International Journal of Scientific Research & Engineering Trends
Volume 7, Issue 6, Nov-Dec-2021, ISSN (Online): 2395-566X

A Review ArticlePower Scheduling and Utility of Grid Demand Side Management Using Fact Power Controller

Preeti Kourav, Dr. Anil Kumar Kori
Department of Electrical Engineering,
Jabalpur Engineering College,
Jabalpur, MP India

Abstract-Grids are considered as the basic and fundamental technology through which environmental pollution and the user's energy cost is reduced. The management of smart grids is done by various demands Side management (DSM) techniques to ensure that there is an efficient flow of power. But it is a complex task in real time as energy demands of consumers rise continuously in an unpredicted manner. A literature survey is conducted to get an overview about the role of heuristic techniques in demand side management. The review states that such algorithms are able to schedule the power cuts in an effective way which in turn minimizes the load on the power grids. But as there are number of heuristic algorithms available it will be a challenge to select the efficient approach using Bus system. Moreover, the important factors such as load, cost etc. are also drawn out from the survey to help the future research to give an efficient DSM system.

Keywords-Demand side management, electrical systems, Bus system, energy management, energy efficiency, etc.

I. INTRODUCTION

Global electricity demand is constantly growing, and conventional power systems cannot meet production demands reliably. Global population growth, which results in higher energy consumption, and climate change, which calls for fossil fuel reduction, renders conventional power systems incapable of responding to such demands. Their slow response due to mechanical switches, the one-way communication between electricity generation and demand, and the low level of information processing, are some of the disadvantages these conventional power systems present [1].

Hence novel energy management techniques are sought, which render transmission and distribution systems flexible and transform them from traditional to smart grids. The term Smart Grid (SG) refers to a power supply system that deploys digital technologies with large distribution networks to optimize energy consumption [2]. Whereas the sole function of a traditional grid is to transmit and distribute energy from the plant to the end user, the SG can detect values in normal as well as in error conditions along the entire length of its transmission lines (sensing along the transmission lines) [3].

II. ELECTRICAL 20 BUS SYSTEM

In order to determine the stability status of the power system for each contingency of any disturbance occurs in power system, many stability studies are defined [4]. Power system stability analysis may involve the calculation of Critical Clearing time (CCT) for a given fault which is defined as the maximum allowable value of the clearing time for which the system remains to be stable. The power system shall remain stable if the fault is cleared within this time. However, if the fault is cleared after the CCT, the power system is most likely to become unstable.

Thus, CCT estimation is an important task in the transient stability analysis for a given contingency. In this paper for the Transient Stability Analysis, an IEEE 20 Bus system is considered. System stability study is the important parameter of economic, reliable and secure power system planning and operation. Power system studies are important during the planning and conceptual design stages of the project as well as during the operating life of the plant periodically. This paper presents the power system stability analysis for IEEE- 20 bus test system. The fault is created on different busses and transient stability is analyzedfor different load and generation conditions [5].

III. UNIFIED POWER FLOW CONTROLLER (UPFC)

A unified power flow controller (UPFC) is an electrical device for providing fast-acting reactive power compensation on high-voltage electricity transmission networks. It uses a pair of three-phase controllable bridges to produce current that is injected into a transmission line using a series transformer.[6,7, 8] The controller can control active and reactive power flows in a transmission line.

Unified Power Flow Controller (UPFC), as a representative of the third generation of FACTS devices, is by far the most comprehensive FACTS device,[9] in

power system steady-state it can implement power flow regulation, reasonably controlling line active power and reactive power, improving the transmission capacity of power system, and in power system transient state it can realize fast-acting reactive power compensation, dynamically supporting the voltage at the access point and improving system voltage stability, moreover, it can improve the damping of the system and power angle stability.

The UPFC uses solid state devices, which provide functional flexibility, generally not attainable by conventional thyristor controlled systems. The UPFC is a combination of a static synchronous compensator (STATCOM) and a static synchronous series compensator (SSSC) coupled via a common DC voltage link.[10]

IV. LITERATURE REVIEW

ParikshitPareek, A Framework for Analytical Power Flow Solution Using Gaussian Process Learning: This paper proposes a novel analytical solution framework for power flow (PF) solutions in active distribution networks under uncertainty. We use the Gaussian process (GP) regression to learn node voltage as a function of effective bus load or negative net-injection vector. The proposed approximation is valid over a subspace of load and provides an understanding of system behavior under uncertainty via GP interpretability.

We interpret the relative variation extent of different node voltages using the quality ratio (QR) defined based on the hyper-parameters of GP. Further, the application of the proposed framework in calculation of voltage limit violation probability and dominant voltage influencer ranking has also been presented. Through test simulations for 33-bus and 56-bus systems, the proposed method achieves low mean absolute error (MAE) of order E-05 (pu) in voltage magnitude and E-04 (rad) in angle.

The discussions on salient features of the proposed method and comparative analysis with large-scale Monte-Carlo simulations, and state-of-art methods is also presented for the proposed applications.

Daiane Mara Barbosa de Siqueira, Transient stability constrained optimal power flow applied to distribution systems with synchronous generators: This paper proposes a Transient Stability Constrained Optimal Power Flow (TSC-OPF) formulation in order to calculate the optimum operating point of synchronous generators in distribution networks, in terms of dispatch of their active and reactive powers.

However, the problem is complex due to the high number of constraints and variables, as well as, the presence of nonlinear constraints. To circumvent these adversities, an optimization problem is proposed in this paper with the application of a set of mathematical approximations in the constraints of the active and reactive power balance equations. In addition, an approximation is explored in the swing equation of synchronous generators belonging to a group of coherent machines, particularly regarding the active power injection from the generators. The proposed TSC-OPF is tested in a 31-bus radial distribution system with two and four generators. The results show that the running time to solve the proposed optimization problem with approximations becomes smaller when compared to the time to solve it without approximations.

David Biagioni, Learning-Accelerated ADMM for Distributed DC Optimal Power Flow: We propose a novel data-driven method to accelerate the convergence of Alternating Direction Method of Multipliers (ADMM) for solving distributed DC optimal power flow (DC-OPF) where lines are shared between independent network partitions. Using previous observations of ADMM trajectories for a given system under varying load, the method trains a recurrent neural network (RNN) to predict the converged values of dual and consensus variables. Given a new realization of system load, a small number of initial ADMM iterations is taken as input to infer the converged values and directly inject them into the iteration.

We empirically demonstrate that the online injection of these values into the ADMM iteration accelerates convergence by a significant factor for partitioned 14-, 118- and 2848-bus test systems under differing load scenarios. The proposed method has several advantages: it maintains the security of private decision variables inherent in consensus ADMM; inference is fast and so may be used in online settings; RNN-generated predictions can dramatically improve time to convergence but, by construction, can never result in infeasible ADMM subproblems; it can be easily integrated into existing software implementations. While we focus on the ADMM formulation of distributed DC-OPF in this letter, the ideas presented are naturally extended to other distributed optimization problems.

Krishna D, Mathematical Modeling and Analysis of Demand Response using Distributed Algorithm in Distribution Power System: In recent time, Demand Response(D.R) has become a vigorous research area. Most of the work only reflects the balance among the combined load, the supply as well as the summaries that went to the primary energy grid. In this work, radial distribution network for demand response analysis has been acquired, expressing it as an OPF problem that maximizes the collective profits of the user and minimizes the cost of supply and power losses of line and also focuses toward power flow restrictions and operational restrictions. Here, completely distributed algorithm is proposed, so that the customer can manage their response assessment to ask all through the nearest contact among their neighbors to reach

the most optimal. The arithmetical results of IEEE-30 bus system by ETAP [Electrical Transient analyzer Program] are helpful to complete arithmetical analysis.

Ying Huang, Holomorphic Embedding Power Flow Algorithm for Isolated AC Microgrids with Hierarchical Control: Power flow (PF) calculation plays a fundamental role in the steady-state analysis of isolated microgrids (MGs). In this paper, a novel analytical PF algorithm based on holomorphic embedding (HE) is proposed for isolated AC MGs considering hierarchical control (HC). With a deliberate design in embedding technique, the presented algorithm not only inherits the deterministic property of the canonical embedding that enables to derive the upper-branch (operable) solution explicitly, but also is compatible with the HC characteristic of isolated MGs.

Furthermore, the embedded PF model features a general structure with a constant recursive matrix, which can accommodate various bus types and network re-configurations (including both radial and meshed networks), as well as non-nonlinearities of voltage-dependent load models. Case studies are carried out on 3 test systems: a 12-bus MG and modified IEEE 33-bus and 123-bus distribution systems. Numerical results reveal the applicability and efficacy of the proposed algorithm.

RaminVakili, Enhancing Situational Awareness: Predicting under Frequency and Under Voltage Load Shedding Relay Operations: This paper proposes a machine-learning-based method to enhance online situational awareness in power systems by predicting under frequency load shedding (UFLS) and under voltage load shedding (UVLS) relay operations for several seconds after a disturbance. Voltage magnitudes/angles of electrically closest high voltage buses to the relay locations along with the relay settings are used as the input features to train random forest (RF) classifiers that predict UVLS/UFLS relay operations, respectively.

A variety of contingencies considering different operation conditions and topologies of the Western Electricity Coordinating Council (WECC) system data representing the 2018 summer-peak load are studied offline using the GE positive sequence load flow analysis (PSLF) software. The results are used to create a comprehensive dataset for training and testing the classifiers. A comparison between the performances of RF models trained with different periods of input data is conducted in the presence of measurement errors.

Muhammad Sarmad Tariq, Optimal Power Flow and Contingency Analysis incorporating Distributed FACTs and Dynamic Thermal Line Rating: Transmission congestion is a major barrier in various electric utilities around the world. Constructing new transmission lines requires a huge amount of investment and thus utilities prefer technologies which are able to enhance the capacity of existing transmission infrastructure.

Two such technologies are Distributed FACTs(DFACTs) and Dynamic Thermal Line Rating (DLR). This paper proposes the combined use of the two technologies in power system operation. In this study, the combined impact of the two technologies has been studied in terms of the DC feasibility of a power flow solution and contingency analysis. This is done for the 118 bus and Polish 2383 bus System. The results show that for weather conditions where the DLR is less than 100%, a power system which does not have a DC feasible solution in the absence of DFACTs can have a DC feasible solution when DFACTs are incorporated in the power flow. Furthermore, for critical contingencies, DFACTs can reduce the curtailed load by a significant amount (20-30%) even for constrained transmission systems taken into account by low DLRs (60-80%) of transmission lines.

Alfredo BoniniNeto, Continuation Power Flow: a Parameterization Technique and Adaptive Step Size Control: The electricity sector, especially in emerging countries, has experienced several transformations, mainly resulting from the increase in electricity demand. These events encourage more investment in the generation sector and cause increasing concerns with the development and improvement of tools for static voltage stability analysis of electrical power systems. This paper presents a new geometric parameterization technique for continuation power flow (CPF) that works based on the addition of a new plane formed by the variables of voltage magnitudes and total real power losses (Pa).

The new plane features a linear aspect around the maximum loading point (MLP), eliminating the Jacobian matrix (J) singularity at the maximum loading point, allowing to obtain the solution trajectory (P-V curve) without any need to change the parameter, which is a common procedure in the currently available CPF. Intending to define a simple and efficient step size control procedure, the distance value between the center of the set of lines and the total real power losses is calculated. This value defines the appropriate step size for the system. The results obtained by applying the proposed technique to the IEEE 14-bus system and one real large system of the 904-bus show its effectiveness.

S. Biswas, Study of Harmonics Contribution by Various Types of Loads in a Low Voltage Distribution System and Reduction of Harmonics: This paper studies the different sources of harmonics from residential and commercial loads in the low voltage distribution zone. To study the impact of harmonics, an IEEE 33 bus radial distribution system is considered. Different types of nonlinear loads are assumed to be distributed along the radial distribution system. The contribution of harmonics

by any one non linear load has almost no significant effect. This paper shows that their cumulative effect can produce a noticeable amount of harmonics and hence has a poor impact on power quality. Some techniques are also applied to study how the harmonics can be reduced. The program is simulated with the help of MATLAB.

Yang Liu, A Dynamized Power Flow Method based on Differential Transformation: This paper proposes a novel method for solving and tracing power flow solutions with changes of a loading parameter. Different from the conventional continuation power flow method, which repeatedly solves static AC power flow equations, the proposed method extends the power flow model into a fictitious dynamic system by adding a differential equation on the loading parameter. As a result, the original solution curve tracing problem is converted to solving the time domain trajectories of the reformulated dynamic system.

A non-iterative algorithm based on differential transformation is proposed to analytically solve the aforementioned dynamized model in form of power series of time. This paper proves that the nonlinear power flow equations in the time domain are converted to formally linear equations in the domain of the power series order after the differential transformation, thus avoiding numerical iterations. Case studies on several test systems including a 2383-bus system show the merits of the proposed method.

NazmulHaiderSonet, Prospect of Demand Side Management in Bangladesh: A Survey on Residential Application: Demand-side management in residential sector has become an essential tool for smart grid implementation, especially when the residential sector contributes significantly to the peak electricity demand.

In Bangladesh, demand-side management also has the potential to facilitate renewable energy integration into the grid and reduce the load shedding issue. In this study, a survey is conducted on residential consumers to determine the daily load curve, flexible loads, consumers' awareness on energy savings, and willingness of the consumers to take part in demand-side management programs. This study will guide to assess the prospect of demand-side management in the residential sector of Bangladesh.

An online survey form is prepared, and responses have been collected from 50 different families living in urban areas. Effects of seasonal variation on energy consumption and load flexibility are taken into consideration in the study. The modified load curve due to the implementation of demand-side management is also estimated. It is observed that the benefits of demand-side management are yet to be fully realized due to inadequate flexible loads and lack of awareness among the people. However, awareness program about DSM will help to reap its benefits as the proportion of flexible loads is expected to rise in the future.

Faisal Saeed, Intelligent Hybrid Energy Resource Connected Demand Side Load Management System-Case of Pakistan: Pakistan's power system is currently facing serious energy crisis issues as the supply of electric power is not increasing at the pace of its demand. Although conventional power system is experiencing a notable transition from the centralized supply-side energy management system to decentralized generation and demand-side load management system certainly due to the integration of hybrid energy systems to the local grids yet the shortfall in supply and energy demand gap resulted into large scale electric load-shading problem in all cities of Pakistan from last few years.

This paper discusses a real-time load management system integrated with a hybrid energy system as a source i.e. grid-tied photovoltaic (PV) system, stand-alone PV system, wind-turbine, local grid and aims to have a customer control overload appliances in peak and off-peak hours, update them for hourly units consumption and also shed the unnecessary loads according to user-set priority and demand. The hybrid energy system and load end is interconnected to the programmable logic controller (PLC) and are also controlled by using PLC. According to the specified site and load demand discussed in the paper, it has been found that by implementing the proposed load management system approach average of 82 units of electricity can be saved in peak hours, and similarly the average amount of 4.875 Rs/KWh can also be saved for specified time dictating that proposed smart strategy can prove to be fruitful to combat electric load problem on large scale in Pakistan in future.

SonaliPatil, Development of Control Strategy to Demonstrate Load Priority System for Demand Response Program: With the increasing need, demand of energy is increasing day by day. Due to this, the gap between demand and supply is also increasing. By implementing priority based Demand Response Management System, the gap between demand and supply can be minimized. Loads can be shifted during peak period based on their priority and helps the consumer to participate in demand response with their flexibility. Prototype hardware has been designed and case studies are done which implements the use of load priority system for Demand Response (DR) program which can help to balance the system.

CemalKeles, A note on demand side load management by maximum power limited load shedding algorithm for smart grids: Demand side load management (DSLM) applications improve grid flexibility and support intermittent renewable energy utilization. In this study, we discuss role of power limited load shedding algorithm for DSLM applications in domestic scales. By using this

algorithm, domestic power consumption is limited with respect to dynamic electricity price signal and renewable energy generation level by switching off the low prior home electronics appliances (HEAs).

The proposed load shedding scheme performs depending on power requirements of HEAs and their user priority presetting. In this study, power limited load shedding algorithm is improved to consider operation modes, which are grid mode, islanded mode and grid+renewable energy (RE) mode and effects of the proposed scheme on domestic consumption is discussed by using simulation results.

OnurAyan, Domestic electrical load management in smart grids and classification of residential loads: Peak demand is an important problem in the electricity grid and this problem was generally solved by supply side management in the past. However, nowadays the demand side management sources have taken attention due to economic and environmental constraints. Normally, reliable electricity supply to customer can be maintained by either increasing the network capacity (supply side management) or reducing the peak electricity demand on the network (demand side management) but reducing electricity consumption within demand side management rather than increasing network capacity provides operational and financial benefits to countries.

Demand response in the residential sector can plan an important role in reducing peak demand. For this reason, in this study, load management system was carried out in order to analyze effects of demand response for residential area using Matlab/Simulink. Some residential loads were shifted to off- peak hours using load management system in order to reduce peak demand and electricity bill saving which can be gained through energy management system was analyzed on consumers. Additionally, a comprehensive study of the classification of residential loads was analyzed in this work.

V. DEMAND SIDE MANAGEMENT (DSM)

Demand Side Management (DSM) is the process of managing the consumption of energy, in order to optimize available and planned generation resources. DSM programs consist of the planning, implementing, and monitoring activities of electric utilities that are designed to encourage consumers to modify their level and pattern of electricity usage. Demand Side Management can be explained as “actions taken on the customer's side of the meter to change the amount or timing of energy consumption.

Utility DSM programs offer a variety of measures that can reduce energy consumption and consumer energy expenses. Electricity DSM strategies have the goal of maximizing end-use efficiency to avoid or postpone the construction of new generating plants." Technologies adopted for Demand Side Management may include one or more of the following: Leveling of Load curve, Load management, and consumer benefit oriented public participation program, tariff measures (Time-of-Use Rates), and Power Factor based Charges, Real-Time Pricing etc.

1. Benefits of DSM:

The benefits of DSM to consumers, enterprises, utilities, and society can be as:

- Reduction in customer energy bills.
- Reduction in the need for new power plant, transmission, and distribution network
- Stimulating economic development.
- Creating long-term jobs due to new innovations and technologies
- Increasing the competitiveness of local enterprises.
- Reduction in air pollution.
- Reduced dependency on foreign energy sources.
- Reduction in peak power prices for electricity.

VI. CONCLUSIONS

Demand Side Management is essentially a tool for optimum operation of power system aimed at reducing peak by rational allocation of load in cycle, energy conservation, and consequent reduction in investment.

In India realizing the importance of it, through proper planning attempt has already been made to derive benefit by implementation.

REFERENCE

[1] ParikshitPareek, A Framework for Analytical Power Flow Solution Using Gaussian Process Learning, IEEE Transactions on Sustainable Energy (Volume: 13, Issue: 1, Jan. 2022), 1949-3029.
[2] Daiane Mara Barbosa de Siqueira, Transient stability constrained optimal power flow applied to distribution systems with synchronous generators, IEEE Latin America Transactions (Volume: 20, Issue: 2, Feb. 2022), 1548-0992.
[3] David Biagioni, Learning-Accelerated ADMM for Distributed DC Optimal Power Flow, IEEE Control Systems Letters (Volume: 6), 2475-1456.
[4] Krishna D, Mathematical Modeling and Analysis of Demand Response using Distributed Algorithm in Distribution Power System, 2021 IEEE International Conference on Distributed Computing, VLSI, Electrical Circuits and Robotics (DISCOVER), 978-1-6654-1244-5.
[5] Ying Huang, Holomorphic Embedding Power Flow Algorithm for Isolated AC Microgrids with Hierarchical Control, IEEE Transactions on Smart Grid (EarlyAccess), 1949-3053.

[6] RaminVakili, Enhancing Situational Awareness: Predicting Under Frequency and Under Voltage Load Shedding Relay Operations, 2021 North American Power Symposium (NAPS), 978-1-6654-2081-5.
[7] Muhammad Sarmad Tariq, Optimal Power Flow and Contingency Analysis incorporating Distributed FACTs and Dynamic Thermal Line Rating, 2021 North American Power Symposium (NAPS), 978-1-6654-2081-5.
[8] Alfredo BoniniNeto, Continuation Power Flow: a Parameterization Technique and Adaptive Step Size Control, 2021 IEEE URUCON, 978-1-6654-2443-1.
[9] S. Biswas, Study of Harmonics Contribution by Various Types of Loads in a Low Voltage Distribution System and Reduction of Harmonics, 2021 International Conference in Advances in Power, Signal, and Information Technology (APSIT), 978-1-6654-2506-3.
[10] Yang Liu, A Dynamized Power Flow Method based on Differential Transformation, 2021 IEEE Power &Energy Society General Meeting (PESGM), 978-1-6654-0507-2.
[11] NazmulHaiderSonet, Prospect of Demand Side Management in Bangladesh: A Survey on Residential Application, 2020 11th International Conference on Electrical and Computer Engineering (ICECE), 978-1-6654-2254-3.
[12] Faisal Saeed, Intelligent Hybrid Energy Resource Connected Demand Side Load Management System-Case of Pakistan, 2021 4th International Conference on Energy Conservation and Efficiency (ICECE), 978-1-6654-0374-0.
[13] SonaliPatil, Development of Control Strategy to Demonstrate Load Priority System for Demand Response Program, 2019 IEEE International WIE Conference on Electrical and Computer Engineering (WIECON-ECE), 978-1-7281-4499-3.
[14] CemalKeles, A note on demand side load management by maximum power limited load shedding algorithm for smart grids, 2015 3rd International Istanbul Smart Grid Congress and Fair (ICSG), 978-1-4673-6624-3.
[15] OnurAyan, Domestic electrical load management in smart grids and classification of residential loads, 2018 5th International Conference on Electrical and Electronic Engineering (ICEEE), 978-1-5386-6392-9.