Smart Grid: How Reliable It Is

Dr.Balamurugan, Dr.Sujithkumar,

Faculty of Engineering and Technology, Jain (Deemed-to-be University), Ramnagar District, Karnataka - 562112

Email Id- m.balamurugan@jainuniversity.ac.in

ASBTRACT: Smart grid is referred as the quantum leap from the traditional grid. This arises due to various challenges such as complications in power grid, demand for reliable system, increased security and efficiency as well as the future which demands sustainability. In this paper all the challenges involved in the transformation or integration of traditional grid with the smart grid has been elaborated. There is demand for response to the change in load, integrating the renewable energy resources and storage equipment. The reliability can be increased further by mixing all these resources ideally and thus leading to the requisite net demand. A framework is given that solves all the challenges and also meets the demand of modern measures related to cyber-security. Thus this is an important part for the success of implementation of smart grid. The requisite of the smart grid are also mentioned and discussed properly.

KEWORDS: Smart Grid, Survey, Information, Protection, Privacy, Security, architecture, global coordination, infrastructure.

INTRODUCTION

Electrical grid is a telecast grid of power with few central generators which serve the function of generating power and then the generated power is send over to meet the energy demands using a cable network and devices such as transformers. Thus it is a web which unites the units such as transmission units, generation units and the distribution units. The generating part is situated in the vicinity of the fuel in order to minimize the conveyance cost and far from the populous areas. Transformers step down the voltage level of the power and then this is sent over to the consumers by distribution. There are broadly two categories:

1. *Regional:*

When a region's transmission grid is connected, the connection is coined as regional grid

2. *National:*

When a number of regional grids are connected, the connection is coined as national grid.

The IT industry is advancing and expanding daily with the objective of improving the dependability, certainty and quality. There is always a complexity in governing the power grid, rising distress of environment, survivability of energy. Thus a demand always arises to update and grow the existing technology. The transition to a grid which is smarter and advanced than the traditional grid is called smart grid. This new and updated grid is expected to have exploited all the technologies such as[1]:

- The operator should have a better awareness of the situation.
- The controlling steps should be independent by increasing flexibility for malfunction of components, naturally occurring phenomenon, limitations of equipment, and requirements for operations.
- Increasing the efficiency by enhancing the usage of all the assets.
- An enhanced flexibility for malevolent attacks by an improved security in order to maintain uprightness of the data secrecy,
- Integrating the sustainable energy resources such as solar plant, wind farms etc.
- Integrating other energy sources such as vehicle which are plugged in.

- A bi-directional communication for the consumer so that he/she is able to get a customized energy plan as per their requirement
- The quality of services should be higher. There should not be any spikes in the voltage or any other form of interruption.

For a permeating control and tracking the grid is coming out as source of information and communication technology along with the complications and applications of power system engineering. In Table 1 bullet points from the comparison of existing grid to the grid which is smart is given.

Table 1: Comparison of smart grid with existing one

Existing Grid	Intelligent Grid
Electromechanical	Digital
One-way communication	Two-way communication
Centralized Generation	Distributed Generation
Hierarchical	Network
Few Sensors	Sensors throughout
Blind	Self-Monitoring
Manual Restoration	Self-Healing
Failures and Blackouts	Adaptive and Islanding
Manual Check/Test	Remote Check/Test
Limited Control	Pervasive Control
Few Customer Services	Many Customer Choices

These features are responsible for an extra layer of understanding and safety over the existing and upcoming framework thus new processes and application can be introduced. As far as these new capabilities are concerned, the feature of communication and managing the data are playing a very important part. In Figure 1, the various components of smart grid are depicted which tell us what it consists of and what technology it should serve[2].

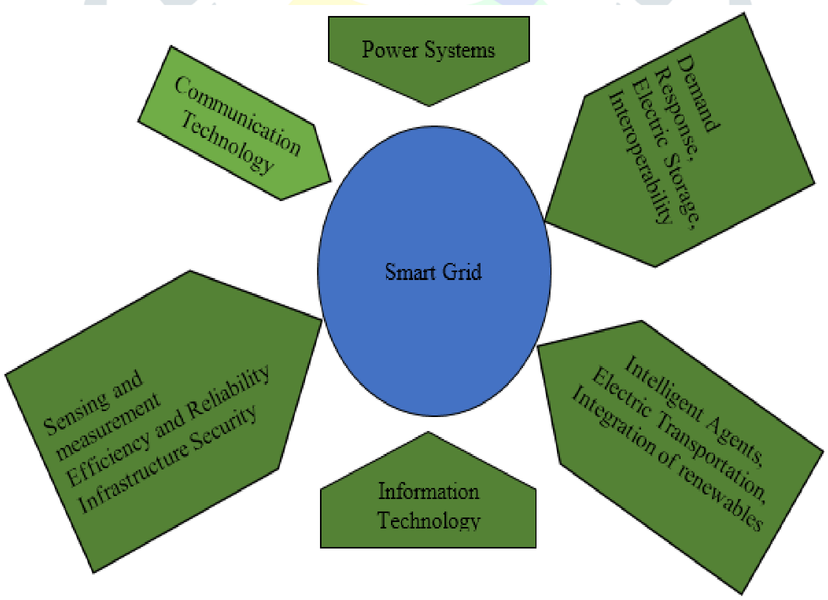

Figure 1: Components of smart grid

The credibility of system is a centre of attention for the planning and working of grid. Due to the versatility of the renewable energy, the credibility is further increased along with providing support to power generation and keeping in view the environmental scenario. Storing the electric energy and getting proper feedback of the demand and this is done by alleviating the maximum demand and properly varying the load. Electric transportation is advantageous in keeping up with the targets. If there is a common vision. This paper tries to create vision by a structured approach whose gist is keeping a track of the the grid challenge. In order to meet these demands, the pre-requisite is an infrastructure technology that can do the tracking and controlling of the grid. This paper presents the various technologies for measurement such as PMUs and equipments for control such as FACTS[3].

Research Question

With the increasing demand of automation and challenges involved in the traditional grid, a lot of research work is being carried out in smart grid technology. But is this newly emerging technology safe to implement fully and replace the existing grid?

LITERATURE REVIEW

Author Costas Efthymiou and Georgios Kalogridis have discussed the concerns related to security and privacy in integration of smart grid with the existing grid and showed that a network which is metered is important for proper implementation of this. The limit is that this paper does not attribute for other features such as billing, management of account and research done on marketing.

Authors Khosrow Moslehi, and Ranjit Kumar have demonstrated the complexity increasing in demands for growing dependability, its security, increasing efficiency and also taking into consideration the technologies on which smart grid is built such as sensors, communication, which offer a very promising future in relation to services and user end. A number of industrial trials are reviewed and the basic requisite in these paradigm has been summarized. All the components should be able to operate independently but also there should be no chance of these being isolated

METHODOLOGY

The various factors required for a smart grid are power lines communication, energy resources which are distributed, sharp metering system, tracking and managing.

1. *Factors:*

1.1.Power Line Communication:

The medium for transmission is feeder line. One way communication is given by ripple controls which are first generation which have earlier carried out control for the load side and limiting the peak. The standard of European limits the frequency range from 3kHz to 95kHZ. In the second generation data rates which were much lower were proposed and a meter reading which is automatic has been used. In third generation a much higher data rate transmission devices are being used which are based on OFDM. To transmit and receive data information between the user and services, PLC has become one of the emerging. It has become really important to understand the characteristics of physical channel of PLC since for the services having different priorities, a PLC system need to be designed which supports different data rates. The signals having high frequency are present majorly on the power lines. For a proper communication to take place the amplitude of these high frequency signals should be reduced. Frequency in the range 10 to 20 MHz is not practicable to be used thus repeaters and various modulation techniques are employed to communicate to user at the end from transformer at the distributing stations. The power feeders are not manufactured for transmission of data and thus easily get interference from the output signal from the inverters. To overcome these limitations, filters with pulse width modulation are used. PLC have been designed to be used for applications that require high data rate such as accessing the internet or communication of media that serve few users. But it can’t be used for utilities such as sensing, controlling and cybernetics.

1.2.Dispersed energy resources:

All the power systems are being converted to disperse energy resources constituting of wind, thermal, solar energy resources. MetaPV showed the advantages of photovoltaics at a very big scale thus projecting a way that shows that cities can powered with these in future. The controlling range improved by using photovoltaic inverters such as capability of ride through low voltage, grid operation which is self-governing. The control increases the role of photovoltaic into the traditional grid and thus usage of renewable energy is possible at lowest speculation cost. For dependable operation of these energy resources

1.3.Smart–Metering:

Here an infrastructure is employed which is advanced metering for bi-directional communication. A meter that recognizes the consumption of power in a detailed manner when compared to the traditional metering is termed as smart meter. It can notify the consumer about their power consumption so that they can reduce and also their carbon footprint. This was the peak load can be reduced and thus the rates for electricity will reduce. These meters have high accuracy, processing and control and thus have gained a great acceptance in the industry. With these meters problems such as dependability, efficiency of operation and satisfaction of the consumer are addressed. But exposing these can lead to cyber security threats. In order for safe operation of these resources, creative monitoring and controlling techniques need to be developed.

1.4.Monitoring:

In order to control and monitor power grids, SCADA systems have been developed. The systems which are existing currently are limited in high voltage systems and don't find application in monitoring in large scale systems. In order for management of power grid, control system which is distributed is preferred. At the generation of micro-level, the renewable and sustainable energy resources should be addressed. In Figure 2, motivations of a grid are given such as system operation, environment aspects.

2. Improvements:

2.1.Experience of customer is enhanced:

The motive is to improve the dependability of the service and quality to the customer. When there is interruption in power it should be rectified in minimum time possible. To avoid any occurrence of blackout the customer should be given proper tools to help them understand the concept of peak time and off – peak time.

2.2.Better Productivity:

Services can take up their existing functions in a more efficient manner with a higher productivity if the information provided to them is intelligent and in a more efficient manner.

2.3.Utilization is improved:

Real time will be provided in a smart grid related to energy generation, transmission of electricity, consumption of power and price in the market. Thus service will get help in decision making and improving that.

3. Benefits:

3.1.Carbon fuel consumption is reduced:

Embedded systems monitor the voltage networks thus keep the demand growth in limit and redoes losses incurred in electricity. This will reduce the carbon emission and other greenhouse gases being released from the system.

3.2.Generation from renewable resources is facilitated:

Smart grid helps in increasing the awareness among the users about their energy consumption and thus there is option available for switching to renewable resources whenever possible.

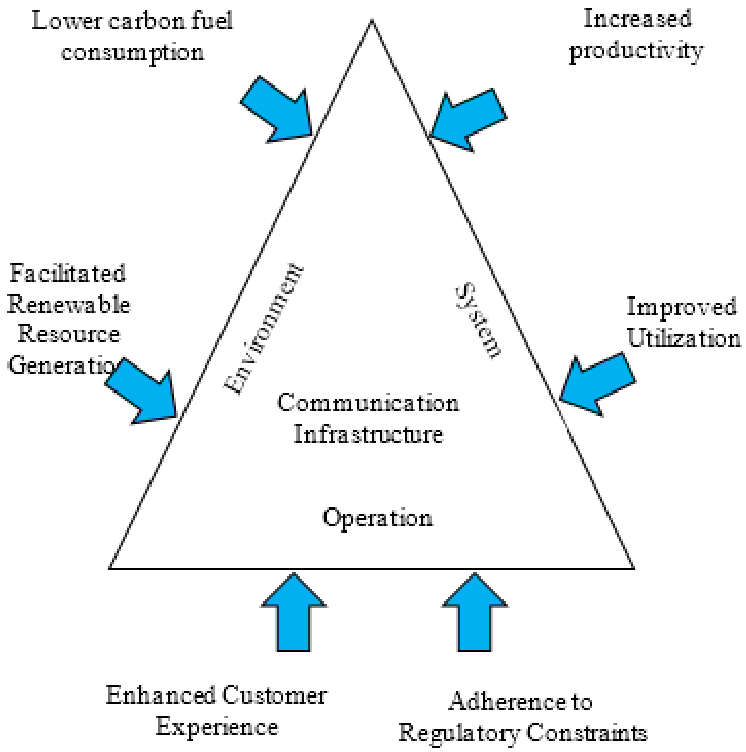

Figure 2: Benefits of smart grid infrastructure

3.3.Compliance to regulatory committee:

The asset data should be tracked for the justification of cost and higher dependability for proper implementation of infrastructure in the smart grid.

Electricity grid are now the backbone in the industry and is thus in focus for technological upgradation. A utility pyramid is given in Figure 3. The framework which provides management of strong points is the base of the pyramid. On this base a foundation is built for smart grid that involves technology upgradation such as infrastructure in information technology, infrastructure in telecommunication and topology of circuit.

A model was given by national institute of standards and technology to realize the new smart grid to be taken as a reference. In this model as given in Figure 4 the grid is divided in seven zones. Each domain has various components which are responsible for making decisions and sending the data and receiving the feedback. In technical view, the grid is categorized into three parts: infrastructure, management and protection system.

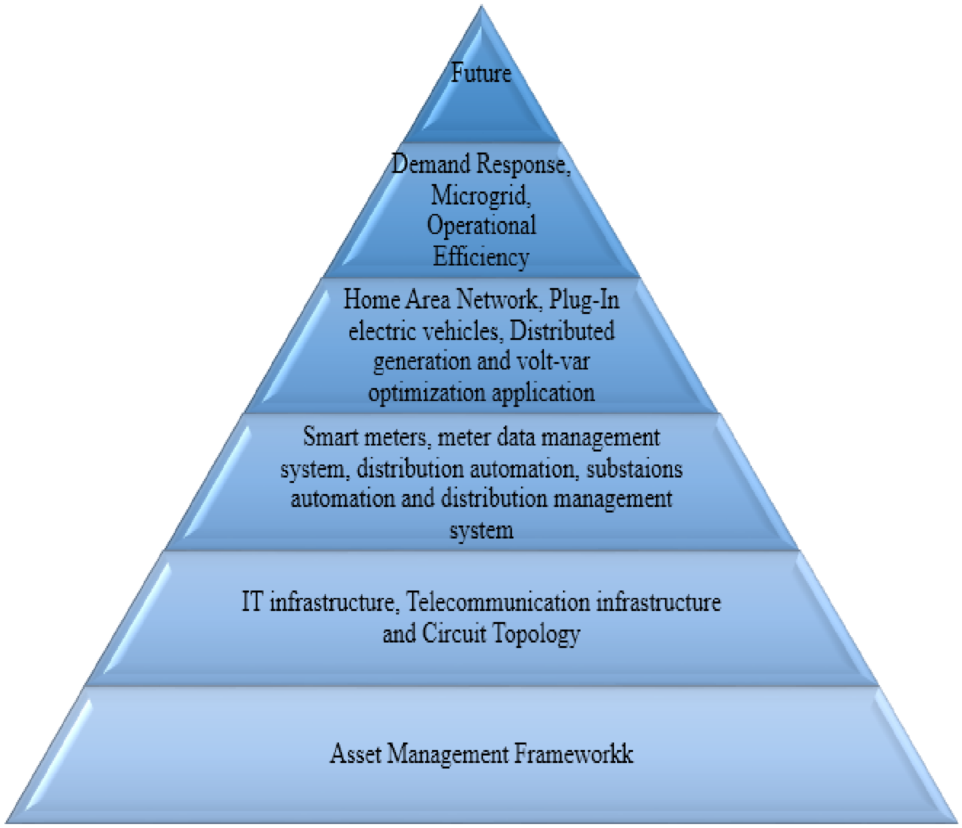

Figure 3: Pyramid for smart grid

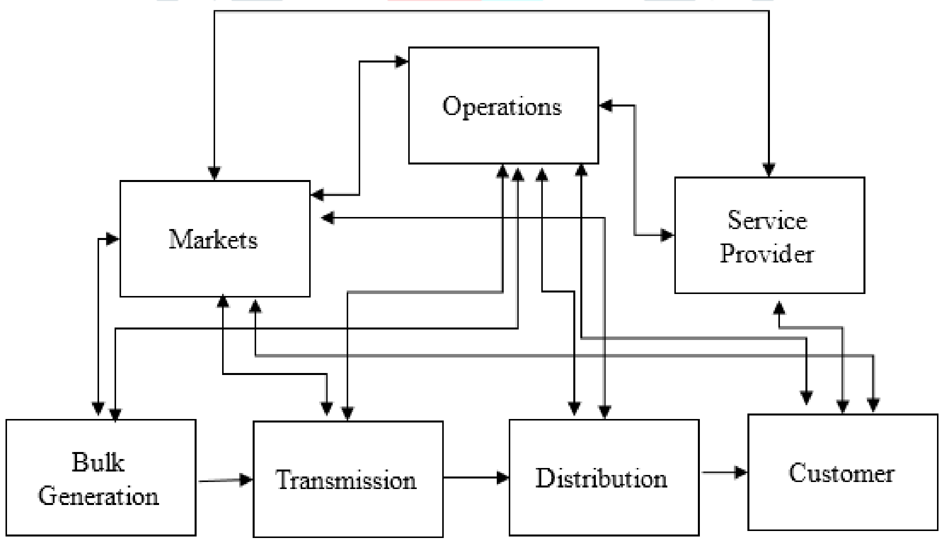

Figure 4: Super Grids Model

4. Framework of the System:

4.1.Infrastructure system:

It consists of communication, energy and information in the grid. It enables bi-directional flow of data and electricity possible. In a traditional grid flow of energy is from the generation plant to the user via transmission grid and distribution grid. This energy cannot flow in reverse direction. Whereas in smart grid the user can give back the energy to the grid. Suppose the user has solar panels installed in his home, thus he can give the energy generated in these panels back to the grid when the demand is high. Further this is divided into:

4.1.1. Energy subsystem:

It is accountable for generating, delivering and for consumption of electricity.

4.1.2. Information subsystem:

It is responsible for recording, tracking and managing of the information.

4.1.3. Communication subsystem:

It is accountable for maintaining connectivity and transmitting information in between various systems and devices.

4.2.Management system:

It provides managing and controlling features and other functionalities. The grid will become smarter only if the management system allows the alleviation of the existing technology.

4.3.Protection system:

It gives study of dependability during a failure and other services such as privacy protection.

In Figure 5, a detailed analysis of the three categories of the subsystem is given.

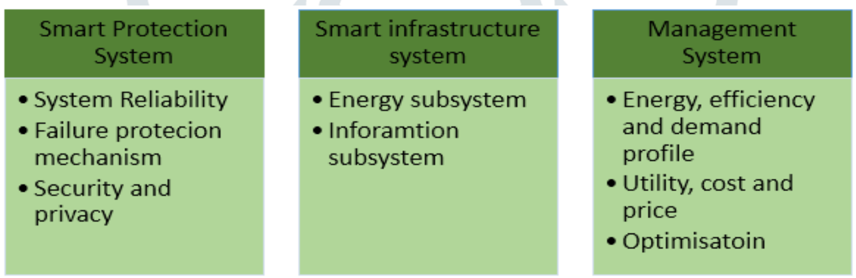

Figure 5: Classification of a Smart grid

5. Research and development:

The service providers are conscious of the problems and challenges in the process of transformation of the existing framework, establishment, and methods involved toward a future which is very uncertain. The reason for this is because the primary objective of the service providers is to keep the light on. Thus it can be understood that the service providers will not easily venture into the new technology unless they are given comprehensive validation since the problem is that no research work has been carried out in a real life scenario to enable the application. Many technologies have been developed like communication concord, sensors, stemmer and much more to direct problems of utilities and get solutions for the grid. The existing utilities have a huge responsibility in maintaining and opting of the infrastructure of the existing technology. Hence it becomes quite challenging for them to switch to newer technology at once. A grid with a proper researching and development architecture will ensure the major sections like generation to the loads but also a pliable and highly sophisticated command line in order to justify the requirement of the service providers.

5.1.Factors affecting the reliability of smart grid:

5.1.1. Renewable Resources:

Solar and wind are the rapidly growing resources. The installed capacity of solar energy in India is 35,739 MW till august 2020. There is still a high growth in wind energy. Due to this unpredictability, challenges are generated for the monitoring and dependability related to the power grid. The variation in load energy is very little related to the variations caused from the load side and thus very little contribution to the

5.1.2. Management of load and meeting the demand:

Management of load means that the reducing load where there is an emergency situation. These conditions occur when there is more chances of a peak load. When there is reduction from the user end, it is called as demand response.

5.1.3. Devices for storage:

The current resources for storing are either hydro or pumped but the demand for storage is growing. Storing in the form of batteries is more promising since is can response in a few seconds. Thus with their introduction everything can be fast.

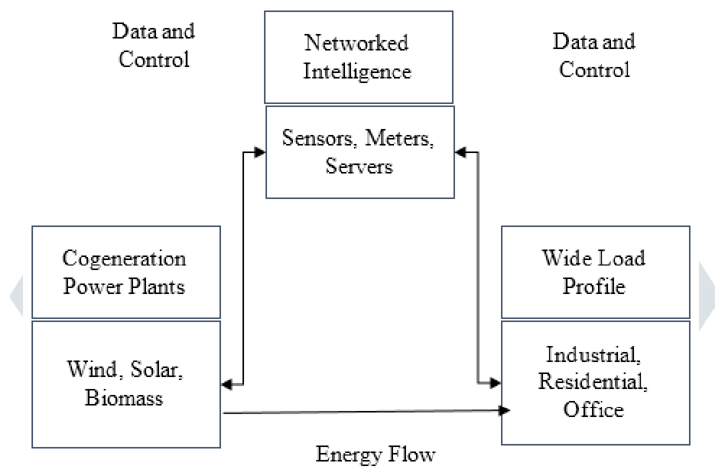

Figure 6: Smart Grid's Topology

In Figure 6, the topology related to smart grid is given. There are three major parts in a smart grid. Generation takes place in traditional and other plants which are wind, solar and many more. Consumption takes place at the load end which consists of office, residential and industrial load. The most important part is intelligence which needs to be networked and it consists of sensors, meters and servers.

RESULTS AND DISCUSSIONS

In this paper, many technologies involved in smart grid have been discussed. A lot of managing goals have been installed in the infrastructure of smart grid but these might be unfeasible in traditional grids. Majority of work that needs to be performed by the managing section is to increase the overall efficiency, the profile of the demand should be shaped, the utility should be improved, overall cost reduction and reduce the emission of greenhouse gases. With the advancement of this technology, a numerous function will come up and more services related to management will emerge. There are repercussions in privacy of customers in case of smart meters also. Since the data and information stored can be further distributed and used as a channel having a lot of sensitive data that can expose consumer's patterns and behaviors at a later stage. If financial and political goals coincide, this data is easily mined to meet their desires. Smart grids security and privacy should be properly investigated. Transition to a smart grid is essential for a nation but also for the planet. But certain measures need to be taken to mitigate these issues before bringing it out in the real scenario. This paper has developed a vision through an approach which is systematic and understands the challenged involve in dependability of grid. The smart grid promises a very motivating future and services for the end user.

CONCLUSION

Smart grid is a leap in enhancing the dependability of grid to harness information and other communication technologies. In this various resources such as renewable sources, response to demand, storing electric energy and transportation of this energy is done. If existing grid is connected to smart grid, the reliability issues will be solved further and will be able to meet the net demands generated by the user. For this a methodical approach is required. After this the blueprint, evolution and unification of different parts and the publication of required level and agreement. The proposed infrastructure can be taken as a network consisting of various networks which will enable execution of the framework. To transform traditional grid to a smart grid a infrastructural approach is required.

For the future use of smart system and usage of smart grid, privacy concern plays a major role since a huge amount of data will be collected when compared to traditional data collection. The data can easily be excavated. This anonymity will lead to a number of practical conditions where it can be removes, such as when there are cases of forensic expertise, when there is a need for replacement of a meter. Also the backward flow of power is useful in case of islanding. This is a condition when the part is isolated from the grid and needs supply of power from somewhere else. In such cases, micro grid can supply power to the islanded section. There is rapid change in the electrical industry and this transformation is decided by the rise in energy cost, electrification in everyday life. Many researches are being carried out to help in transforming and developing into this process of acquiring the newer technology.

REFERENCES

[1] K. Moslehi and R. Kumar, "A reliability perspective of the smart grid," *IEEE Transactions on Smart Grid*, 2010, doi: 10.1109/TSG.2010.2046346.

[2] H. Farhangi, "The path of the smart grid," *IEEE Power and Energy Magazine*, 2010, doi: 10.1109/MPE.2009.934876.

[3] Y. Yan, Y. Qian, H. Sharif, and D. Tipper, "A survey on smart grid communication infrastructures: Motivations, requirements and challenges," *IEEE Communications Surveys and Tutorials*. 2013, doi: 10.1109/SURV.2012.021312.00034.