Emerging Trends to Relieve Power System Stress Condition

Sheetal Shinkhede

***Abstract:** To relieve congestion in the power swystem while increasing static security margin and voltage profile, demand response (DR) and demand side manage-ment (DSM) encourages the costumer in smart grid to use the electricity in response to varying electricity prices. In this paper the distributed algorithm and load management for price based demand response scheduling is studied. The future scope is suggested to relive the power system stress condition. Power system stress issues like issues like small signal analysis, transient conditions and voltage stabilities are studied.*

***Index Terms-:** Energy management, demand side management (DSM), demenad response(DR), load modeling*

I. INTRODUCTION

To keep the supply and demand balanced, fossil fuel pow-ered generators along with the ancillary services are connected to the power system. but most of the time that are idle, mainly used to satisfy the peak load. This significantly increase the carbon emission and also the cost of power. the other option is to integrate natural energy sources in the power system. Gen-erally renewable energy sources are the better option, but that are intermittent , uncontrollable and uncertain in nature.[1]. In the current electricity markets, fixed pricing schemes with constant rates are used, which are constants over months. Due to this there is sometime no relation between the cost paid and power generation during the peak hours and this may lead to inefficient overall resource uses.[1].Due to lower and uncertain residential load, DR plays an important role in electricity market by reducing investment of the service provider in peak power generation and savings in the electricity bill by providing incentives [2]. DR reduces the capacity investments in peak generation units and provides short term reliability benefits as it can offer load relief to resolve system and local capacity constrains.[2]. Participating in demand response has significant advantages for both consumers and electricity producers. Real time scheduling of load through automation is the resent approach. Real time modeling is done for direct load control in cyber-physical power system. [3]. To satisfy the load capacity and to provide the desired voltage to the customer, network planning is done. In this process customers demand which is uncertain is taken as a coincidence factor and load curve is, analyzed for network planning and for network operation. [4]. The smart grid is mainly used for power system automation. It focuses on two way interaction between electricity provider and user.

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Sheetal Shinkhede, Department of Electrical Engineering Polytechnic, Maharaja Sayajirao University of Baroda, Vadodara (Gujarat). India.

II. ENERGY MANAGEMENT

Energy Management means the balance between demand and the supply in order to avoid the interruption in supply system. Residential loads have been large sectors in terms of consuming energy. Mostly HVAC systems, like heating ventilation and Air-conditioning are the major goal of power management as they consume significant part of total annual energy.[5]. In most of the residential and commercial sectors programmable thermostats (PT) are used to control temperature, humidity[6]. In the Environmental Protection Agency's (EPA) Energy star Program include programmable thermostats, suggesting that homeowners could save about $180 a year with a programmable thermostats. Use of PT does not guarantee the energy management it depends on how the PT is programmed. To take in PT programming one should participate in DR to reduce load during peak hours. To manage the energy distribution load can be modeled as a. schedulable b. unschedulable. HVAC appliances can be schedulable while lighting load is unschedulable. The European Smart-A project investigates how smart appliances can contribute to load management in future energy systems and provides a detailed assessment of the acceptance of smart appliances.[7], [8]. The National Energy Modeling System (NEMS) in USA employs end use load shape to build the overall load shapes in each region. This load profiles consists of data for 3 day types (weekday, weekend day and peak day), each for 24 hourly values, for each of 12 months. Regional load shape for space heating and cooling are constructed using regional weather information.[9], [7]. The residential Energy consumption survey (RECS) is conducted in order to collect statistical data of energy consumptions and usage patterns from households. According to RECS data and reasonable assumption, the alternative load shapes have been built for all of the home appliances in each region.[www.eia.gov]

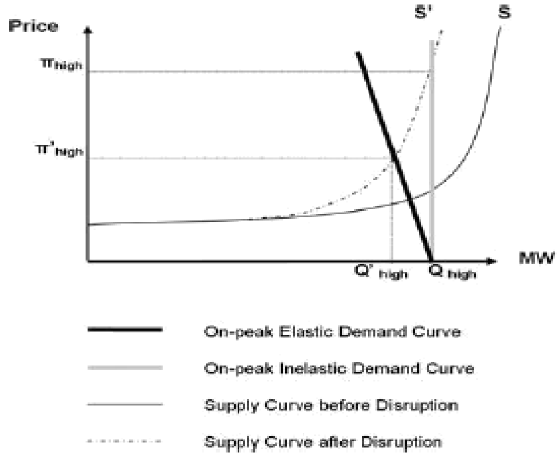

Fig. 1. Demand response vs prices [10]

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III. DEMAND SIDE MANAGEMENT AND DEMAND RESPONSE

The demand-side is merely considered as a anticipated load to be served under balancing generation condition and load is done almost entirely through actions taken from the supply side in the wholesale electricity market. Same way, end consumers in retail markets are rarely offered time-varying prices that reflect the underlying costs of serving the system load. To bridge a gap between retail and wholesale markets , Without active demand-side participation, generators have less incentive to sell their capacities at true cost. This increases the price that is to be bared by the consumers. Consumer could the demand in response to time varying prices. They may shift some of their demand from one period to another in response to price signal. During high price if consumers reduced their demand, and could not satisfy their load at other times, the value they put on electrical energy is not consistent. There-fore the challenge here is how to incorporate these demand responses into electric market design to achieve the efficient performance. for this the economic feasibility of demand side participation has to be evaluated. Also it is not cost effective to store electricity in bulk. Hence there is extreme price volatility due to shortage during peak hours. Demand response (DR) is demand driven process. It is normally not set up as a daily action, but takes place when there is specific situation at the production and transmission side [11]. It potentially reduces the power system stress condition through load management. To satisfy the peak load there is penetration of renewable energy sources. The main goal is to avoid peak load for system reliability and for handling emergency situations and prevent-ing outages [6]. High penetration of intermittent renewable energy imposes new challenges to the operation and control of power systems. Therefore DR requires dynamic control capability (load management) to shed the loads or shift them to other time. The dynamic stochastic optimal power flow (DSOPF) control algorithm using the Adaptive Critic Designs (ACDs) has shown promising dynamic power flow control capability and has been demonstrated in a small system.[12] To reduce the peak load and use of power in a regulated way set of electrical devices are controlled in a coordinated manner. The physical system of load is modeled using timing parameters can be derived from real time scheduling system. The set of rescheduling techniques can be executed using controllers [13]. In [14]the methods of peak load shifting via a computer based system to measure and manage energy consumption is described. The peak load shifting is based on time of use (TOU) method and DR incentives by pro-grammable thermostat. House hold can use energy storage devices DR can defined as " 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.[15], [16]. DR reduces the capacity investments during peak generation unit and satisfy the sudden called demand and provides short term reliability benefits. DR programs marks the baseline energy consumption of the customer below that demand reductions are not allowed. The load can be distinguished as flexible load or non-flexible load. Flexible load can be reallocated over time according to certain load management method, while non-flexible load consume amount of energy at specific time period. In this paper two methods are studied for load management based on block scheduled model and a distributed algorithm of appliance scheduling. A multi-layer demand response model is developed that takes into account both concerns from utilities for load reduction and concerns from consumers for convenience and privacy. An analytic hierarchy process (AHP)-based approach is put forward taking into consideration opinions from all stakeholders in order to determine the priority and importance of various consumer groups. [17]. A day-ahead scheduling model in which the hourly demand response (DR) is considered to reduce the system operation cost and incremental changes in generation dispatch when the ramping cost of thermal generating units is considered as penalty in day-ahead scheduling problem.[18].

IV. LOAD MODEL

Electric Power system is utility company or service provider and there are N customers. Meters measures hourly consumption of electricity and communicates these activity to the service provider. Day is divided into T time period,

T = f1; 2; 3:::T g. There is a set of A different appliances denoted as A = f1; 2; : : : Ag. Each user has selected An of the appliances from set A. Appliances can be flexible load or non-flexible load. For.e.g refrigerator, heating and lighting are non flexible load where as dishwasher, washing machine, PHV comes under the category of flexible load. Total load of the nth user at time t, t 2 T is given by

$$l_n(t) = \sum_{x 2 A^f_n} l_{n;x}^{f}(t) + \sum_{x 2 A^n_{nf}} l_{n;x}^{n}f(t) \quad (1)$$

where ln;xf(t) is the flexible load and ln;xnf(t) is non flexible load. Afn and Annf is a set of flexible and non flexible load respectively.

It is not possible to control the power continuously. Therefore the appliances are operated in several possible modes and in each mode energy conservation is taken into consideration. Let x(th) appliance, for x 2 A have Mx operating mode denoted as Mx = 1; 2; ::::mx; :::::Mx. Energy consumption of the appliance in each mode is given by ex = [e(x; 1); : : : ex; Xa]t.

The non-flexible load ln;xnf(t) = ex(m) if the x(th) load of the n(th) user is operating in m(th) mode at time "t", or it

is "0" For the x(th) schedule appliance of the n(th) user, we define F(n; x)[t; m] = 1 if the x(th) appliance is scheduled to operate in m(th) mode at time t. or it is zero otherwise.

The load

Ln= xnf(t) can be expressed as a function of F(n; x) as

ln;xnf(t) = F(n; x):em.

The user can chose the operating mode and time of appliances. The objective function is to

find optimal F(n; x) for x 2 A(nnf) for n = 1::::N that

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minimizes the cost to users. In [19] time dependent unit is set. A distributed framework is proposed where each user independently minimizes his own cost using greedy approximation. The same problem is solved by real time pricing scheme [2]: linear pricing scheme and threshold pricing scheme.For linear pricing the problem is formulated as a convex optimization problem. For threshold pricing detailed characterization of different optimal load profiles are given [2] assuming discrete load unit model. A search algorithm is also proposed to find optimal load profiles for both constant and dynamic pricing threshold scenario. A dynamic threshold pricing scheme encourage the customer to adapt an optimal demand response profile that will naturally lead to peak-load shaving and load flattening.

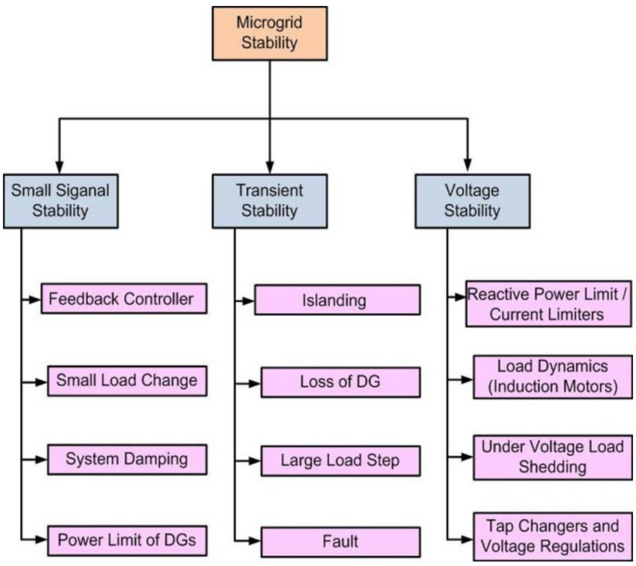
V.FUTURE SCOPE

The paper aim is to model the load to relieve power system stress condition. Most of the work is time of use method or by providing price incentives, the load is flattened and power system is stabilized. But with the available power system and load, the stability issues are small signal, transient and voltage stabilities.[20], [21]. These are the causes of stress in the power system. Voltage stability problem is due to reactive power limit, load dynamics, tap changers etc. To relieve the power system from such stress condition like, various voltage stability improve-ment methods are adopted, like, reactive power compensation, load shedding, modified current limiters, voltage regulators.

In figure[2] there are two options, Option [1] is fix switching and option [2] is advanced load shedding method that monitors the data and optimize the network.

VI. CONCLUSION

This paper reviews the load management techniques to re-live the power system stress conditions by load modeling. Load is modeled as flexible load and non-flexible load. There are



[22] Fig. 2. Different stability issues

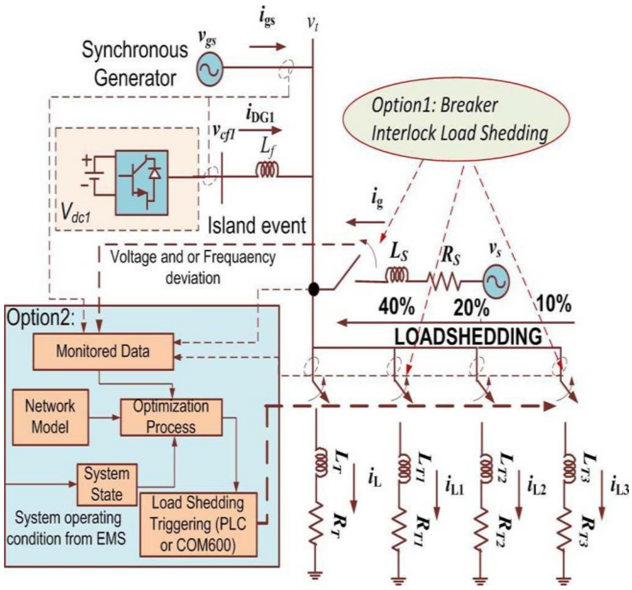
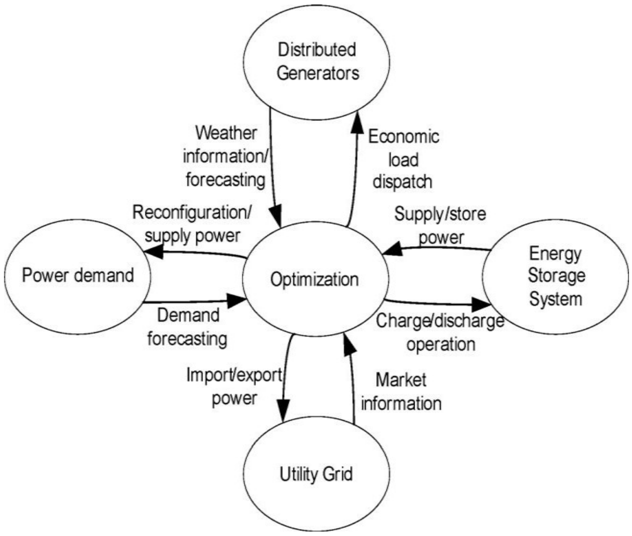


Fig. 3. methods of load shedding [22]

There are various operating modes for switching loads, Based on energy consumption the cost of power consumed is calculated and the system is optimized to reduce the cost of power. The power system stress can be relieved by solving the stability issues. With the same load model and installed power generation, the load flow strategy can be studied and voltage stability issues can be solved.



[22] Fig. 4. Syatem Structure

REFERENCES

1. C.W. Gellings, M. Samotyj, and B. Howe. "The future's smart delivery system [electric power supply]." Power and Energy Magazine, IEEE, 2(5):40–48, 2004.
2. Ding Li, Sudharman K Jayaweera, Olga Lavrova, and Ramiro Jordan. " Load management for price-based demand response scheduling-a block scheduling model". In International Conference on Renewable Energies and Power Quality (ICREPQ11),(Las Palmas de Gran Canaria, Spain), 2011.
3. T. Facchinetti and M.L. Della Vedova. Real-time modeling for direct load control in cyber-physical power systems. Industrial Informatics, IEEE Transactions on, 7(4):689–698, Nov 2011.
4. J. Dickert and P. Schegner. Residential load models for network planning purposes. In Modern Electric Power Systems (MEPS), 2010 Proceedings of the International Symposium, pages 1–6, Sept 2010.
5. Therese Peffer, Marco Pritoni, Alan Meier, Cecilia Aragon, and Daniel Perry. How people use thermostats in homes: A review.

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Building and Environment, 46(12):2529–2541, 2011.
6. Keshtkar and S. Arzanpour. A fuzzy logic system for demand-side load management in residential buildings. In Electrical and Computer Engineering (CCECE), 2014 IEEE 27th Canadian Conference on, pages 1–5, May 2014.
7. H.P. Khomami and M.H. Javidi. An efficient home energy management system for automated residential demand response. In Environment and Electrical Engineering (EEEIC), 2013 13th International Conference on, pages 307–312, Nov 2013.
8. Wilma Mert, Jurgen¨ Suschek-Berger, and Wibke Tritthart. Consumer ac-ceptance of smart appliances. Smart domestic appliances in sustainable energy systems (Smart-A), 2008.
9. M. Pipattanasomporn, M. Kuzlu, and S. Rahman. Demand response implementation in a home area network: A conceptual hardware archi-tecture. In Innovative Smart Grid Technologies (ISGT), 2012 IEEE PES, pages 1–8, Jan 2012.
10. Chua Liang Su. Optimal demand-side participation in day-ahead electricity markets. PhD thesis, The University of Manchester, 2007.
11. Mohamed H Albadi and EF El-Saadany. A summary of demand response in electricity markets. Electric power systems research, 78(11):1989– 1996, 2008.
12. Jiaqi Liang, D.D. Molina, G.K. Venayagamoorthy, and R.G. Harley. Two-level dynamic stochastic optimal power flow control for power systems with intermittent renewable generation. Power Systems, IEEE Transactions on, 28(3):2670–2678, Aug 2013.
13. Giorgio C Buttazzo. Hard real-time computing systems: predictable scheduling algorithms and applications, volume 24. Springer Science & Business Media, 2011.
14. E. Williams, S. Matthews, M. Breton, and T. Brady. Use of a computer-based system to measure and manage energy consumption in the home. In Electronics and the Environment, 2006. Proceedings of the 2006 IEEE International Symposium on, pages 167–172, May 2006.
15. Ding Li and S.K. Jayaweera. Distributed smart-home decision-making in a hierarchical interactive smart grid architecture. Parallel and Distributed Systems, IEEE Transactions on, 26(1):75–84, Jan 2015.
16. Q QDR. Benefits of demand response in electricity markets and recommendations for achieving them. 2006.
17. Shengnan Shao. An approach to demand response for alleviating power system stress conditions due to electric vehicle penetration. PhD thesis, Virginia Polytechnic Institute and State University, 2011.
18. Hongyu Wu, M. Shahidehpour, and M.E. Khodayar. Hourly demand response in day-ahead scheduling considering generating unit ramping cost. Power Systems, IEEE Transactions on, 28(3):2446–2454, Aug 2013.
19. P. Chavali, Peng Yang, and A. Nehorai. A distributed algorithm of appliance scheduling for home energy management system. Smart Grid, IEEE Transactions on, 5(1):282–290, Jan 2014.
20. A.M. Salamah, S.J. Finney, and B.W. Williams. Autonomous controller for improved dynamic performance of ac grid, parallel-connected, single-phase inverters. Generation, Transmission Distribution, IET, 2(2):209–218, March 2008.
21. M. Shahabi, M.-R. Haghifam, M. Mohamadian, and S.A. Nabavi-Niaki. Microgrid dynamic performance improvement using a doubly fed induction wind generator. Energy Conversion, IEEE Transactions on, 24(1):137–145, March 2009.
22. R. Majumder. Some aspects of stability in microgrids. Power Systems, IEEE Transactions on, 28(3):3243–3252, Aug 2013.

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