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THE SMART POWER GRID: TODAY AND TOMORROW

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ABSTRACT

The Smart Grid, considered as the upcoming power grid, uses bidirectional flows of power and information to create a widely distributed automated and robotized energy delivery network. Power plays a critical role for social, economic and industrial development. As a result of built-up simplification, especially in agricultural and economical activities, the energy demand has increased rapidly in developed nations. Production and practice of energy has nonstop brunt on modern power grid. In this scenario energy management is a tough assignment to engage in because load is dynamic and we don't have control over it. Renewable or undepleted energy assets have immense applications and bang in existing electric power system circumstances. For example it gives contamination free (green) energy which is environment and user amusing. It is cost efficient, it uses ordinary assets for its production and so do not devastate any coal, gas etc. There are many affectations to empower energy yield. As current smart grid is complex and non linear in operation and design, it utilizes an upgraded technique that gives greatest productivity with minimum sum input.

Keywords: *Smart Grid (SG), Demand Response (DR), Distributed Generations (DG), Renewable Energy.*

I. INTRODUCTION

CONVENTIONALLY, the term grid is used for an electrical energy structure that probably will hold up the entire or a quantity of the mentioned four operations: Electricity generation, electricity transmission, electricity distribution, and electricity control. The theory of well-groomed grid or network combines a number of technologies, customer solutions and addresses some strategy and regulatory drivers. Smart Grid or network does not have any solitary definition. The European Technology Platform defines the Smart Grid as: A smart grid uses sensing, embedded processing and digital communications to allow the power grid to be observable (able to be measured and visualised), controllable (able to manipulated and optimized), automated (able to settle in and self-heal), fully integrated (fully interoperable with existing systems and with the capacity to incorporate a unlike set of energy sources). In other words, a Smart Grid is an energy set-up that can elegantly assimilate the dealings of all users coupled to its generators, consumers and those that do both in order to efficiently deliver sustainable, financially viable and safe and sound electricity supplies. From the above mentioned definitions, the Smart Grid can be described as the crystal clear, faultless, and instant bidirectional delivery of energy information, enabling the electricity production unit to better supervise energy deliverance and transmission and empowering consumers to have additional control over energy decisions. Power is a vital input for economic and industrial progress [1]. The fast progression of world economy, power needs rushed extremely, particularly amid emergent nations. Smart Grid responds to ample range of events and has a number of categorization because of its extensive usage in a variety of systems such as smart Power grid, sharp grid and imminent grid. SG is inducted in all energy power sources and in system of power and energy generations for most favorable marketing, commerce and improved organization. The central view is to take both the active customer involvement and resolution making at single grid and creating a running atmosphere for both utilities and electrical energy consumers to deal with each other. DRPs in the service field improve stability by means of dispersed production or energy storage space at substations, and on the whole giving the robotic control to the network [2]. SG measurement and certification assets toil in a structure of sensors, communications system, supercomputer hardware and software programmed chips or processors. The software allows monitoring, communication and breakdown of the burning up of energy source in the whole network by comparing it with software data for gauging the routine of the store. The energy supply has to be there in the complete grid for the extent of the course of measurement and confirmation [3]. Efficient energy management and distribution is empowered through DR. A series of devices function collectively with advanced software system for enabling DR. The software assets consist of AMI, communication systems, automated building systems and complex devices. Measurement resources play a vital role of operating and running fundamental SG operations.

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These functions include automated meter reading and conveying cost signals. Validation, measurement and authentication are additional benefits and nominal amount is required for installation [4]. SG is a strong and resourceful structure that ensures consistency, effectiveness, suppleness and delivers power in a controlled and smart way lowering peak demand. Investments are done in power zone to intensify expansion, progress and to bequeath with utility to consumers. By humanizing technology the grid will turn out to be a self healing system and incorporating power storage devices, renewable energy, and AMI and demand response programs will stabilize the grid. All such qualities of Smart Grid make the whole power system supple and highly reliable for the future and present needs of the consumers.

The typical diagram of the Modern Smart Grid is given below in Figure 1.

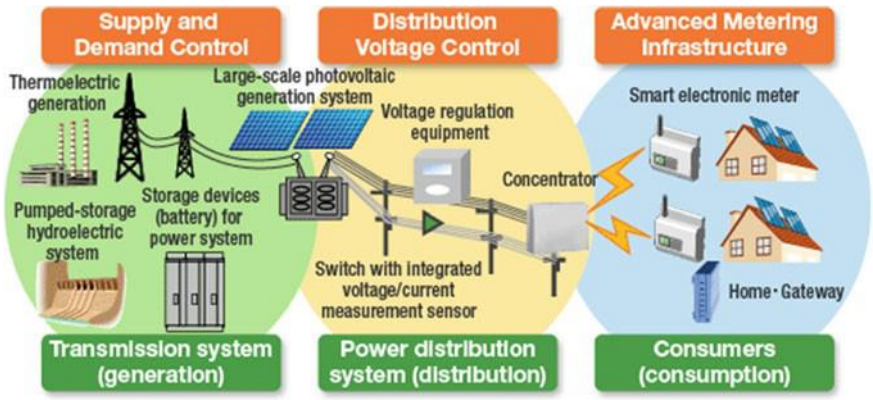

Figure 1 Smart Grid

II. SMART GRID AND ITS TERMINOLOGY

The Advance Metering Infrastructure (AMI) and its functions are briefly described below and also the various other terminologies related to Smart Grid are also explained in the next sections.

II.I Advanced Metering Infrastructure (AMI)

AMI measures the capacity of Power used, analyzes how it is used by identifying the tribulations and reads the definite energy consumed by a consumer. AMI is considered as the foundation of SG and enable consumers to use electricity more proficiently and efficiently by informing consumers about detected problems on their systems [5]. Figure 2 describes the advantages of AMI. Automatic meter reading system differs from conventional meter. Automatic meter reading system is bidirectional and has various sophisticated features such as energy larceny applications, bidirectional interactions for valid time statistics and has information with reference to power network and end user circumstances. AMI consists of smart meters and communication networks. This AMI structure is linked to the running coordination, customer information displays and smart energy measuring devices. Thirty percent attenuation can transpire in the demand for the duration of peak hours through the AMI in vogue. Setting up of AMI system enhances consumption in a logical, economical and efficient manner [6].

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The Figure 2 below describes the advantages of advanced metering infrastructure (AMI).

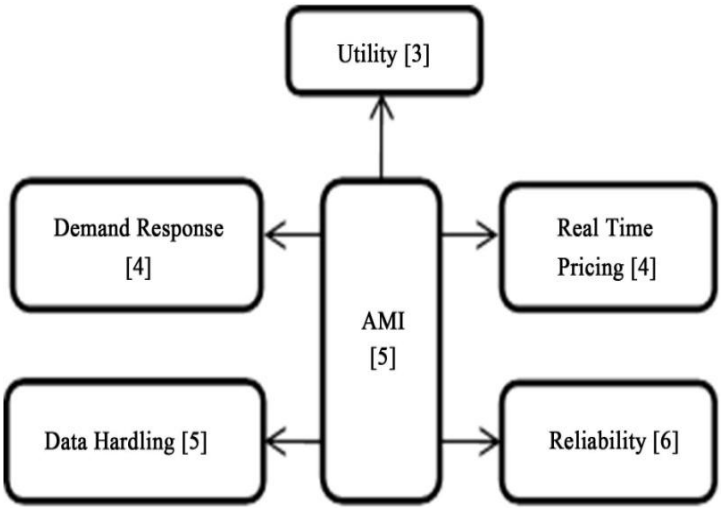

Figure 2: Advance Metering Interface

II.II Integration of Renewable Energy into SG

Demand of renewable has augmented and 19 percent of the global electric power share is of renewable power out of which hydroelectric energy makes 83 percent [8]. Shifting to renewable machinery is necessary for green house defense and to boost power and resources protection. As a consequence renewable energies and disseminated generation are getting backing and their stakes in power generation are increasing. Table 1 illustrates the advantages of renewable energy. The budding renewable production is the foremost unease for people working for growth in SG system and the introduction of strewn generation to the electrical distribution system has been the key driver in the progression of distributed system. However assimilation of renewables is not getting the ideal market consideration nor has chipping in system management [9].

Renewable energy consumption in Smart Grid is escalating and supports the network by enhancing power eminence, trustworthiness and dipping cost. Climate change has become a setback and to deal with this concern renewable power assets are chosen and it provides overall power system strength [10].

II.III Demand Response Programs (DRPs)

The Demand Response (DR) enables the supply companies and authorities to have a solid control on the load and tariffs management which includes the control for the duration of peak hour periods of power demand and off demand periods. This mainly gives the power supply authorities to transfer energy spending whilst the demand is elevated for the period of peak hours of the daylight, to the off hours when the demand for electricity is the least. Demand Response is put into use by two ways in vogue worldwide which includes direct load control or dynamic pricing [11]. Table 2 below shows the distinctiveness of traditional or conventional DR and SGDR. In direct load control the central appliances at the consumers end are controlled by switching off and on at unlike times of peaks hours of energy demand and leaner time of electric demand. The pricing techniques is put into use by enhancing the due charges for the duration of peak power demand hours in order to hold down the consumers to switch or turn off high power spending appliances in order to save elevated rates and same way to use them during leaner time of electric demand as the cost is very low [12].

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Table 1: Advantages and Disadvantages of Renewable Energy.

Renewable Energy	
Advantages	**Disadvantages**
Easily Regenerated [2]	Weather Dependency[7]
Boost Economic Growth [3]	High Setting up Cost [8]
Easily Obtainable [4]	Noise Caused by Wind Energy [9]
Support Environment [5]	Fluctuation Problem (Solar) [10]
Low Maintenance Cost [6]	Intermittency Issue (Wind) [11]

Table 2 Characteristics of Traditional DR vs. SGDR [12].

Renewable Energy	
Conventional DR	**SGDR**
Controlled by Utility	Controlled by Customer
Interruptible Charges are Controlled	All Available Loads are controlled
Equipment is Provided by Utility	Equipment Provided by Market suppliers and customers
DR Products are Restricted to Trustworthiness	DR products not limited includes Capacity, service markets and load management
Participation by Targeted, limited to residential	All Customers Chipping in

II.IV System Operational Efficiencies

SG applications are designed to provide efficient electrical energy service and it provides benefits to both consumer and utility. The benefits that result from these efficiencies include proficient real-time operations of power generation and further services. Efficient exercise of capital investments for new infrastructures is made for the principle of generation, transmission and distribution including efficient maintenance and paperwork. Since peak demands for electrical energy is somewhat elevated than typical intensity, So SG should enhance the utilization of resources. Resource consumption can help out in smoothing peak periods thus plummeting the probability of crisis and producing electrical energy more resourcefully. In distribution system SG technology can have substantial arrangement to capital investments. DR schemes are synchronized with individual distribution feeders to lower peak loads thus controlling voltage or electric potential proficiently [13] [14].

II.V Grid Modernization for Enhanced Efficiency

Modernization of grid includes upgradation of transmission and distribution (T & D) networks that expand electrical energy services to novel population and develops the grid's productivity in supplying those services. The mounting principles need to identify the global standards to improve own potential for more implementation of these values to gain the maximum and best possible level from the technology development, deployment and operations. Moreover, development of a regulatory frame work is essential to control and prolong SG investment by enabling adequate monetary returns for the power industry. For the rationale of shifting to SG a sustainable production models and a synchronized expert and industry loom is required to look after

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investment in new technologies that helps to accomplish the benefits of the smart grid. Effective consumer security and commitment is the fundamental need which will shoot up the consumers demand for SG technologies and ensure utility and for the consumer [15]. The Figure 3 below shows the characteristics of modernized or rationalized grid and the relation of integrated information and communication technology with modernized grid.

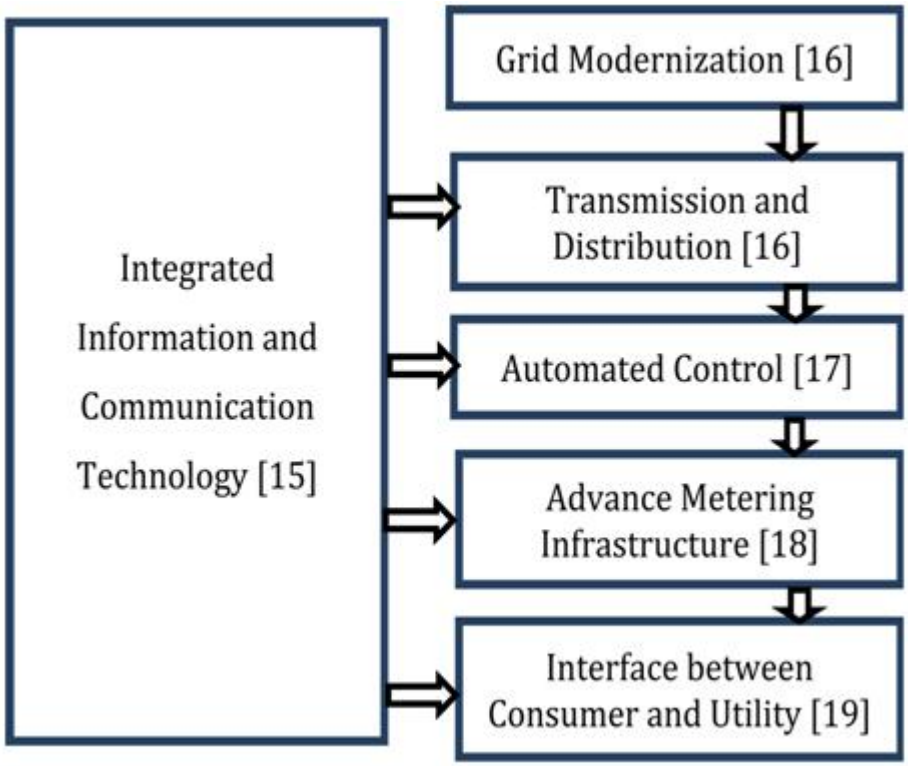

Figure 3: Characteristics of Modernized Grid.

III. CHALLENGES IN POWER EFFECTIVENESS MODELING

Energy efficiency modeling is of great disquiet within the field of smart grid (SG). The SG implementation needs range of improving constraints and challenges. Efficiency modeling is achieved by the implementation of optimization schemes. An immense information set is needed to allocate totally unlike modeling techniques on the principle of various constraints and challenges increasing inside the field of smart grid. The definition to the optimization is that the procedure adopted to implement totally different techniques for locating conditions to maximize the profit or in other words to trim down the price of whole process. The two main challenges of SG and DG are discussed as:

III.I Communication Infrastructure Complication

The communication infrastructure of a SG is a structure that is a blend of diverse systems and is very much multiple. While modelling, analyzing and designing a communication infrastructure, a number of new challenges are required to meet. As a way to express promising behavior, the communication models that are being anticipated are required to have the capability of accounting for ambiguity. The numeric tools used to solve very large scale problems must have the potential to carry out analysis. As a fact that the power system is a nonlinear and extremely strong coupled system [16]. The communication infrastructure will be designed particularly to degrade control system and time required to deal with elastic or graciously uncertainties and inconsistencies [17]. The complication of a SG

communications infrastructure modelling challenges are encapsulated as: It is not feasible to effortlessly simulate electrical subsystem as it is tightly interconnected (Required to aid multi-physics approach) [18]. While taking into account a range of factors (energy flow, control, and communications) different users are required to work at the similar condition (need to hold multidisciplinary approach) [19].

III.II DG Integration Challenges

The integration of DG must be correctly investigated so as to conquer most favourable system performance. The DG integration could cause more challenges in security, reactive power management, and voltage fluctuation [19]. Moreover, the weather dependent nature of RER based DG heave the reliability apprehension of the system. Optimal system performance is achieved by watchful investigation of DG integration. The DG is inserted, bounded by the area of giant consumption and the overloading conditions arise from low load density areas.

IV. CONCLUSION

The Smart Grid (SG) possesses huge catalogue due to its prolonged practice in a range of power grid networks and is believed to be the prospect of modern power system engineering. Smart Power Grid technology by now has gained the main position for a well in time power giving out and is inducted in all energy power sources and in coordination of power and energy generations for chief promotion, trade and advanced administration. The emanation of CO_2 is the worry for greenhouse and the theory of EVs alongside with SG has addressed the trouble. Sustainability plays a vital part in effectiveness. Operations ought to be sustainable and spotlight should be on exercise of spotless energy and a better upbringing. SG applications are intended to provide efficient electricity service and provide benefits to both consumer and utility. The well-organized control of power system is becoming slowly but surely trickier as they gain in intricacy and dimension. Computerized power group structure with swift and best possible communication arrangement trounces every chief discrepancies of undue or inadequate load reprieve that were present in old conventional systems. This paper presents the basic observation, challenges and analysis of competent energy performance within smart grid. Possible research track that is necessary to decide the control tactic prospective for realistic purpose is the utilization of more detailed system models both on the production or generation and load side.

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