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3a-Algorithm Distributed Approach to Precise Side-Load Management in the Smart Grid with Labview

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Abstract

A customer-owned grid is become more prevalent as hybrid energy sources like solar and wind power develop. It gives normal customers the chance to get inexpensive energy prices and gives the power supplier the ability to control the utility infrastructure. Smart systems must be created in order to submit energy demand schedules and track energy price signals in real-time without the involvement of clients. This study presents smart preparation of electrical appliances and demand-side energy management for a grid-connected household. Additionally, it lowers the customers on the grid's power bill. Additionally, during periods of strong production, the customer-owned grid's excess energy is transferred to the larger grid or nearby microgrids. Using Lab VIEW software, the simulation of the full system is displayed.

Keywords: *Distributed renewable energy resource, power storage devices, scheduling, smart meters, smart micro grid, and electric vehicle.*

INTRODUCTION

Numerous issues with the conventional power system include the steady depletion of fossil fuel supplies, environmental degradation, an increase in demand, etc. The availability of small renewable energy generators like natural gas, biogas, wind power, solar PV cells, fuel cells, and combined heat and power (CHP) systems and their integration into the utility distribution network make the new concept of changing our energy system from a hierarchical design into a set of independent microgrids feasible.

Utilizing Distributed Renewable Energy (DER), smart microgrids improve the conventional power system by generating, transmitting, distributing, and consuming electricity while utilising computer, communications, and control technologies [3]. The two-way electricity flow and real-time information are crucial components of Smart Grids (SG), which offer both utility providers and consumers a variety of assistance and elasticities for timely matching of power supply and demand as well as for improving energy efficiency and grid stability [2].

Photovoltaics (PV) are being included into the electricity grid today. It is anticipated that the total load profile would eventually shift dramatically as PVs' impact grows. This effect results from the fact that these components are movable and might potentially subside current on the grid in addition to ingesting electricity. Additionally, the majority of home charge operations will happen at night. It is anticipated that the addition of PVs would significantly alter the grid's behaviour [6].

Existing Methodologies

Microgrids are a crucial part in the deployment of the future grid. By ensuring the quality of usage (QoU) of users in a microgrid under both random current flow and demand, the problem of grid stability is resolved [1]. To determine and rank the influence of several uncertainties, such as changes in temperature, electrical demand, and thermal demand, a sensitivity analysis is conducted [2]. It was suggested to use an ideal combined centralised scheduling algorithm to manage how much power is used by plug-in PVs and residential appliances, as well as how electric cars are discharged when they have extra energy.

Lower power rates are provided to customers while microgrid stability and dependability are increased [3, 4]. On the basis of the idea of QOS in electricity, a framework for smart energy management was created. A stochastic programming problem is how the issue is presented [5]. For optimal use, the microgrid may if required block specific apps. By combining smart metres, smart loads, and staff members who can modify it and regulate their service level through statement flows, this may be accomplished [6].

This work draws on knowledge obtained from energy scheduling and smart power grid energy management. Numerous surrounding residences are explored using various methods for energy scheduling during off-peak and peak hours. Related works concentrate on timing the load to lower consumers' power expenditures as a result of the fluctuating price of electricity.

The daytime, when people are at work and consuming less electricity, is regarded to be the typical time. The time of night when there is a significant demand for electricity is termed the peak hours. The initiative focuses on reducing consumer energy prices and developing a low-carbon environment with renewable resources. Smart metres are used to monitor energy use, and they are designed to update the website daily through WAN.

The Proposed System

The proposed system consists of a central controller that schedules the power produced by the microgrid and manages the load. It plans the use of electricity for off-peak and peak times and minimises power loss via charging and discharging. Accurate data is required for this efficient management of loads in order to balance supply and demand.

They automatically transition to utilise the energy stored in the backup battery bank in the event of a power generating deficit. Neither the voltage being provided to a load nor the current being drawn by it are being continuously monitored by the current system. Aside from providing load drives when needed, there is also very little interaction between the general public and the power system. The internet is used to drive the proposed system, which opens up the possibility of much more extensive monitoring and control across the entire power system.

Four essential parts make up a standalone microgrid renewable electricity system: 1. A power source that can be either a generator, a solar panel array, or both. 2. A system for storing energy, which is typically a bank of lithium-ion deep-cycle batteries. 3. To stop the batteries from being overcharged, a charge control system is used. 4. A low voltage DC to 110 volt AC inverter used to power typical household loads

A microgrid that generates power using solar and wind energy is a viable answer to the current energy problem. For the charging system, a 1 MW solar array, a 1.5 MW wind turbine, a 4000 Watt inverter, and a battery bank with lithium titanate batteries are all used. Additionally, a battery status metre is installed in the battery bank. It displays the voltage, charging time, and amp hours (AH) of battery usage. Calculating and measuring the charging and discharging rates of batteries will be highly beneficial.

Although lead acid batteries are quite well known, they have certain drawbacks. They need upkeep, are quite heavy, and are hazardous. Sustainability and the influence on the environment are additional concerns. Batteries made with lithium have various benefits.

They are less dangerous since they do not deteriorate when exposed to sulfuric acid or emit hydrogen gas. The lithium-titanate battery, which has a high power, quick charge and discharge rates, a long life, and a better power-to-weight ratio than its lithium-ion based predecessors, is the most widely used battery. The rate at which electric current is drawn from or charged into electric batteries is controlled by a charge regulator.

Because overvoltage and overcharging are prevented, the battery's performance and longevity are increased. Depending on the battery technology, it could also execute regulated discharges or stop a battery from completely draining, protecting battery life. The type of inverter being utilised is an MC-thermistor inverter, making it appropriate for both high current and high voltage applications.

Fig. 1 shows the overall block diagram of the project. It consists of power generation module which includes the solar and wind energy for generating power. The generated solar power will be in the form of DC. It can be stored directly into the battery bank. The wind energy generated can either be in the form of AC or DC depending on the type of wind turbine used. Batteries run on DC current. This battery power cannot be used for home appliances. So, DC-AC inverter is used to convert DC to AC.

The PIC microcontroller is utilised in the process of controlling the overall operation of the grid as well as scheduling the supply of power. It does this by using voltage and current sensors both before and after switching in order to monitor the current and voltage.

If there is any excess difference in the amount of power that is distributed, then it considers that there has been power theft or that there is a malfunction in one of the power lines. This information is then updated on the website of the micro grid via WAN.

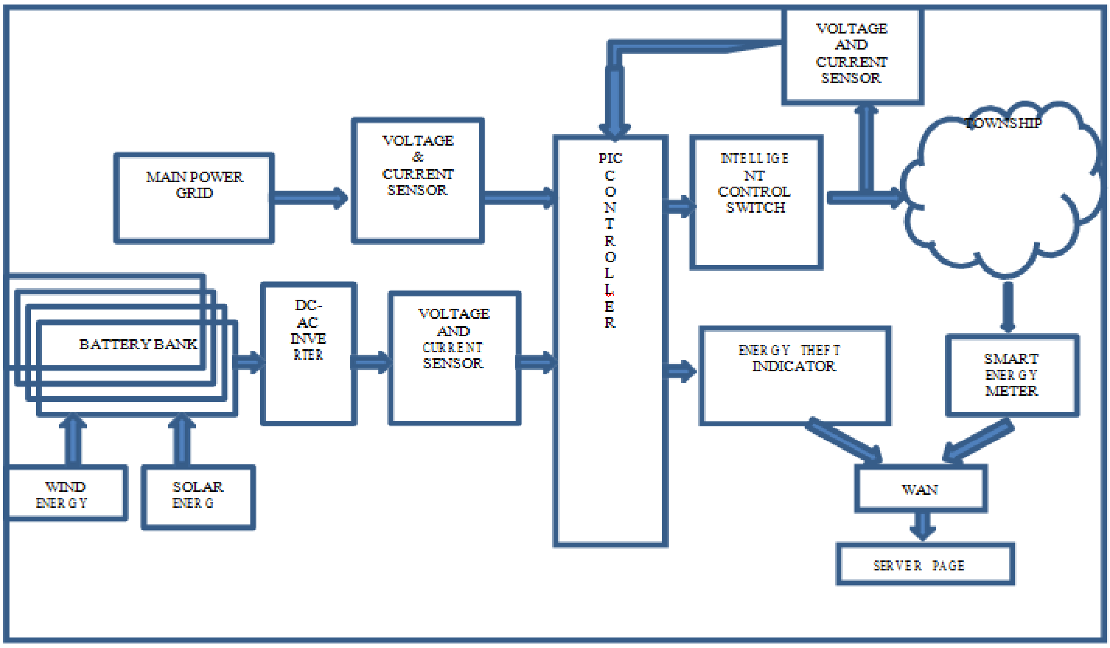

Fig. 1 Block diagram of the project

If a distributed energy resource is offline, as a backup to the utility grid, circuit breakers or a contract-based MG switch are preferred, as they provide not only switching but are also used for over-current protection. It can be employed in microgrids when large-scale battery storage is used.

Smart metres are equipped with two-way communications, which are utilised in order to give a display of information on energy use and price that is current at all times.

1. If micro grid power is not available, it automatically switches over to main grid.
2. If main power is available it checks whether it is normal or peak hours.
3. If it comes under normal hours it charge batteries and also switches supply from the micro grid.
4. If it comes under peak hours first it stops charging the batteries and checks the availability of battery power. If it is available it will switch supply from the micro grid. Otherwise it will switch supply from main grid.

Fig. 2 explains about the flowchart of scheduling technique employed in this project.

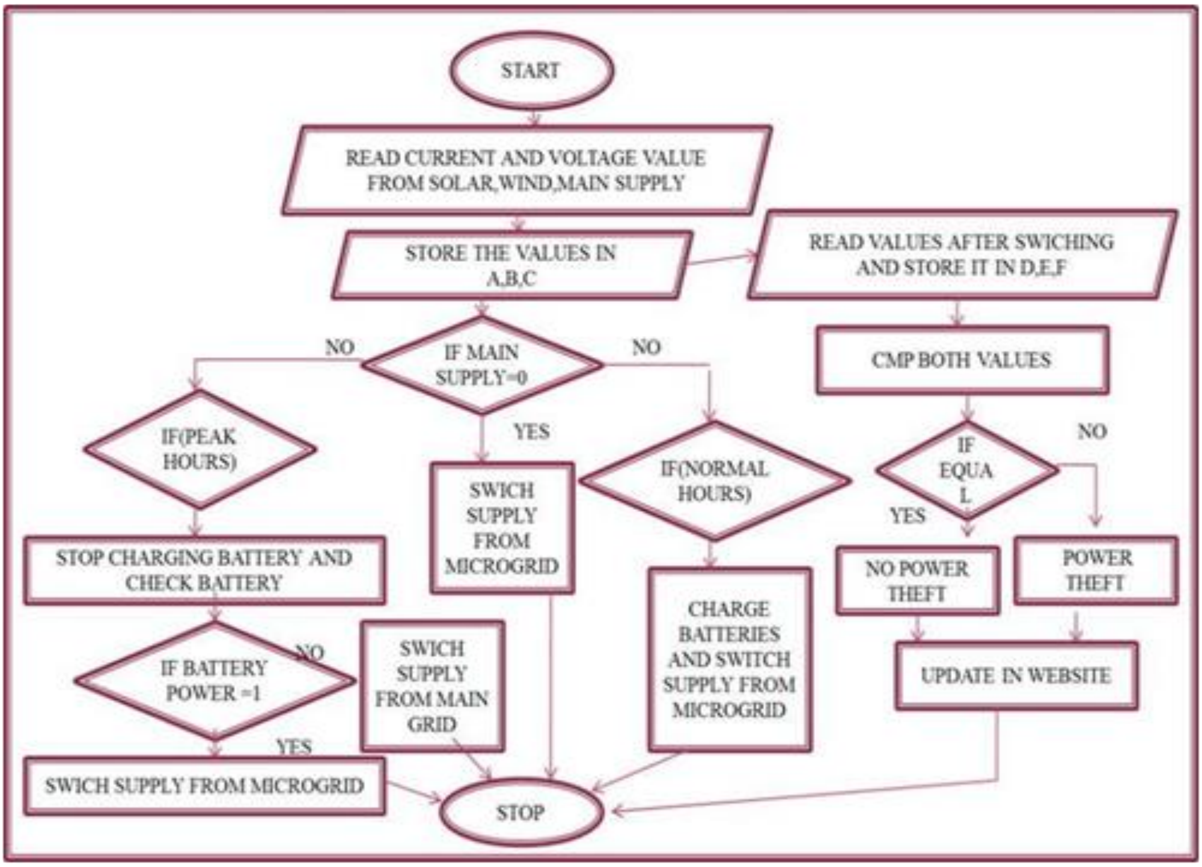

Fig. 2 Scheduling Flowchart

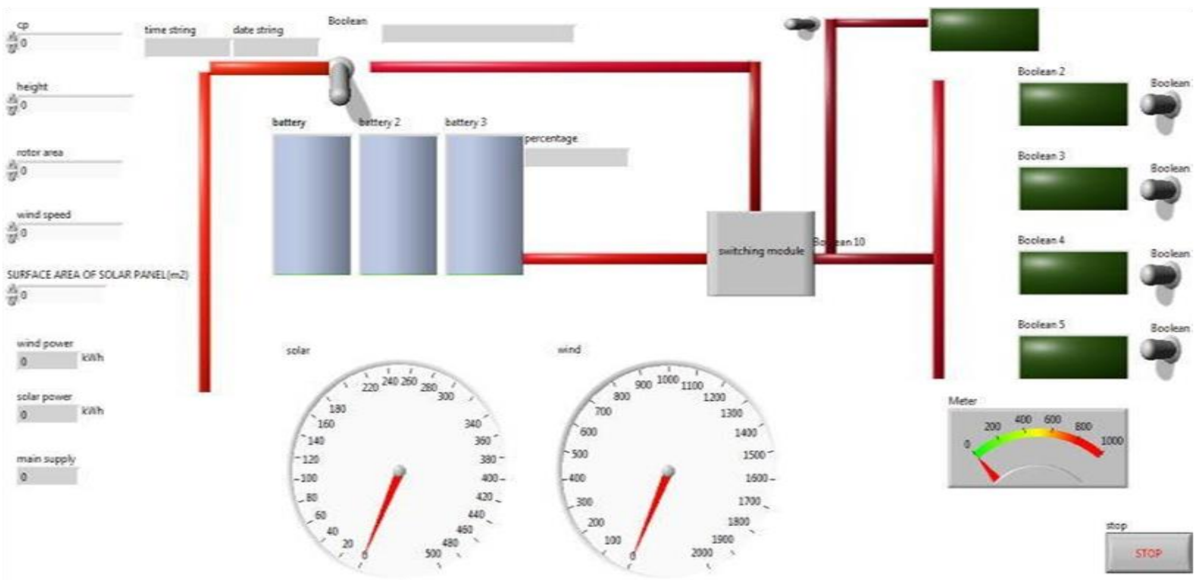

Fig. 3 When microgrid power is not generated and batteries are not charged

System Model and Formulation

The power generation module uses two DERs such as wind and solar. The wind power output can be calculated using (1):

Wind Power Output= P_o= $CP*\frac{1}{2}*\varrho AV^3$(1)

where,

CP = Maximum power coefficient

(value ranges from 0.25 and 0.60),

ϱ = Air density (kg/m³),

A = Rotor swept area,

m² ($A = (\Pi D^2)/4$

where

D is the diameter (m)), V = Wind speed (mps).

As height increases the density of air also increases. The more the air density, the more the power is generated. The CP is the maximum power coefficient whose value normally varies from 0.25 to 0.59. A 20% increase in the wind velocity increase the power generation up to 73%. For solar power generation solar arrays are used.

A solar selection is an interrelated system of lesser PV modules called PV cells/solar cells. These arrays are connected in series to charge a bank of batteries. The solar power output is calculated using (2):

$$P_o = N*Efficiency * Irradiance \qquad (2)$$

Fig. 4 When battery charges and grid utilizes battery power

Fig. 5 when battery power discharges and grid utilizes main power

where, N = No of panels, Efficiency = 0.75 (default), Irradiance = 5.5 (climatic conditions of INDIA).

Irradiance is a measurement of solar power and is defined as the rate at which solar energy falls onto a surface. Solar irradiance is given by power (W)/Area (m^2).

The sequence bank is where the electricity that is created is saved. The bank makes use of lithium-ion titanate batteries, all of which are linked to one another in series. Because of how well its design accommodates the rapid rates of charge and discharge that occur in microgrid applications, it is particularly successful at creating output that is calming to the ears. In addition to this, it achieves a better level of efficiency while incurring less losses. Two positive variables are shown in (3) in order to individually record the charging and discharging cycles of the battery. These variables are as follows:

Battery Power = P(b)= P(in b) -P(out b) (3)

where, P(in b) =Battery input power, P(out b) =Battery output power.

The algorithm has two very significant properties:

1. Load regulation
2. Energy or power regulation.

The shared charging schedule achieves optimal regulation of power and load, which results in the microgrid requiring the lowest possible amount of imported electricity. The combined centralised scheduling schemes do not depend on the multiple interactions that take place between the end systems and the central controller. These interactions are necessary for the decentralised PV charging control techniques in order to find the ideal schedule. The combined scheduling strategies are flexible enough to accommodate models for a variety of different energy sources.

Simulation and Results

LabVIEW is used to do an analysis on the outcomes of simulating intelligent microgrids that make use of renewable energy resources for low-cost application development.

CONCLUSION

In order to reduce operating expenses in a microgrid connected to the grid and powered by renewable energy sources, this study provides a centralised scheduling model for residential appliances and PVs. To increase the system's effectiveness and dependability, the microgrid stores power using lithium-titanate batteries and photovoltaics (PVs). Power that is produced in excess is exported on a cost-plus basis to non-grid members. It has been shown that regulating electricity consumption and moving soft loads from high demand (and/or low power generation) times to low demand (and/or high power production) periods results in scheduling systems that perform better overall. Additionally, smart metres are employed to communicate data instantly to the microgrid members' website so they can monitor specifics of their power use and energy cost per usage.

Future Works

It is advised that future research look at topics including the organisation and scheduling of several microgrids, their power quality, and their involvement in energy markets. Future energy storage choices and capacities can be enhanced. The expense of setting up a microgrid in a location does not outweigh the dependability advantages that may be attained by other methods, including stopping generators. Micro grids need to have issues like physical and cyber security addressed.

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