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A Survey Renewable Energy Grid Load Balancing Techniques and Features

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Abstract- The electric grid is rapidly replacing the smart grid which is known for providing improved efficiency of currently available resources. There is a detailed survey of various techniques available for load management and grid management. Whole paper brief the work of load balancing methods adopts and proposed by scholars. The paper also mentions the micro grid requirement as well for balancing the electrical load by various researchers. Some of features were also summarized in the work which must be present in smart grid. Electrical load was also explored in the paper as this directly increase or decrease the load requirement.

Keywords: Renewable Resource Management, Load Balancing, Feature Study.

I. INTRODUCTION

A number of factors are contributing to increases in renewable energy production in the India. These factors include rapidly declining costs of electricity produced from renewable energy sources, regulatory and policy obligations and incentives, and moves to reduce pollution from fossil fuel-based power generation, including greenhouse gas emissions.

While not all renewable energy sources are variable, two such technologies–wind and solar PV–currently dominate the growth of renewable electricity production. The production from wind and solar PV tries to capture the freely available but varying amount of wind and solar irradiance.

As the share of electricity produced from variable renewable resources grows, so does the need to integrate these resources in a cost-effective manner, i.e., to ensure that total electricity production from all sources including variable renewable generation equals electricity demand in real time.

Also, a future electric system characterized by a rising share of renewable energy will likely require concurrent changes to the existing transmission and distribution infrastructure. The control and monitoring once seen in the generation and Distribution. The concept of micro grids has facilitated the integration of renewable resources at this level. A micro grid is a small-scale distribution network containing a set of distributed generations (DGs) designed to supply electrical power to a local area (LA), connected to a large network (host grid) as a single controllable entity [1]. Micro grids became popular because of their ability to work in isolation.

A micro grid operation can be in two modes. When the micro grid fulfils its energy demand by the main grid, it is called grid-connected mode and when demand is supplied from its own local generation, it is called islanded mode.

In grid-connected mode, the main objective of a controller is to provide energy management, while in islanded mode; the objective is to control both its frequency and voltage, while supporting the energy demand. If there are no synchronous machines to balance demand and supply for island operation, the inverter is responsible for providing these controls especially the frequency control [2, 3].

II. TYPES OF ELECTRICAL LOAD

1. Soft Demand Response:
The response time required in soft demand response

is often flexible and can vary from hours to days. Soft demand response events are targeted at the daily power consumption macro cycle which is driven by higher usage during the day followed by lower usage during the night. Energy curtailment can typically be planned and scheduled in advance [4]. Load response strategies include both load shedding as well as load shifting. Load shedding involves curtailing equipment that is not missioning critical and load shifting is the rescheduling of energy-intensive operations to a different time period. This includes production lines and processing equipment.

Equipment typically curtailed includes:
- External and internal lighting including parking lot lighting
- External water fixtures
- Air handlers.

The load response times of these systems vary from seconds to hours. Longer response times can be accommodated through pre-ramp down control strategies while equipment with faster response times can be actuated directly.

2. Firm Demand Response:
The response time required in firm demand response varies between five (5) minutes and ten (10) minutes. This aligns with ten-minute wholesale ancillary markets. Firm demand response provides the grid balancing authority with the ability to balance a reduction in generation capacity with a compensating reduction in load. This category is appropriate for balancing variable renewable generation that has sufficient inertia, capacity or prediction [5].

Examples of equipment typically capable of firm demand curtailment include:
- External and internal lighting including parking lot lighting
- External water fixtures
- Air handlers
- Elevators and escalators
- Irrigation pumps
- Motors
- Outside signage
- Pool pumps

Near real-time demand response: Near real time demand response requires response times of one (1) minute to five (5) minutes. These are appropriate for fast responding ancillary energy markets driven by significant quantities of variable renewable generation. Only equipment capable of high speed ramp down can participate in near real time demand response.

Typical examples include:
- External and internal lighting including parking lot lighting
- External water fixtures
- Air handlers
- Irrigation pumps
- Motors
- Outside signage
- Pool pumps

3. Real Time Demand Response:
Real time demand response requires response times from one (1) second to one (1) minute. These applications include power frequency and load regulation as well as emergency response to grid faults. Real time response requires very high speed equipment shutdown capability as provided by motor-driven equipment or lighting. In general, the ease with which a customer can react will decrease moving from category 1 to category 4.

In order to achieve five (5) minute down to one (1) minute response, the decision making processes involved in load shedding, shifting or shaping must be automated and streamlined in order to provide a high degree of determinism and reliability. Demand response signals will contain both discrete and continuous information. Discrete information will often be in the form of dispatch triggers that initiate action. Continuous information will be in the form of value metrics such as dynamic pricing which will be used as input into decision-making algorithms.

III. RELATED WORK

M. S. Hossain et al. in [6] has objective of this work is to develop a traffic ware grid connected solar photovoltaic (PV) optimal power supply system endeavouring the remote radio head (RRH) enabled heterogeneous networks (HetNets) aiming to minimize grid energy consumption and carbon footprint while ensuring long-term energy sustainability and energy efficiency (EE).

Moreover, the load balancing technique is implemented among collocated BSs for better resource blocks (RBs) utilization and thereafter, the performance of the system is compared with an existing cell zooming enabled cellular architecture for benchmarking. Besides, the techno-economic feasibility of the envisaged system has been extensively analyzed using HOMER optimization software considering the dynamic nature of solar generation profile and traffic arrival rate. Furthermore, a thorough investigation is conducted with the help of Monte-Carlo simulations to assess the wireless network performance in terms of throughput, spectral efficiency (SE), and energy efficiency as well under a wide range of design scenarios.

D. Arcos-Aviles et al. in [7] study aims to design an Energy Management System (EMS) to reduce the impact on the grid power when renewable energy sources are incorporated to pre-existing grid-connected household appliances.

The scenario considers a residential micro grid comprising photovoltaic and wind generators, flat-plate collectors, electric and thermal loads and electrical and thermal energy storage systems and assumes that neither renewable generation nor the electrical and thermal load demands are controllable.

The EMS is built through two low-complexity FLC blocks of only 25 rules each. The first one is in charge of smoothing the power profile exchanged with the grid, whereas the second FLC block drives the power of the Electrical Water Heater (EWH). The EMS uses the forecast of the electrical and thermal power balance between generation and consumption to predict the micro grid behaviour, for each 15-minute interval, over the next 12 hours.

N. Chhabra et. al. in [8] aims at assessing the operating philosophy of the TN state grid in 2022 due to planned renewable energy (RE) integration. The load-generation balance of TN power system has been analyzed for various operating scenarios. A reserve margin of about 15% on the net load basis (difference between actual demand and potential RE generation) is expected to be maintained to accommodate solar, wind and load variations. The study explores options to compute the curtailment of combined RE resources and suggest operating practices that TN can adopt to maximize RE generation.

W. Yi, Y. Zhang et. al. in [9] proposed a new method of utilizing multitier demand response (DR) resources to smooth fluctuations in renewable energy on different timescales is proposed. A multi objective robust scheduling model considering renewable energy and DR uncertainties is established using this method. First, the robust optimization theory is introduced, and uncertainties in renewable energy and multi-type DR resources are described in the form of robust intervals on multiple timescales.

Then, the multi-objective scheduling model is constructed with the objective of obtaining the lowest operating cost and the highest renewable energy utilization rate, while considering renewable energy integration constraints, DR output constraints, and system power balance constraints.

Finally, according to the model characteristics, the uncertainty problem is transformed into a deterministic problem by using a robust counterpart transformation, and a non-dominated set genetic algorithm-II is used to solve the deterministic problem. A case study is presented to verify the effectiveness of the proposed scheduling model and solution method.

Y. Fan, X. Zi et. al. in [10] presents a mathematical model for active distribution network load shedding considering the number of blackouts and power shortage based on detailed classification of load after power failure. By establishing the output model of fan energy storage and adopting gray model to forecast wind speed and load, the genetic algorithm is used to solve optimal load shedding scheme considering the influence of distributed energy.

R. R. Khalid et. al. in [11] investigate these efficient approaches by deploying price based DSM as real time Genetic Algorithm based optimal load scheduler. It provides real time control to home appliances according to grid price, renewable energy generation and local energy storage. To develop optimal load scheduler Model Centric Development (MCD) approach is used and simulation environment is established using simulator coupling.

IV. SMART GRID FEATURES

There are recognizing attributes of the smart grid [1]. For example

- Expanded utilization of computerized data and

controls innovation to enhance unwavering quality, security, and effectiveness of the electric network
- Dynamic enhancement of network activities and assets, with full digital security.
- Sending and incorporation of appropriated assets, and age, including inexhaustible assets;
- Sending and consolidation of interest reaction, request side assets, and energy effectiveness assets.
- Sending of "shrewd" innovations for metering, correspondence concerning network tasks and status, and circulation computerization.
- Combination of "shrewd" machines and purchaser gadgets.
- Sending of incorporation of cutting edge power stockpiling and pinnacle shaving innovations, incorporating module electric and crossover electric vehicles, and thermal stockpiling aerating and cooling;
- Arrangement to end users of opportune data and control choices.
- Advancement of gauges for correspondence and interoperability of machines and gear associated with the electric lattice, including the framework serving the network.
- Identification and bringing down of irrational or superfluous obstructions to appropriation of smart grid practices, and administrations.
- Techniques of Load Balancing

V. STATIC ALGORITHM

Here as per the prior knowledge of the whole framework each task is assigned to respected node where changes in the current queue after assignment is not allow. The choice of shifting load does not rely upon current condition of framework.

So number of situation arise when static algorithm have dump whole system like sudden failure of required asset, additionally the task is appointed to processors or machines simply after it is made and that assignment can't be moved to other machine in the course of its execution for adjusting the load.

These calculations are appropriate for homogeneous situations. These calculations are non pre-emptive so each machine has only one task for execution and that task is looking for any resource than whole waiting state is start [8].

Round Robin Load Balancing Algorithm In this calculation, settled quantum time is given to the activity. It allots job or task to all nodes in a round manner. Processors are appointed in a roundabout request and henceforth there is no starvation [8]. This calculation gives quicker reaction on account of equivalent workload conveyance among forms. However, a few nodes might be over loaded while others stay sit idle and under-used [6].

MIN-MIN Load Balancing Algorithm a series of assignment is kept up and least fulfilment time is computed for the entire accessible node. A task with least execution time is allocated to the machine. So the name of the calculation is min-min load balancing algorithm [5]. Refresh the series and running time of the machine. It gives great outcomes when number of low execution task are high[8].

MIN-MAX Load Balancing Algorithm A series of assignment is kept up and least fulfilment time is figured for all the accessible node. A task with most extreme execution time is moved out to the machine. Thus the name of the calculation is min-max [5]. Update the series of job and running time of the machine help in executing other task [8].
Dynamic Algorithm

It defeats the disadvantages of static approach as choice of adjusting the load relies upon current condition of framework. Any earlier learning of framework isn't required. It enables a procedure to move from an overused machine to underutilize for quicker execution. This permits acquisition which isn't bolstered by static approach [9].

Their calculations are intricate yet they give better execution and adaptation to internal failure. These calculations are more adaptable than static calculations and can without much of a stretch embrace the change and give better outcomes so more reasonable for heterogeneous and dynamic condition moreover. Dynamic load balancing calculations can likewise be of conveyed and non dispersed nature.

VI. CONCLUSION

In this paper, the primary objective was to increase the output of the micro grid framework controller so that the fuel utilization cost can be reduced to a certain extent. The work mainly focuses on the situation where the control of the grid operation is done as per the requirement of the client. To handle several varieties of power sources either renewable or non-renewable. In this paper, the challenges of renewable energy and several load balancing techniques were discussed. Paper has brief requirement of grid, with characteristics. In future scholars should propose a dynamic load balancing algorithm.

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