Before execution, a thorough financial feasibility report is necessary. This financial viability needs to take into account the nation's ability to finance the infrastructure development costs for smart grids. Usually, this is determined for each customer that needs to be serviced. In 2017, Young used a different approach to determine the GDP ratio of a country to the cost of implementing smart grids in developing nations. The majority of the financial information used in this computation came from a 2015 World Bank report. An overview of these findings is provided in.

Future research in smart grid

A great deal of research is being done to create smart grids. There is still a great deal of need for further research into various facets of the smart grid. This covers the fields of microgrid integration, communication, forecasting, power flow optimization, scalability, demand and energy management systems, compliance with standards for interoperability, data encryption, economical considerations and most crucially automation.

CONCLUSION

Technological and gadget advancements have the potential to reduce energy consumption and improve the environment. The Smart Grid concept's evolution has the ability to fulfill all the in order to meet future energy needs, carbon emissions must be reduced and a greater proportion of renewable energy sources must be integrated. It can significantly alter how consumers use energy and how the traditional grid operates by enhancing the quality, efficiency, and dependability of power transmission.

Government regulations are required to make the deployment of smart grids easier. This article discussed the necessity of updating the traditional grid and the ways in which smart grid technology is being applied by researchers to electrical power distribution networks. However, there is still a great deal of room for development and application of this idea. Thus the modern grid's new era is only getting started. The amount of research needed to completely execute the smart grid concept is yet unknown, but recent developments in smart grid technologies, such as big data, demand side management systems, smart meters, and self healing, are encouraging.

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