

Power Demand Optimization in Smart Grid via Wireless Networks

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ABSTRACT: *The smart grid is expected to be an integration of intelligent microgrids featured by localized electricity generation, storage, and consumption. In this paper, we optimize power based on demanding smart grid via wireless communication. Purpose of Wireless communication is to monitor and control the renewable energy generation as well as estimate the consumption. In order to avoid a single point of failure, multi agent (mesh topology) system based decentralized microgrid control is widely considered.*

Keywords - *smart grid, wireless network, mesh topology, power generation.*

I. INTRODUCTION

The objectives that are set forward for smart grid implementation can be summarized as: Integrating renewable energy sources, Enabling two-way flow of information and electricity, Self-healing, Being environment-friendly, Enabling distributed energy storage, Having efficient demand management, Being secure, Being future proof, etc.,

In this paper, we investigate one of the critical control problems in microgrids, i.e., the droop based decentralized inverter control. Featured by a decentralized control strategy with a communication network infrastructure, the traditional droop control strategy emulates the droop characteristics of synchronous generators based on local estimates of power generation. The operation principles and the components of the electrical power grid are recently undergoing a major renovation. This renovation has been triggered by several factors. First, the grid recently showed signs of resilience problems. The second factor to trigger the renovation of the grid is that in a near future, the imbalance between the growing demand and the diminishing fossil fuels, aging equipment, and lack of communications are foreseen to worsen the condition of the power grids. Growing demand for energy, diminishing fossil fuels, desire to integrate renewable energy resources, efforts to reduce Green House Gases (GHG) emissions and resilience issues in the electrical power grid, have led to a common consensus on the necessity for renovating the power grid. The key to this renovation is the integration of the advances in the Information and Communication Technologies (ICTs) to the power grid. The new grid empowered by ICT is called smart grid. Growing demand is a result of growing population, as well as nations' becoming more dependent on electricity based services. The third factor that triggers the renovation, is the inefficiency of the existing grid more than half of the produced energy is wasted due to generation and transmission related inefficiencies. This means that the operation of the power grid is rather inefficient.

The renovation targets to increase the penetration level of renewable energy resources hence reduce the Green House Gas emissions. Finally, the power grids are not well protected for malicious attacks. Smart grid aims to integrate the opportunities that have become available with the advances in Information and Communications Technology to the grid technologies in order to modernize the operation and the components of the grid. A mesh topology is the most flexible topology of the three. Flexibility is present because a message can take multiple paths from source to destination. If a particular router fails, then ZigBee's self-healing mechanism will allow the network to search for an alternate path for the message to take. In our project, one of the scenarios is to investigate this feature by removing a router from the network during operation, and seeing the end devices find an alternate path to communicate with the coordinator.

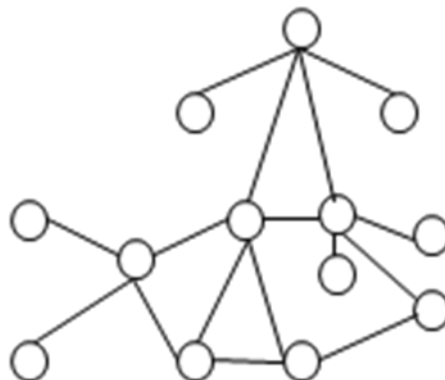


Fig1 Mesh Topology Model

The illustration shows distributed renewable energy generation and storage, consumer energy management, and communication between the utility and the parts of the grid.

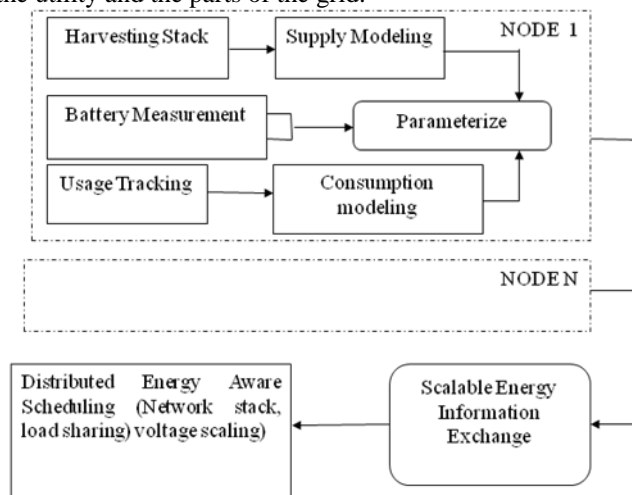


Fig2 Overview

II. SYSTEM MODEL

As shown in fig3, this project contains N number of nodes. Each node represents the home, industry, or one floor, based on the designer code. This paper going to deals with the 3 objectives, these are: (i) Power generation and storage(ii)Peak demand estimation(iii)collection of nodes information via wireless network. First one is Getting power from Renewable energy source like solar wind are used here to generate power always stores in a battery. The power demand is happen that time backup energy will be used. Here inverter (DC -AC) used because consumer need only AC it has to happen automatically. Secondly peak demand estimation, Peak hours refer to the time of day when the consumption exceeds the capacity of the base power generation plants that are built to accommodate the base load. When the amount of load exceeds the capacity of base power plants, they are accommodated by the peaked power plants. In smart grid, Automated Demand Response is being designed. In Automatic Demand Response programs, utilities send signals to buildings and industrial control systems to take a pre-programmed action based on the specific signal.

A. Power generation, Distributions & consumption

Every node should have the usage tracking, consumption modeling. Usage tracking is nothing but each node of input is connected with the current and voltage measurement circuit. The measured information passed to the parameterize Generation of power, Getting power from Renewable energy source like solar are used here to harvest the power , output of solar is DC so can directly store into battery. Hope of the generation is, use these renewable energy resource whereas usage needed in AC supply. so that solar energy initially saved in battery

and then it is converted into AC by the help of inverter. This is detail about the power generation. Power distribution, after the inverter section energy is ready to use in needed places, here single node is connected to the generation module.

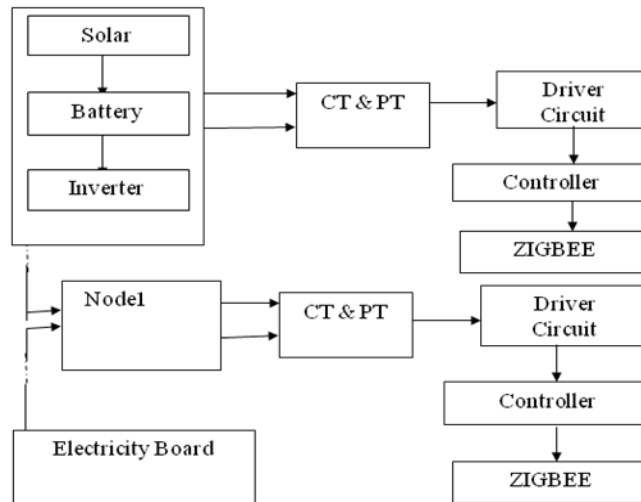


Fig3 Generation, Distributions & Consumption

Same node can consume the power from the renewable source as well as from the Electricity Board (EB). How to measure usage of power? Current Transformer (0-5V) and Potential Transformer are used to measure usage of current and voltage.

Based on that load power voltage and current varied in both the transformers. Whereas the output of those is weak signals in range of mv to v, this voltage is not readable by our controller. So that those outputs are given to driver circuit, purpose of this circuit is amplification of weak signals into micro controller readable signal. Controllers send that information to monitor station. This information about generation of power only. Node 1 is consumer's power from EB as well as from renewable source, this usage of power information how to send to monitoring station. Let's take 2nd load as an example. The load is may be home or bulb. The load is user definable. How much load issued in circuit will be measured by CT & PT driver circuit. This gives the variation between the 0 to 5v. This given to controller, here we are used pic 16F877 controller. This has the A/D conversion inbouded. When the power demand is more that time it's automatically on the relay section. These all consumption will be send via zigbee to EB office from the each individual home

B. Monitoring

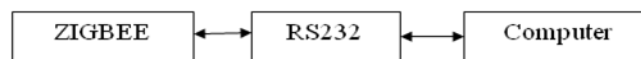


Fig4 Monitoring

Monitoring deals with, Figure 4 explains about monitoring section of this project. Similar to note 1 we can connect more nodes with generation section as well as with EB board. So now nodes can consume the power from EB or renewable source based on condition. Each nodes contain separate zigbee section, has send the information to monitor section. Monitor section works like server.

III. SMART GRID AND WIRELESS NETWORKS

In this section, we will briefly summarize the literature on the use of wireless networks in the power grid in order give a complete picture of the state of the art. The electrical power grid is a large network that can be partitioned into three main conceptual segments as energy generation, power transmission and electricity distribution, and consumption segments.

In the smartgrid, the traditional radial organization and this partitioning will change since the electricity will be also produced and used within a distribution system forming a microgrid. In this section, we follow the organization of the traditional grid for the sake of increasing the understandability of the text. We start with electricity generation sites, continue with power transmission and electricity distribution and finally

reach to consumption which is the last mile of the electricity delivery services. Wireless networks have broad range of applications in all of those segments.

A. Wireless Networks for generation facilities

In the traditional power grid, energy generation facilities are generally monitored with wired sensors which are limited in amount and located only at a few critical places. This is due to the high cost of installation and maintenance of those sensors. Wireless Networks offer low-cost sensors that can communicate via wireless links hence have flexible deployment opportunities. In fact, the utilization of Wireless Networks becomes even more essential with the increasing number of renewable energy sites in the energy generation cycle. These renewable energy generation facilities can be in remote areas, and operate in harsh environments where fault-tolerance of Wireless Networks makes them an ideal candidate for such applications. Furthermore, the output of the renewable energy resources is closely related with the ambient conditions such as cloudiness for solar panels. These varying ambient conditions cause intermittent power generation which makes renewable resources hard to integrate to the power grid. For those reasons, WSNs can offer solutions for renewable energy generation sites, such as solar (PV) farms or wind farms. Furthermore, wireless sensor and actor networks can take part in increasing the efficiency of the equipment. In (Shen et al., 2008), the authors address the challenge of varying wind power output by employing prediction where Wireless Networks are used to collect and communicate the cloudiness and harvested data to a central location that is Electricity Board. Wireless Networks can also be used for condition monitoring of the solar panel.

A Wireless Networks based energy evaluation and planning system for industrial plants have been introduced in (Lu et al., 2010). The authors have discussed the feasibility of using Wireless Networks and the benefits of replacing the conventional wired sensor with Wireless Networks. A similar Wireless Network-based system can also be used for condition monitoring of power plants. Low-cost, ease of deployment, fault-tolerance, flexibility are among the advantages of the Wireless Network-based systems.

B. Wireless Networks for transmission and distribution assets

Transmission system consists of towers, overhead power lines, underground power lines, etc., that are responsible for transportation of electricity from the generation sites to the distribution system. In the traditional power grid, the voltage is stepped up in order to reduce the losses at the transportation, and then, it is step down at the distribution system. Distribution system consists of substations, transformers and wiring to the end-users.

In the transmission and distribution segment, an equipment failure or breakdown may cause blackouts or it may even pose danger for public health. Moreover, these assets can be easily reached from outside, therefore they can be a target of terrorism. Wireless networks, once again, provide promising solutions for monitoring and securing the transmission and distribution segment. In (Leon et al., 2007), the authors utilize Wireless networks for detection of mechanical failures in the transmission segment components such as conductor failure, tower collapses, hot spots, extreme mechanical conditions, etc. Wireless networks provide a complete physical and electrical picture of the power system in real time and ease diagnosing faults. Moreover, power grid operators are provided with appropriate control suggestions in order to reduce the down time of the system. The authors employ a two-level hierarchy where short-range sensor nodes collect data from a component and deliver the collected data to a gateway. This gateway is called as Local Data and Communications Processor (LDPC). The LDPC has the ability to aggregate the data from the sensors, besides it has a longer-range radio which it uses to reach the other LDPCs that are several hundreds of meters away. The mechanical status of the transmission system is processed and delivered to the substation by the LDPCs. This hierarchical deployment increases the scalability of the Wireless networks which emerges as a necessity when the large geographical coverage of the transmission system is considered.

The use of an IEEE 802.15.4 based WSN in the substations has been discussed in (Uillo et al, 2010) and data link performance has been evaluated. The communication services provided by WSNs have been shown to be useful for automation and remote metering applications. Similarly in (Lim et al., 2010), the authors utilize Wireless Networks in transmission and distribution system for power quality measurements. The authors proposed a data forwarding scheme between pole transformers and the substation using multi-hop Wireless Networks. Power quality measurements include harmonics, voltage sags, swells, unbalanced voltage, etc. These measurements are communicated using the IEEE 802.15.4 standard. Further potential applications of sensor networks in the power delivery system have been defined in (Yang et al., 2007) as:

- Temperature, sag and dynamic capacity measurements from overhead conductors
- Reclosed, capacitor, and sectionalize integrity monitoring

- Temperature and capacity measurements from underground cables
- Faulted circuit indication
- Pad mount and underground network transformers

C. Wireless Networks for demand-side applications

In the traditional power grid, power grid operators do not have services for the demand-side except the Distributed resource programs for large-scale consumers. However, in the smart grid, by using the smart meters and the utility Advanced Metering Infrastructure (AMI), it will be possible to communicate with the consumers. A smart meter and AMI interconnection using Zigbee has been considered in (Luan et al., 2009). Furthermore, energy generation at the consumer premises will be also available. In fact, energy generation by solar panels and wind turbines are already possible, even the locally generated energy can be sold to the grid operators. However, Distributed Generation is not fully implemented. , Distributed Generation refers to a subsystem that can intentionally island. There are several reasons why this has not been implemented yet. Power quality problems may occur in an islanded system, safety of power personnel may be endangered due to unintentionally energized lines and there might be synchronization problems. In this context, utilization of Wireless Networks can provide efficient monitoring and control capabilities to increase the reliability of the Distributed Generations (Sood et al., 2009). Wireless Networks applications in the demand-side will be discussed in detail in Section A.

IV. RESULT ANALYSIS

GENERATED POWER FROM SOLAR	CONSUMER NO 1	CONSUMER NO2	CONSUMER NO3
1000 WATTS	100 WATTS	150 WATTS	60 WATTS
230 VOLTS	230 VOLTS	230 VOLTS	230 VOLTS

Buttons: DATABASE, EXIT

Fig 5 Front design EB section in VB6.0

Fig5 explains about the front end design of the VB6.0 in EB section. What power is Generated by the solar? the generated power will be recorded in the server section that means of EB section via wireless networks. Each node should connect with the other node. If any node code to reach the target node that is weak signal with the server node or master node, by the help of other node it's send the information to the master node. Anyone can use the extra load, on that time EB server section will send the warning message. Consumer should obey for that warning, or else server waits for few minutes than turn off the power for the particular customer. For example here one generation section, 3 number of customer sections are manage by the one samole EB section.

V. CONCLUSION

In this paper, we reviewed the demand management schemes for the smart grid with a focus on the potential uses of Wireless Networks in the building blocks of the smart grid. We first discussed the use of WSNs at the electricity generation sites. We, then, continued with power transmission and electricity distribution, and finally reached to demand-side which is the last mile of the delivery services. Then, investigate inverter control in distributed generation smartgrids. A wireless network is established to acquire the information of total power generation of all Distributed Generation units. A power sharing based control strategy is proposed, which introduces additional terms to the traditional droop control strategy to capture the differences between the desired and actual power generation. An analytical model is developed to evaluate the small-signal stability of the microgrid under our proposed control strategy. Demand Management and Wireless Sensor Networks in the Smart Grid promising solutions for efficient integration of intermittent renewable energy resources, low-cost monitoring of traditional power plants and high-resolution monitoring of utility transport assets.must .

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