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Smart Grid: A Review of Future Electrical Technology

Paramveer Singh Gill[1], Hardeep Saini[2]
[1]Department of ECE, CGC Landran, Mohali, [2]Department of ECE, CCET-Degree Wing, Chandigarh

Abstract: As cities and countries become more advanced, electricity use keeps growing. If not managed, this can become a serious problem. The Smart Grid helps support cleaner technologies like distributed generation and microgrids. Public awareness and support from researchers and policymakers are very important. This paper is intended to give the readers a clear picture of given energy demands and supply. And discuss some of the main drawbacks of existing power grid. There is need of need power grid which is not only more efficient but also accommodate some intelligence. Smart is based upon dual communication, making it more interactive, reliable, secure and consumer friendly.

Key Words*: AMI (Advanced Metering Infrastructure), BPL (Broadband Over Power Line), Communication*.

I. INTRODUCTION

Electricity has found its applications more than the Edison's bulb, since the date of its invention. With the advent of technology modern day appliances have become an important part of our lives. Since, if the dependency increases there is needed to have more reliable, secure efficient source of power. Nicole Tesla was among the first ones who designed the modern day power grid, and making it possible to transfer power from the point of generation to end user. As demand of power is increasing is increasing day by day, and there is significant decrease in non-renewable resources, a system needs to design which could use the available resources more wisely and in efficient manner. It is evident from the 2003 blackout [1] that existing power grid have severe drawbacks which needs to be dealt with. It is not only blackout or power failure but also a national security threat. Central power generation and distribution makes the grid a cascading one, a failure at one part leads to failure to the parts following it. Others major reasons which demand the upgrading of grid growing old is major loss of energy while transferring it to the end users. Smart Grid is capable of answering all these questions, based upon communication network as basic skeleton and accommodating renewable sources of energy.

II. BACKGROUND

"Smart" means intelligent, neat, or automated. A "grid" is a network that delivers electricity. So, a Smart Grid is an intelligent power network. There is no single agreed definition of it. It can be explained in simple or complex ways. Once just an idea, it is now a key topic in modern power systems. Unlike the old grid, which only sent electricity, the Smart Grid can store energy, share information, and make decisions. It works in a more efficient and responsive way. Smart grid can be modernization of current power grid or its upgradation. Smart grid provides power along with two way digital communication to control home appliances to save energy, reduce cost, increase reliability and transparency. It introduces the concept of Advanced Metering Infrastructure (AMI). These new meter accounts various advantages over traditional meters, becoming an effective communication interface between grid and consumer [2]. The review paper has been designed to give holistic view of smart grid. It is divided into four sections. (I) Distributive power generation (II) Concept of Net metering (III) Role of Communication (IV) Conclusion. The idea is to tap domestic, renewable and non renewable power sources and share them with consumers with through an internet style smart transmission grid [3]. With new policies, innovative technologies and infrastructure upgrades smart grid is well poised to change the way we live our lives.

III. DISTRIBUTIVE GENERATION (DG)

Here a conceptual layout is given to understand some basic fundamentals upon which smart grid is based. The main emphasis is on the relationship between transmission interfaces and consumer entities. Smart grid comes up with option of joining all transmission interfaces themselves, directly with the sources or can be controlled by central grid. The key concept over here is that all interactions between transmission interfaces and consumers are multi-directional i.e. uncommon to traditional grid now users can also participate in reverse direction. Communication between grid and consumer makes the grid smart and intelligent.

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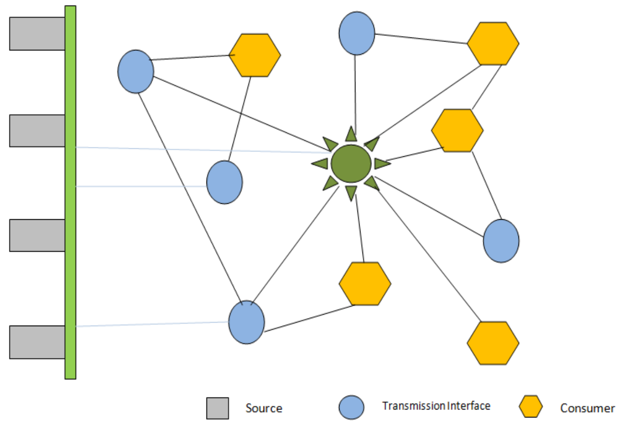

Figure 1: Relation between transmission interfaces and consumer entities

Transmission components are smart enough to adjust according to consumer demand and requirements. Depending upon the consumer load transmission components become micro and macro size and so are consumers.

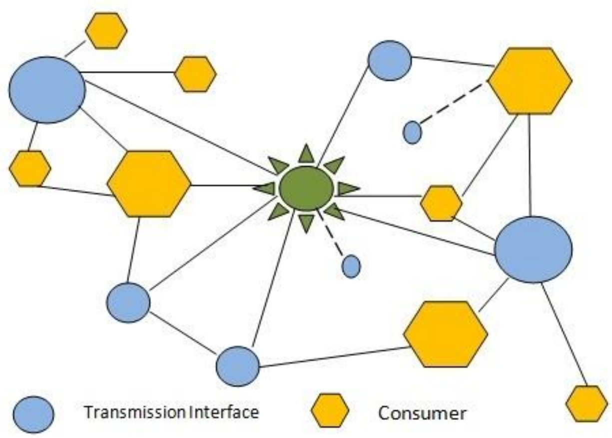

Figure 2: A Conceptual picture showing Micro and macro size components

The figure shows that components with higher loads become larger in size and called as macro size and they could virtually get disconnected also when there is no demand hence saving the power these features are responsible for making the grid configurable and intelligent [4].

IV. Advance Metering Infrastructure (AMI)

Making the grid more reliable, efficient and secure it is required to be more interactive. This concept can implemented using improved/upgraded meters also known as smart meters [5]. Unlike traditional meters at our homes which only gives monthly or bi-monthly reading of power usage in KWh and consumer is charged accordingly. These are unidirectional and doesn't educate user about usage of electricity. AMI (Advance Metering Infrastructure) consist of Advanced Meter (AM), display unit and associated components for communication with power grid achieving our aim of bidirectional communication. AMI is accountable for various services like cost effectiveness, remote monitoring, load demand/request, notification, net metering, scheduling [6].

A. Advance Metering Infrastructure (AMI)

AMI not only contributes towards efficient grid but also helps consumers to intelligently use power to reduce its usage and eventually reduced power bills. AMI keeps the track of charges and power usage continuously. As charges of electricity is not uniform throughout the day, it cost higher to watch a movie at peak our rather than at night when there is not much load at power generating company [7]. AM guides its user of how much they are charged for this hour, allowing the user to wisely use the appliances such as using the washer or dryer at off-peak hours. This solves multiple purposes, firstly reduced power charges, reduced power wastage, and reduced pressure at power generating companies at peak hours. More the power plant operates below its peak capacity less is cost per unit needed to generate it, which eventually got transferred to its users.

B. Remote Monitoring

This feature allows the electricity providers to control and monitor the meter remotely. Power Company (PC) could connect or disconnect a connection to a user while looking at his status [8]. Automatic Meter reading (AMI) could be taken from anywhere and anytime, ruling out the process of visiting to the meters personally. Moreover service providers could also keep an eye over network to avoid any unauthorized use.

C. Notification

Based upon the concept of interactive grid Power company could notify with recent updates and forecasting. In case of technical fault in grid users could notify its consumers about the incident. Notification could be of many types like remainder for due date to pay the charges, blackout, peak hours. Offers could also be provided by PC such as at the time of Christmas when there is huge lighting throughout; PC could ask for cooperation in reducing the net load at this hour and giving some deal like coupons or vouchers in return. Even an end user could notify grid regarding any fault or malfunctioning at their end.

D. Load Demand/Request

An individual can increase or decrease its effective load. As shown in figure 2, a consumer also could become macro size and micro size depending upon its consumption. So in order to implement this, there is a need of real time communication between user and supplier. AMI allows the user to send request to supplier demanding increase or decrease of power being delivered at their end.

E. Net-metering

Net-metering is a method of charging the consumer/user for net units on the meter at the time of billing. This concept made it possible to accommodate non renewable source of energy more efficiently and reliably. This method involves AM (Advance Meters), which could roll back to its previous values. For an instance user have surplus energy being generated from his solar panel at roof top he could sell back the energy to grid. This can be done in two ways firstly, by selling the power for cash or secondly by reducing the reading of meter at users home. It needs to be checked with state regulation whether the state allows the net metering or not [9]. To implement this either a single meter which could roll back or two meters for both directions. When a user wants to send surplus energy to grid, first the grid is notified by the user. On receiving the notification grid reconfigures itself to allow this process and acknowledgment is send to user to start send power in reverse direction. Flow of energy in reverse direction is accounted by net metering, and user is charged for the balance units. Using the AMI a consumer could schedule its utility components according to need. For instance a consumer wants his washing machine to work only in off-peak hours he/she can program its schedule.

V. COMMUNICATION IN SMART GRID

Reliable and efficient communication system forms the basic skeleton upon which complete smart is based upon. As in previous sections we discussed the AMI and communication between user and grid proving that how vital is communication for existence of smart grid. Communication in smart grid is not only responsible for notifications or remainders but also includes software based transmission and control, re-routing algorithms, fault finding. It is required to understand existing power grid architecture to make some significant moves in smart grid. Figure 3 explains basic distribution characteristic of existing power grid. Power is generated and transmitted at very high voltage from power plant to transmission substation (TS) then it is down converted and brought at medium level voltage to distribution substation (DS) and control center. Here again power is down converted to low level voltage to make suitable for user utilities. The flow of current in different levels poses some challenges while designing effective communication. Now for designing

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communication architecture for Smart Grid among the available option there are couple of options which could be used. Among wireless, wire line to be more specific broadband, cellular, or power line itself each with different advantages and disadvantages, or hybrid combination of them could be used.

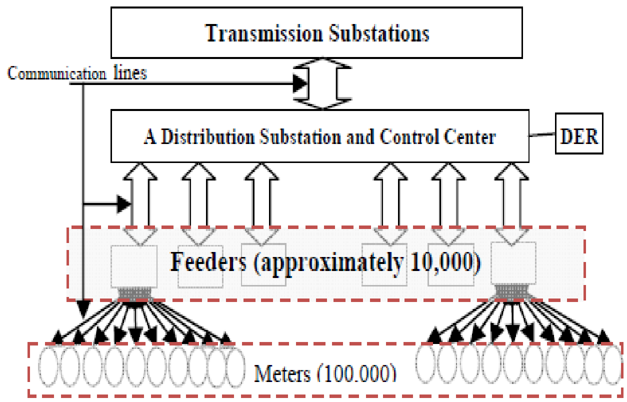

Figure 3: Diagram showing distribution of power from TS to end user

A. *BPL (Broadband over Power Line)*

BPL is also known as PLC (Power Line Communication). This implies to use power lines itself as a medium for effective communication and achieving bidirectional communication. This concept is quite old but not brought into use on massive scale for commercial purpose. Power company use this service and keep it restricted to them only.

There are many reasons that hinder BPL from being an anonymous choice as communication medium. First and foremost, as we have discussed that power reach to the user from the point of generation via three stages. So, it becomes very difficult and costly affair to sustain the data signal thought the three stages, but it could be used at same level while maintaining the quality well above the minimum threshold. Another major reason is that a data signal inject onto power line could not pass through transformer. Although this step can be dealt by using the bypass devices but it increases the complexity and overall cost. Data signal instead of going through transformer are separated before transformer and again injected to power line after the transformer.

A huge loss of power lines is another characteristic which makes BPL a secluded option. A clique is produced when a device is switched ON or OFF in a network. This depletes the signal quality and also introduces noise in the system. As power lines are not insulated, they could act as an antenna hence interfering with signal being generated from high tension wire in close vicinity. Some factors discussed [10], [11] over here avoid BPL as complete mature communication network for smart grid. Some architecture have been proposed by smart grid using BPL based upon packet oriented approach

B. *Conceptual Architecture*

The basic architecture of smart grid involves AMI, sensors, renewable sources, distributed Generation, intelligent interfaces, wireless devices. Here a conceptual layout is given which involves all those parameters required for a grid to be smart [12]. Type of communication media can be selected depending upon the availability, as in the case of rural consumers where both cellular and internet based cannot be applied but PLC method can be to cover the basic services.

The plus point of the system is its flexibility and re-configurability. Grid re rout itself when there is reverse current flow from consumer. Some requirements that a Smart grid fulfills are:-

- **Self-Healing:** use of sensors at different check allows the grid to keep track about its health and take necessary action when required.
- **Self-Configurability**
- **Self-Reliability**
- **Dual communication**

The Beginning of the Smart Grid

There is no exact date for when the Smart Grid began. It has evolved over time, starting soon after power grids were first used. As electricity began to spread, there was a need to track energy use, costs, and services. Reliability and efficiency have always been key goals. Today, many countries are moving toward renewable energy to cut emissions, fight climate change, and secure future energy needs. Upgrading the power grid plays a big role in this shift. Smart Grid projects often involve smart meters, which started appearing in the 1970s and became common in the 1980s.

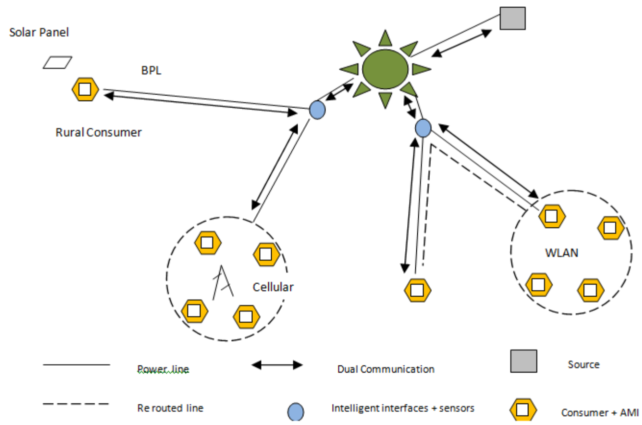

Figure 4: Conceptual Layout of Smart Grid

Conclusion

This paper gives the review of smart grid why we need it, what are its advantages and forth coming challenges. Smart grid is required if were to deliver on the requirements of electric generation, distribution, and usage in the future. It is discussed that Smart Grids build on the technologies of sensing, communication, and control could answer are question to increasing pollution, energy crisis, high power cost and clean energy.

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