

# SMART GRID IN UTTARAKHAND POWER SYSTEM PLANNING AND OPERATION

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**Abstract**— Uttarakhand power system is facing the various problems. Due to these problems, the operation, maintenance and electricity generation market is very slow. The present grid system in this state is incapable to handle these discrepancies. These discrepancies can be handled by Smart Grid. Smart Grid is the requirement of present time of every state of India as well as whole world. In these days, Smart Grid is the remedy of problems of the present power system of. In this paper, the authors describe the smart grid and its main component and about of operation of Smart Grid in Uttarakhand.

**Index Terms**— Smart Grid, self-healing process, Distributed Generation

## I. INTRODUCTION

The power technology plays a vital role for the development of any country. To develop and maintain the modern economy and society, the economical, social and environmental sustainability are required in the energy sector. For the economical and social growth, the prime movers are more important. The electrical energy is main prime mover for this [1]. But there are crisis of electricity in India as well as in the whole world. The society of any state has become dependent on electrical energy at every level [2]. The ability to meet the energy requirement will depend upon India's ability to expand domestic production in the critical subsectors such as petroleum, natural gas and coal, and meeting the balance requirement through imports. The power system of India has been facing a series of problems viz., inefficient structure, inadequate generation, frequent outages, poor power quality, etc [3]. India is the world's fourth largest energy consumer after United States, China and Russia [4]. Indian central government and state governments jointly regulate power sector in India. In India as well as in Uttarakhand, two factors are very necessary to fulfill the condition of electric energy: (a) variety of energy's sources (b) the infrastructure of electric power grid respectively. To rectify the crisis of energy the renewable energy sources are being used and various types of power plants have to be installed in the different areas of states [3] because the atmospheric condition in different areas of India is very different. The Government of Uttarakhand has

initiated the various methods to rapidly expand education of energy in the state, to introduce courses related to energy capacity addition, maintenance and production in the curriculum of the educational institutions. This initiative includes both renewable and conventional form of energy. Indian power sector suffers from high transmission and distribution losses, electricity shortages, poor economic

condition of the State Electricity Boards and a big gap between demand and supply in electricity power [9]. According to ministry of power, in Indian power grid transmission and distribution losses are nearly about 27% of total electricity production and in some states, it is high as 62%, including non-technical losses such as energy theft losses as may go as high as 50% [10]. Due to the poor condition of current grid, inefficient, congested and incapable to fulfill the demand of electrical energy of consumers in future [11], [12]. The Grid failures have become severe problems in India. This problem is caused due to the insufficiency of present power infrastructure and lack of latest technology. To overcome the present power scenario, Government of India has been taken the great initiative to improve and enhance the current power system with advanced emerging technologies. The main aim of modern technology viz. Smart Grid is to renovate the current power grid by integrating intelligent components and with the communications technologies for monitoring and automation of the power grid to apply the Demand Response and demand-side energy management effectively [2]. Smart Grid can be used to optimize the operation of the component of power system viz. generation, transmission and distribution, reliability and reduce the cost [13]. The basic aim of Smart Grid is to identify and correct demand imbalance supply instantaneously and detect faults through a "self-healing" process that improves services quality, efficiency, enhances reliability and reduces electricity bill [14]. With the implementation of Smart Grid technology, the Power System Planning and Operation will be more effective [15].

In Indian power sector, the central, state government and private electrical companies have played an important role. According ministry of power, the installed capacity of central government, state government and private sector are 74806.75 GW, 97950.59MW and 115247.63 MW % respectively as on 31<sup>st</sup> January, 2016. The total installed capacity of power is 288004.97 in India as on January, 2016 [8]. The RES all India as on 31.12.2015 is given below (in MW):

Small Hydro Power	Wind Power	Bio-Power		Solar Power	Total Capacity
		BM Power/Cogen	Waste to Energy		
4176.82	25088.19	4550.55	127.08	4878.87	38821.51

In Uttarakhand power sector the installed capacity of central government, state government and private sector are 851.80 MW, 1315.03MW and 1010.45MW as on 31.01.2016:

## II. PRESENT GRID TO SMART GRID

The current power grid is unidirectional. The generated electricity cannot store in present power grid. So till date, the both process viz. generation and consumption worked simultaneously. There are balance problem for generation and consumption in the present grid. The Indian power grids are not secure, reliable and up to the mark. The operation of present grid is based on one-way communication from the utilities to the users. The power flow is unidirectional from centralized supply sources (power plants) to demand. The Fig. 1 represents the schematic diagram of present power grid. Due to many factors, a major overhaul is requirement in the old power grid [3]: (a) A large gap between supply and demand (b) Very high transmission and distribution losses (c) Manual operation of the network mainly (d) Poor use of a huge potential for renewable energy (e) low metering efficiency and less friendly user involvement (f) Lack of utilization of advanced in information technology in the power grid. To rectify the above deficiencies and upgrade the conventional grid, modern the technology is required viz. **“Smart Grid”** is required.

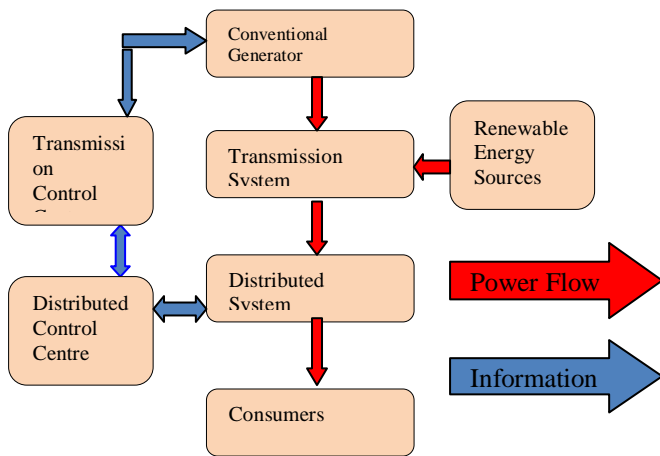


Figure1. Block Diagram of Present Power Grid

The Smart Grid can be made by advance technology, instruments and intelligent management system. Smart Grid is a necessary response to the environmental, social, and political demands, placed on energy supply. The smart power grid becomes much more complex than a traditional power grid as time-varying sources of energy and new dynamic loads are integrated into it. The smart grid's complexity will evolve over time and require new technologies for efficient, reliable and secure operation and control as the demand for electricity increases. Traditionally, the term grid is used for a power system that may support to the following four operations: power generation, power transmission, power distribution, and power control [16]. A power grid is a grouped name for all the electrical wire, transformers and infrastructure that transport electricity from power plants to consumers.

The challenges to Uttarakhand's current electric power system, from the different sources,

- Low level of equipment sophistication in parts of the electric power grid in Uttarakhand, especially at the distribution grid level.
- The old distribution transformers, which are inefficient in operation.

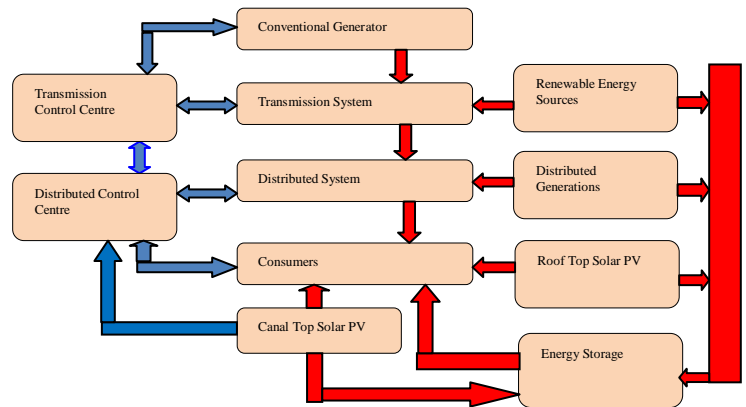


Figure 2 Block Diagram of Smart Grid

Figure 2 represent the block diagram of Smart Grid. The block diagram evident the operation of flow of the electricity from various energy resources and information from costumer to generation sources through transmission and distribution system. However, the operation of the Smart Grid is based on both side communications for information and power flow using of power engineering, communication engineering, digital and information technologies [1]. In the both side communication process, the users communicate with utilities on hourly or daily basis to know about relevant information. By initiative the modern technology viz, Smart Grid, the balancing problem of electricity between utilities and consumers will be rectify [17]-[18].

By using the Smart Grid technology, the small renewable energy sources, distributed generation (DG). Roof top solar PV, canal top solar PV and energy storage can be integrated [19]. With the advanced development in power system technology, the smart grid recommended the seamless integration of renewable energy sources into the present electrical grid [20]. To develop the Smart Grid, the present grid is facing the large number of challenges. The challenges can be overcome with the advanced technology of power electronics devices viz. HVDC, FACTS, STATCOM and UPQC etc [21]. With the introduction of smart grid, consumers can manage their energy consumption by monitoring their voltage and power [22]. By deploying the smart technologies, demand response and load management can be enhance to makes the power transmission system more efficient, encourage renewable energy resources, and give facility to consumer for control over their usages and costs. At present, The Uttarakhand Government and Government of India have given more attention on the Smart Grid technology to cope up with the energy crisis in future. Presently, the Government of India considered, the Smart Grid is the main feature to development of nation [23]. Smart grids – an essential part of Uttarakhand's future electric power system. Uttarakhand government aims set up ambitious development

targets for the future electric power system: amongst others, generation and grid capacities are to be expanded substantially, the share of renewable energy sources (RES) in the generation mix is to increase considerably, the number of power outages and supply interruptions is to decrease significantly, and the efficiency of energy and electricity usage is to increase markedly. Moreover, Uttarakhand government continues to modernize the energy sector regulation: it plans to establish a more effective electricity market system, considers downsizing and further unbundling the integrated electric grid operators, and aims at optimizing the electricity pricing system.

### III. DEFINITIONS OF SMART GRID

While there is no formal definition of the smart grid, but according to the features of it based on literature, “the Smart Grid is a modern grid which consist the advanced technologies of electrical engineering, communication engineering and software engineering with the present power grid”. According to the U.S. Department of Energy Smart Grid System Report ,smart grid as today’s grid joined by advanced metering and control devices such as information technology, sensors, high speed and real-time two way communications, energy storages, distributed generation and in-home energy controllers[24]. The State Grid Corporation of China interprets the Smart Grid [25] as “A strong and robust electric power system. It is backboneed with Ultra High Voltage (UHV) networks; based on the coordinated development of power grids at different voltage levels; supported by information and communication infrastructure; characterized as an automated and interoperable power system and the integration of electricity, information, and business flows.”

In brief and following the International Energy Agency (IEA), smart grids can be defined as:

» An electricity network that uses digital and other advanced technologies to monitor and manage the transport of electricity from all generation sources to meet the varying electricity demands of end users. Smart grids co-ordinate the needs and capabilities of all generators, grid operators, end users and electricity market stakeholders to operate all parts of the system as efficiently as possible, minimizing costs and environmental impacts while maximizing system reliability, resilience and stability. [6]

### IV. COMPONENTS OF SG FOR POWER SYSTEM PLANNING AND OPERATION

The Smart Grid consist the various component. All components are inter-related and inter-linked too. All components must be integrated to enhancement the reliability, more efficiency and security as shown in Fig.3. With the component of Smart Grid, the designing and operation of Uttarakhand power system will be more efficient and effective.

**Smart Meter:** It is a foundation for Smart Grid. It is a measuring device which measures the consumption of energy with more details over the conventional energy meter. It is a two-way communication device between energy providers and consumers. Through it, the customer can be shared the information for power consumption directly to the utilities via e-mail or other communication method, so that consumers can reduce their use of electricity and electricity bill [27].

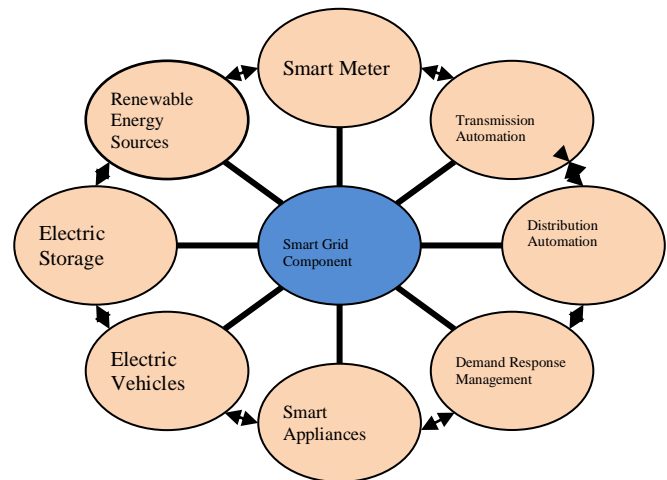


Figure 3. Component of Smart Grid

The main functions of smart meter are following [28]:

1. Respective statistic of multi-period multi-rate model power, measures active power and reactive power usage amount. Smart meter should have two-way metering function, and independent storage space for storing electrical energies.
2. Supports bi-directional communication, can send data and receive command, such as sending real-time power usage information, receiving real-time rate standard and meter program upgrade set etc. remote operations.
3. According to the demand response requirement, achieves the intelligent restraint of total load. Smart meter and smart interactive terminal will work together to realize smooth transition to an isolated system when power grid fails.
4. Supports multipurpose value-added service, for example, reading smart gas meter, water meter, etc. According to the functions of smart meter, the block diagram of smart meter as shown in Fig. 4.

**Distribution Automation:** IEEE has defined Distribution Automation (DA) system as “a system that enables an electric utility to remotely monitor, coordinate and operate distribution components, in a real time mode from remote locations” [29]. The distribution automation consists the four main components e.g., field instrumentation, RTUs, communication engineering and automation software.

**Demand Response Management:** The definition of “demand response” that was used by the U.S. Department of Energy [30] “Changes in electric usage by end-use customers from their normal consumption patterns in response to changes in the price of electricity over time, or to incentive payments designed to induce lower electricity use at times of high wholesale market prices or when system reliability is jeopardized”. Demand Response, is most important



component to electrical utilities to get higher efficiency and smoother load curve [31]. Demand response plays an important role to the retail and wholesale power markets. Demand response means by which demand will be dynamically and continuously balanced with supply-side resources to produce a cost effective electricity system. It should have both supply sides and demand sides that respond to transparent pricing schemes.

**Demand Side Management:** Demand management is a mechanism to influence the ability and willingness to reduce electricity consumption of customers. It is a program of utility in order to fine-tune power consumption pattern of consumers, according to the energy production of utility and distribution capacity. DSM programs consist of the monitoring, implementing, and planning activities of the utilities that are designed to encourage consumers to modify their level and pattern of electricity consumption [32].

Demand management is based on a combination of the use of high-efficiency equipment and the efficient use of electricity through good operating practices.

Demand Side Management (DSM) is the implementation of policies and measures that serve to control, influence and usually reduce demand of electricity. The aims of DSM to enhance the electricity-consuming systems reduce energy consumption, while maintaining the same level of service and comfort.

**Electric Vehicles:** The wide use and deployment of an electric vehicle consists two concepts (a) Grid-to-Vehicle (G2V) and (b) Vehicle-to-Grid (V2G). In **G2V**, electric vehicle are powered by stored electricity originally from an external power source, and thus need to be charged after the batteries discharged. This technology is conceptually simple [32].

One solution to mitigate the impact of electric vehicle on the grid is to optimize their charging profile. In other words, we need to keep the peak power demand as small as possible, taking into account the extra power consumption from the vehicle charging. This can be done by coordinating the charging operations of different electric vehicle so that they are not charged at the same time.

In **V2G**, electric vehicle provide a new way to store and supply electric power. V2G-enabled electric vehicle can send the signal to the grid to deliver electricity into the grid, when they are parked and connected to the grid.

**Electric Storage:** Electric Storage technologies such devices as advanced batteries, pumped hydro and others require electricity to be stored and dispatched during times of peak demand or to provide power from renewable resources.

**Smart Appliances:** The Smart Appliances is also important component of smart grid. The consumption of energy is very less in smart appliances. The advantages of smart appliances are not limited to making life easier, but very much helpful in energy saving also.

**Transmission Automation:** The power transmission system can be augmented by embedded carrier communication system along with the exciting transmission system and newer which are under pipe line. This automation can be supported by optical fiber communication. All types of information will be available at every point of the power system which will be excellent facility for the entire power person all engaged in the system and even to consumers also. Transmission automation

system can be developed by joining the smart substations, smart communication system and smart measurement, command and control centres [34].

**Renewable Energy Sources:** The Renewable Energy Sources are most important component of Smart Grid. To protect environment and for sustainable development the importance of renewable Energy sources cannot be overemphasized. It is an established and accepted fact that renewable and non-conventional forms of energy will play an increasingly important role in the future as they are cleaner and easier to use and environmentally benign and are bound to become economically more viable with increased use. Renewable Energy Sources are following types: wind generation small hydro, micro hydro, bio-gas and solar technologies etc. In the solar technology, two process are very important (i) Roof top PV Solar (ii) Canal top PV Solar

### Rooftop PV Revolution in India

As part of Prime Minister, Narendra Modi's vision of adding 100 GW of solar energy to the Indian grid in next 7 years, Ministry of New & Renewable Energy (MNRE) has allotted year wise target for each state in the country for setting up Rooftop PV. The target for Rooftop PV, under this plan, is 40 GW by 2022 starting with 200 MW in 2015.

With the price of PV systems steeply going down, it is estimated that the price of electricity from rooftop PV is in the range of Rs 6-7 per kWh (without storage). High volume consumers and commercial consumers pay more than Rs 8 per kWh in most states. While the PV cost will be stable for next 25 years, grid tariff could see steep increase. Government has also advised banks to treat the cost of PV systems as part of the building cost for home loans.

### Uttarakhand Government to Focus on Rooftop Solar Power

Uttarakhand Renewable Energy Development Agency for promoting solar rooftop projects in the state. A 50 kw rooftop solar project set up by the Uttarakhand Renewable Energy Development Agency at the Pithoragarh collectorate building. Uttarakhand is all set to promote rooftop solar power as part of alternate energy initiative, with the Union Ministry of New Renewable Energy already having a target of 7 MW of power generation through solar rooftop projects for 2014-15. The ministry aims to identify 100 campuses in the country as green campuses that resort to consumption of solar energy to meet their energy requirements. He said the Pant Nagar University in Uttarakhand has already been identified as one such green campus. He lauded the Indian Institute of Technology, Roorkee for putting solar energy to maximum use, generating 1.8 MW power solely through rooftop solar plants.

### V. REGULATORY ENVIRONMENT OF SMART GRID

The Various regulatory areas will be used to new research and implementation of Smart Grid in Uttarakhand's power systems.

- Policies for Research Institutions of Electrical Engineering

- Design of Structure of Electricity Market
- Rules for RES Integration
- Establish network regulation for transmission and distribution grid operators
- The Role of Information and Communication
- Developed the Coordination between Generation and Consumption.
- Involvement of Academic Institutions with power grid
- Development of Power Engineering Laboratory

## VI. CONCLUSION

In the paper, the features of present power system operation in Uttarakhand have been discussed. The comparison of current power grid and modern grid viz. smart grid has been elaborated. It is proved by comparisons, the smart grid system is superior than present grid. Viewing the technological advancement in the world in power system, Uttarakhand should also adopt the latest methods like Smart Grid for the operation, management and planning of advancement in power system. The integration of smart grid technologies will help the present power system to manage and eradicate the existing problems in the present power system management in Indian power sector as well as Uttarakhand power sector.

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