Role of Demand Response in Smart Grid Environment

Vijaya Margaret
Department of Electrical and Electronics Engineering
Faculty of Engineering, CHRIST (Deemed to be University) Bangalore, India

Abstract : **Demand response is one of the consumer driven program proposed in smart grid environment which enables the consumers to voluntarily participate in supply-demand balance (balancing the supply and demand) in grid by changing their load pattern. Further it also improves the economic and reliable operations of the grid. In this paper, survey of literature adopted for demand response and the optimization technique, Particle Swarm Optimization which is extensively applied in power system engineering is done. The study shows that the mentioned optimization technique is the simplest, robust and fast converging among all other algorithms, which can be used for optimizing demand response program in smart grid environment more efficiently.**

IndexTerms - Demand Response, Smart Grid, Optimization, Customers, Peak loads.

I. INTRODUCTION

Balancing the supply and demand is more essential in the existing grid for economic and reliable operation. Whenever grid is subjected to any abnormalities such as faults, load imbalance etc., it is required for system operator to act immediately for obtaining stability in the network which otherwise leads to various issues [1]. Capacity addition or adjusting the generation level during imbalance in the supply demand is the most commonly used conventional method and it has many drawbacks. In order to overcome this, various other programs are initiated in which the end-users are encouraged to adjust their loads during such conditions [2]. Demand response program is the most successful program initiated by the utilities in which the consumers are motivated to change their load pattern instead of using conventional method to balance the network. At present, industrial and commercial consumers are initiated with the demand response programs and less importance are given to residential consumers because of their inconsistency in the power consumption technique and difficulty in promoting the knowledge of such initiatives among this type of consumers. Hence it is required to understand the implications of demand response program for residential loads in the smart grid environment.

In this paper an attempt is made to study the demand response models used for residential loads and also the optimization techniques suitable for obtaining the best results. PSO is one of the widely used optimization technique in the area of power system engineering which is used in this survey [1, 2].

II. PARTICLE SWARM OPTIMIZATION MODEL

An objective of using optimization techniques in any field is to find the best solution out of the possible solutions available. Many heuristic and metaheuristic optimization algorithms are developed by researchers to get best solution for the problem defined. Particle Swarm Optimization (PSO) is that type of algorithm developed by Eberhart and Kennedy in 1995. It is an algorithm based on the number of inhabitants, which adopts the behavior of birds belongs to the same species or fish schooling [3, 4]. Literature shows that PSO is easy to implement and practice and also only few parameters are used compared with other minimization or maximization algorithms such as Genetic Algorithm (GA) [5, 6], Neural Networks, Fuzzy logics etc. [7].

In order to obtain the best among all solutions, a search space of dimension ‘m’ best solution is considered. . Population size is taken as ‘n’, velocity as ‘v’ and position ‘p’ of the k^{th} particle is expressed as below [4, 8]:

$$v_k = (v_{k1}, v_{k2}, \ldots . v_{km}) \qquad (1)$$

and

$$p_k = (p_{k1}, p_{k2}, \ldots . p_{km}) \qquad (2)$$

Where,

k = 1: n;
n = total number of particles.

Among the total 'n' particles in the process the best among the individual 'pbest' and the most accurate particle among the overall particles 'gbest' can be expressed as,

$$p_{bk} = (p_{bk1}, p_{bk2}, \ldots . p_{bkm}) \quad (3)$$

$$p_{gk} = (p_{g1}, p_{g2}, \ldots . p_{gm}) \quad (4)$$

Where,

p_b = best optimal position of the individual particle;
p_g = global best position of the individual particle;

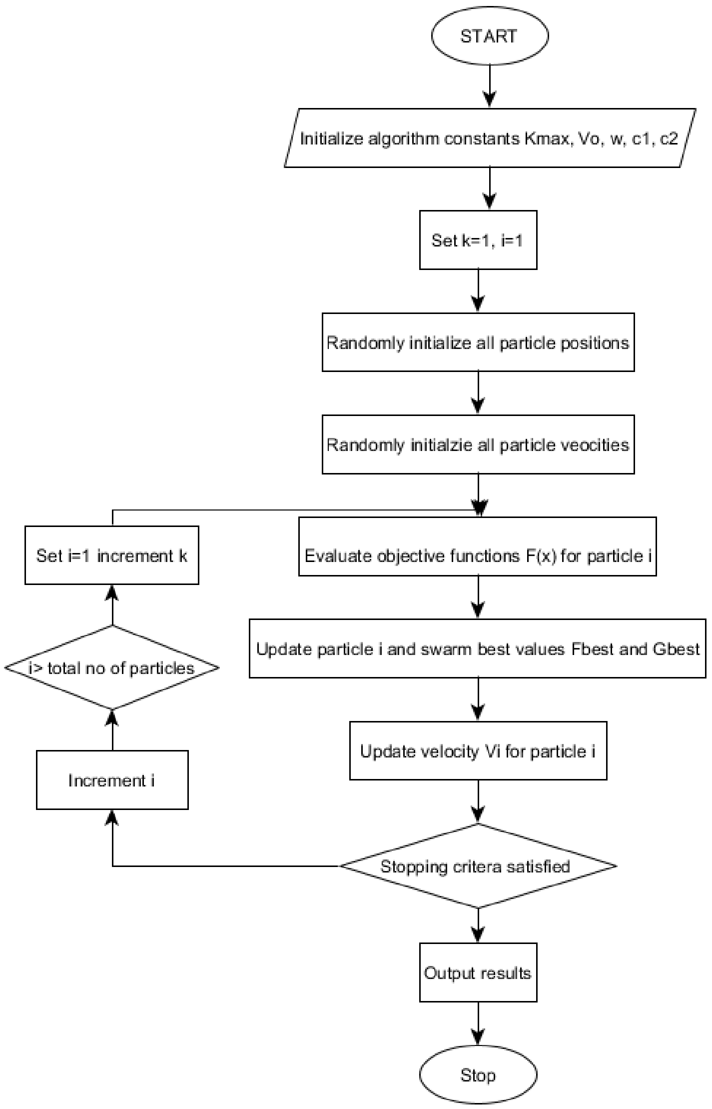

Fig 1:- Step by step process of PSO algorithm

The position of the particles and speed are updated iteratively according to the following equation:

$$v_{km}^{t+1} = (wv_{km}^{t} + c_1 r_1 (p_{km}^{t} - x_{km}^{t}) + c_2 r_2 (p_{km}^{t} - x_{km}^{t})) \quad (5)$$

Where,

v_{km} = velocity of ‘k[th]’ particle in the m-dimension search space;
w = inertia weight factor;
c_1 = exploration coefficient;
c_2 = exploitation coefficient
r_1 = arbitrary number between (0, 1);
r_2 = arbitrary number between (0, 1);
x_{km} = speed of ‘k[th]’ particle at ‘t’ times in the m-dimensional space;
p_{km} = the m-dimensional quantity of the individual ‘k[th]’ particle at its most optimist position at its ‘t’ times; [4-10]

Figure 1 depicts the flow chart of PSO. It is a method that requires arithmetical calculations which can optimize the problem in an iterative manner such that the final solution will be the best. Initially velocity is assigned to the particles by choosing appropriate values [3]. At each location the objective function is evaluated and initializes the position and velocity of the particle. The best function value and the best location are decided after analyzing the objective function. The velocity is updated in an iterative manner in such a way that the velocity of the particles travelling should be within the limits and also the velocity is updated (v_{km}) for particle ‘k’. Until and unless the stopping criteria is met and the constraints are satisfied the iterations will go on [9-12].

III. DEMAND RESPONSE

The separations of electrical services have made the electric utilities face certain uncertainties about the ability to recover the investments that were already invested in electricity infrastructure. As a result, many investments by the utilities were delayed in the generation and transmission part, which has led to some hindrance and insufficient generating capacity. The advantage of the demand response is that it will encourage the consumers to take part in the initiatives taken by the government by reducing their consumption during the on-peak hours. This program benefits with the reduced electricity bills and also it encourages the consumers with incentives [13].

IV. TYPES OF DEMAND RESPONSE PROGRAM

The demand response programme can be categorized as Load Responsive and Price Responsive

a) Load Responsive

As part of these program loads reduction techniques are decided by the utilities, with little discretion in compliance. Independent system (grid) operators, entities, which serves the load and distribution companies at the utility side are called for a load response [13].

Load response program is again classified into three. They are:

Direct load-control programs — for the reduction of electricity usage during peak hours. They adopt some strategies like control over certain appliances. This program mainly focuses the residential consumers. [13].

Curtailable load programs — usually applied for large industrial and commercial consumers whose loads can be reduced at least with a minimum threshold of 100 kW per an event. The notice will be given for the most part from 30 minutes to two hours [13].

Interruptible programs — used for industrial operations whose load can be cut either fully or partially depending on the need. If backup generators can provide a backup commercial facilities may also participate in this program [13].

b) Price Responsive

Price response program operates depending upon the actions that are taken by the consumers themselves in response to market signals They chiefly transfer on discount clearing costs is an essential flag. Cost responsive interest mitigates spikes in discount showcase costs [13].

Price response programs consist of:

Economic programs — this program centers on the extensive commercial and industrial offices who can give a base measure of load abridgement, for example, 100 kW per occasion. In response to a proposed cost or a set of hurly costs in the day-ahead market participants may offer load decrement for certain period of time. Their installment depends on the availability offered by the user and acknowledged by the purchaser for day-ahead projects [1].

Time-of-Use rates — the consumers eligible for this program includes industrial, residential and commercial consumers. The participation of the consumers is dependable and it depends on the jurisdiction they can mandatorily participate or voluntarily participate. In order to gauge the utilization amid the crest, off-crest and now and again middle of the hours extraordinary meters are introduced. Depending on time, day of week and season the rates may vary. The consumers will know the rate for a particular period in advance since it is fixed [13].

Real time pricing — This type pricing is mainly focused on industrial and commercial facilities whose loads are shiftable. The improvements in the correspondence frameworks enable the clients to watch the continuous vitality utilization and forward the costs. In this pricing the consumers are provided with hourly prices for the next day. The authorities or the managers are free to maintain operations as per the planned operations. The "Two-part" tariffs system establishes a baseline for the energy utilization for each hour of the year. Based on the historical use the usage is agreed upon by both parties for appropriate adjustments in load usage i.e., during weather changes. Fluctuations in utilization from the limit are charged a premium if above, and a rebate if underneath, the gauge utilizing spot showcase clearing costs. An option in contrast to the two-part tariff is a "one-part" tariff that connects the entire use to hourly costs to advertise clearing spot costs and keeps away from gauge estimation [13].

V. Influencing Factors of Demand Response

Influencing factors in the demand response program are as shown in figure.2 which includes the price, demand supply, budget and the promotions and these are also called as market variables. Price is always a matter on which the consumers think so, incentivizing the price plays a mandatory role. Then comes the demographic factors they include the income, age, education and the family size. These factors are mainly bounded by their thoughts like they compare it with the past. Then the regulations and the policies come into picture which includes the controls and the information. Regulations and policies which are already implanted and the consumers hesitate to break those rules. Social factors include the people around us, their attitudes, preferences and cultures, these factors also affects demand response programs in country like India which has got large diversities in everything. Then the last factor which is the culture, their beliefs, norms and the attitudes makes them hesitate to adopt a new development.

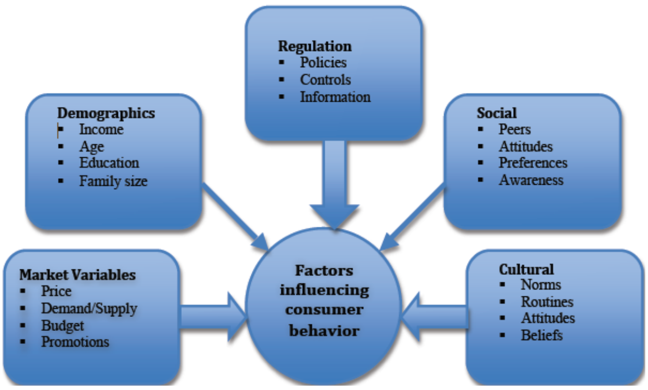

Fig 2:- Demand Response influencing factors

VI. Demand Response Benefits

The following are the benefits of Demand Response programs [14].

- *Financial benefits* to the *participant* are the bill savings and incentive payments that are saved by the end-users whose electricity demand is adjusted with respect to time or based on incentive given by the utilities.
- *Market-wide financial benefits* are the lower wholesale market prices since; demand response averts the need to utilize the most costly power plants during periods of high demand, driving production costs.
- *Reliability benefits* are the operational security and adequacy savings because demand response reduces the likelihood and reduce the effects of power outages.
- *Market performances benefits* refer to demand response's value in estimating suppliers' capacity to practice advertise control by increasing force costs altogether more than the generation cost.

Demand response benefits such as cost decrement, outage reduction, participation of users, diversified resources, market power reduction, and bill savings are explained in [14,15].

VII. DEMAND RESPONSE IN SMART GRID

In smart grid demand response has an essential role. As the electricity market has become restructured and deregulated it is important for the participants to adopt demand response program. The enablers and barriers of demand response program have been classified in the smart grid context. The barriers are classified as fundamental and secondary. The two barriers are related to particular functions they are intrinsic human nature i.e., social or economic behavior, the second one is related to regulations and markets behaviors [16, 17]. Based on the classifications the Demand Response is enabled. The demand response has the capability of eliminating the power jumble. It conveys an audit on the load scheduling and frequency regulation procedures proposed before, as per which, demand response has the capability of removing power befuddle [18].

A major role is played by demand response in smart grid implementation, which allows system benefits such as operations and expansion on market efficiency. Power reservation is an important part for efficient use of electricity as well for the availability of power. Any resources available need to be used properly so that it will be easily available for us and for the future. The reservation of power can be raised during the peak loads and it reduces prices on day ahead and market balancing is done using demand side response. Demand side response program helps to reduce the inconveniences and to improve the utilization of the standby power supply sources and helps the customer with the load reduction techniques [19].

In a power framework, a heap bend or load profile is an outline representing the variety popular/electrical load over an explicit time. Generation companies use this information to arrange how much power they will need to generate at some random time. Certain methods are used which helps the customers to obtain better optimized and efficient seasonal load profiles for better system utilization. The methods adopted includes changing the electricity prices for the reduction of total peak load thereby it helps in reshaping the demand profile thus decreasing the price [20, 21, 22].

Multiple energy intensive processes i.e., multiple appliances running at the same time consumes more energy and they are the main contributors to the peak demand. This can be exampled here when multiple rooftops cooling unit switch on its power for providing cooling to the space it consumes more energy when all are on at an instance. The only solution to this is to run at off peak hour and to cycle the appliance at different pieces such that all of the equipment is never on the same time. In order to achieve this customer need to be encouraged for adopting demand response program or incentive based demand response program. Incentive based programs adopt new strategy and frameworks. The pricing program effectively influences the load profile. So there must be a link between the user and the utility. For deciding viability of such plans on load reductions grid operators and authorities have developed new algorithms [23, 24].

The demand charge is a significant component of the electricity bill. Effective demand management offers substantial savings opportunities. The demand profile is considered as a record of power consumed and supplied at any point of instance. Implementation of demand response needs a frame work, architecture, and hardware platform and also some functional modules related to the demand side management, load profiling is also an important part of this. A demand profile needs to be created using the appliances that were used in the house. Three groups can be created like refrigeration, lighting and stand-by, which could be applied each alone or mixed. Flexibility concept can also be considered i.e., load that are flexible and non-flexible. Flexibility is related how easily we can shift the usage of the appliances. This makes the consumers more user friendly as well as it make them how easily they can handle the appliances. Flexibility loads are those loads which we don't need 24*7. Non- flexible loads are those loads ne need 24*7. In shifting those loads we need to adopt certain strategy which has to be planned by the authorities [25, 26, 27].

Modeling of demand response dealer includes a client's eagerness factor assigned in an irregular manner. This model considers, the load traits, for example, use and accessibility factors. And for the analysis purpose they have used mathematical models such as nonlinear, linear and exponential formulas [28]. New values are applied for Incentive Based Demand Response (IBDR) that is important for customer side. The problem was analyzed under actual data of WECC 240-bus reduced model. It has showed how the incentive based elasticity of users could improve demand response performances. The two cases are estimated with the standard price based elasticity [29].

Integration with the renewable resources has brought new developments in the peak reduction techniques. Matrix of self-elasticity and cross elasticity has been used here for modeling the customer behavior. By adopting renewable energy integration and using demand response it is seen that energy cost has reduced. Utilizing the renewable energy will help to meet the demand such that supply and demand will be balanced. The following are the advantages of the dynamic pricing and they are net profit got raised and secondly the peak load got reduced and thirdly the clean power resource ratio got rise, which makes it more environmental friendly [30, 31].

Customers need to be encouraged to take part in the demand response program. For that customer awareness need to be given since India is a large country with huge population and also with large diversities in culture they may hesitate to follow the newly developed strategies. In order to make them clear about it awareness need to be given which is essential to increase the participation in demand response program. For that they need to be attracted to the program that can be succeed through making them know how flexible the usage is and ease of use and also about the incentive programs. With this the participation of the customers will get enhanced which will lead to sustainable power system operation [32, 33].

A new mathematical and economical model has been proposed based on the tome of use method for the demand response program. The demand response model has the capability to adjust the energy consumption levels at different instance. This model will be a flexible model with all types of loads with flexible prices. This proposed model will enable the demand response actions based on their preferences which in turn will help them to improve the utility functions. This model can be taken as a future work related to pricing methods such as Real-Time Pricing method (RTP) and Critical Peak Pricing method (CPP) [34].

To examine the residential AC consumption a model has been proposed, a recognition model. Firstly the duty cycle curves are produced using the Non-Intrusive Load disaggregation (NILD) secondly the customers who rarely use AC are recognized and a parted from the given data and the users are categorized into regular and irregular customers. And thirdly the customers are clustered into different clusters. The impacts of the NILD are considered and the investigation delineates the legitimacy of the acknowledgment display under the current calculation [35]. Integrated demand responses have modified the conventional demand response programs with their advantages and they include peak reduction, more flexible usage of energy etc. The interactions among the smart energy hubs are considered as a game with unique Nash equilibrium. The results obtained shows that in addition to load curtailment, users in the smart energy hubs can engage in the integrated demand response program by shifting the energy resources during peak hours. This program increases the daily pay off and the company daily profit can be reduced [36].

The residential demand is found out utilizing an approach, which provides an actual evaluation of the actual amount of the controllable and non-controllable resources. Whether controllable or non-controllable the schedule of all appliances is optimized by minimizing the consumer electricity related costs. Demand response offer time- varying tariff due to the liberalization of the electricity markets. Direct load control and load shedding can be used to activate demand response. Several price based strategy for residential users are studied. For the affective scheduling of household appliances a new algorithm was proposed. This algorithm is based on time-varying priority [37, 38, 39].

Demand response assets are equipped for upgrading the proficiency and unwavering quality of expansive power frameworks by giving various items and administrations. This report finds and surveys demand programs, with specific spotlight on keen networks where diverse interest reaction plans are actualized as an approach to reshape private demands. One crucial part of this program is the choice of customers to change their utilization pattern [40, 37].

The impacts of demand response in consumer load profiles are identified and are applied to smart meter data set. Data from the smart meter is obtained from the smart metering project the data collected are mainly for the residential household. Collecting the data mainly aims at creating new strategies and frameworks for load reduction. Developments in the technology and modernization have helped the data mining more easily. Load profiles are generated from the database. The load profiles obtained are segmented into clusters using 'k' means clustering and the obtained results are good enough. Besides the conventional methods like storing the energy in pump and adapting the demand response is an option. As smart meters are used mainly by the residential consumers, Time Of Use (TOU) tariffs encourages the consumers to reduce their demand during the peak time for an instance [41].

VIII. ROLE OF PARTICLE SWARM OPTIMIZATION IN DEMAND RESPONSE

Optimizations are the techniques that are used to find the best solutions. These methods for the consumers are characterized individually and separately in order to manage the energy resources by planning which appliance need to be operated in the given strategy, energy storage systems and sustainable power source assets and in addition dealing with the vitality trades in the power network and the energy trades in the power grid. The main aim of these kinds of techniques is to provide profit to consumers in terms of the cost and optimally manage the comfort of consumers. It also helps to maximize the generation and it also benefits the demand side management. The energy bill and the energy losses can be reduced by this technique. Living in this era of technologies, innovations and modernization things around has become smarter.

The increasing demand for energy has provided more opportunities for new technologies which made the system more reliable, smart and efficient. Development of computation, automation and communication has made the idea of smart grid real. In order to maintain this network real we need to implement certain minimization techniques for attracting the users. PSO is such a technique that can be used for the minimization problems [13]. Majority of the electricity users see the electricity bill as an average electricity price and have small relation to true generation price of power as they change over time. Demand response is a program that was put forward to encourage change in energy use by end use users to the change in price of power or to give incentives for reducing the usage of electricity at the time of high market price [3, 4, 13]. PSO helps in solving non-linear problems through computation methods which optimizes the problem through iterations.

Demand response offers a wide variety of financial and operational benefits for the users, utilities and the operators. Power systems have got three important characteristics. Firstly the power can't be saved economically, the supply and the demand need to be balanced. Secondly the grid condition can change, which can change the demand level unexpectedly. Third is the high capital incentive in generation and transmission systems. Investments and incentives is an important part of demand response for attracting the users for adopting the demand response program. For the minimizing of cost we need to go for PSO optimization which is one of the fastest converging optimization techniques. The marginal cost of electricity supply is varying according to the variation in demand and can increase due to the unpredictable events like seasonal changes, weekend etc, It can also happen when generation or transmission availability fluctuates which leads to variation in the cost. Which makes the users feel uncomfortable [13, 37].

GA is used for the optimization for the utility with an intension to increase the profit. Even though coding of GA is easy it has also got the following disadvantages. It's hard for the people to come up with a good heuristic which actually reflects what we want the algorithm to do. It's hard to obtain the best optimal solution using GA. Choosing parameters like population size, generations etc is hard. The program will be run for a fewer generation. In this paper the customers have been categorized based on some historic consumption pattern. All the customers will not be able to shift the load there will be some non shiftable loads. The customers whose consumption level is high are more able and efficient than the others [43, 44, 45].

A day-ahead and intra-day two stage stochastic optimization was employed. In order to solve the generation scheduling problems a fuzzy optimization approach was introduced considering the wind and solar energy systems. Demand response model for real time pricing is built, and optimal power scheduling model is proposed. In demand response programs both the power resources and demand side resources are programmable to meet the supply and demand balance. The operation cost is more sensitive to payment satisfaction index than the consumption way satisfaction [42].

Data mining is used for collecting the information from a given database. After that clustering process takes place, clustering process are done mainly for the analysis purpose. They focus on new clustering techniques, specially the indirect one and also the classification procedures. This information's are very important for load clustering. Further the application of load clustering is classified as price based and incentive based programs. There are some challenges and opportunities of load clustering in the context of big data and energy internet [46].

Optimization techniques are mainly used for obtaining the global best, there are many optimization techniques used. For a comprehensive customer demand modeling a distributed optimization algorithm has been proposed in smart grid. Firstly the optimization techniques are applied for home energy management software which minimizes the bill based on the demand. Secondly probability behavior model is proposed that calculates the probability distribution of various energy usages proposed for the customers that can handle their energy usage. Further a multi- population genetic algorithm is introduced. The obtained values imply suitability and capability of the proposed models and its advantages [47, 48].

The calculation they utilized here is non-commanded arranging based multi-objective developmental calculation (NGSA-II) with nonlinear constraints. The level of consumer loyalty is utilized as a standard for assessing the system and breaking down the business practices of intensity retailing organizations from the point of view of economic sociology [49]. An estimation and comparison have been done on customer base line model based on a disintegration technique to demand response based on a demand-price flexibility framework. It has been explained with some numerical examples i.e., 6 bus system and 24-bus IEEE RTS (reliability test system) [50].

Execution of a streamlined based SCADA framework utilizes a few controlling and observing techniques to deal with the measure of vitality devoured and it additionally deals with the age of the working for taking an interest in demand response occasions. The controllable devices like air conditioners are suitable with direct load control demand response and flexible loads like lighting system loads can be reduced or curtailed. Controllers can be used to adjust the usage of appliances for building optimization model. SCADA system is considered as an aggregation model, which is an entity that manages the demand response programs and its performance will be surveyed. The outcomes got demonstrate that decrease in the lighting and curtailable gadgets the users can effectively partake in the demand response programs and furthermore it helps in the productive use of power [51].

Combination of different markets with the demand response program is shown here. The Local Energy Markets (LEM) in combination with the demand response in the German energy market context is shown here. The LEMs is shown as a manner to decentralize the massive energy market. An agent based simulation was developed for pricing scheme and the demand shifting scheme, certain models which are appropriate to the concept were integrated and adapted to our LEM concept. Such communities obtain energy at beneficial cost. At the distribution and transmission grid levels the congestion management can be done in a long term. Further the pricing scheme is mainly related to discerning economic criteria [52].

IX. CONCLUSION

PSO is an optimization technique which can be used for optimizing the nonlinear problems. The salient features of particle swarm optimization shows the benefits of adopting this in optimizing the demand response program in smart grid environment. The PSO technique along with demand response is used for reducing the energy price and also to improve the performance of the appliances by shifting their usage. This combined method helps the consumer to consume more power with minimum cost in an efficient and feasible way. The studies shows particle swarm optimization is the simplest, robust and fast converging optimization technique for optimizing demand response programs in smart grid environment.

REFERENCES

[1] J. Jose, V. Margaret and K. U. Rao, "Impact of demand response contracts on short-term load forecasting in smart grid using SVR optimized by GA," Innovations in Power and Advanced Computing Technologies (i-PACT), Vellore, pp. 1-9, April 2017.

[2] V. Margaret and K. Uma Rao, "Demand response for residential loads using artificial bee colony algorithm to minimize energy cost," TENCON 2015 - IEEE Region 10 Conference, Macau, pp. 1-5, November 2015.

[3] Qinghai Bai, "Analysis of Particle Swarm Optimization Algorithm," Computer and Information Science, Canadian Center of Science and Education, vol. 3, No. 1, P180, February 2010.

[4] Y. del Valle, G. K. Venayagamoorthy, S. Mohagheghi, J. Hernandez and R. G. Harley, "Particle Swarm Optimization: Basic Concepts, Variants and Applications in Power Systems," IEEE Transactions on Evolutionary Computation, vol. 12, no. 2, pp. 171-195, April 2008.

[5] M. Yue, B. Guo, T. Hu and X. Guo, "The research of parameters of genetic algorithm and comparison with particle swarm optimization and shuffled frog-leaping algorithm," 2nd International Conference on Power Electronics and Intelligent Transportation System (PEITS), Shenzhen, pp. 77-80, December 2009.

[6] NI, L., WEN, F., LIU, W. et al. J. “Congestion management with demand response considering uncertainties of distributed generation outputs and market prices” Mod. Power Syst. Clean Energy 5:66. vol. 5, Issue 1, pp 66–78, December 2016.

[7] J. A. Dickerson, J. Hong, Z. Cox and D. Bailey, "A comparison of radial basis function networks and fuzzy neural logic networks for autonomous star recognition," IJCNN'99 International Joint Conference on Neural Networks. Proceedings (Cat. No.99CH36339), Washington, DC, USA, , pp. 3204-3207 vol.5, July 1999.

[8] Rini, dian Palupi & Shamsuddin, Siti Mariyam & Yuhaniz, Siti. “Particle Swarm Optimization: Technique, System and Challenges”. International Journal of Computer Applications. 1. 10.5120/ijais-3651, vol. 14, No. 1, January 2011.

[9] Talukder, Satyobroto, “Mathematical Modeling and Applications of Particle Swarm Optimization” Independent thesis Advanced level, Blekinge., p. 65, February 2011.

[10] Alam, Mahamad. “Particle Swarm Optimization: Algorithm and its Codes in MATLAB”. 10.13140/RG.2.1.4985.3206, March 2016.

[11] D. Bratton and J. Kennedy, "Defining a Standard for Particle Swarm Optimization," 2007 IEEE Swarm Intelligence Symposium, Honolulu, HI, pp. 120-127, 1-5, April 2007.
[12] Abdi, Hamdi & Ranjbaran, M & Nazari, P & Akbari, H. “A Review on PSO Models in Power System Operation. International Journal of Emerging Technology and Advanced Engineering”. 3. 33-43, Vol 3, Issue 7, July 2013.

[13] A report to the United States Congress Pursuant to Section 1252 of the Energy Policy Act of 2005 “Benefits of Demand Response in Electricity Markets and Recommendations for Achieving Them.”, February 2006.

[14] US Department of Energy, “Benefits of Demand Response in Electricity Markets and Recommendations for Achieving Them: A Report to the United States Congress Pursuant to Section 1252 of the Energy Policy Act of 2005”, July 2006.

[15] O. Elma and U. S. Selamoğullari, "An overview of demand response applications under smart grid concept," 2017 4th International Conference on Electrical and Electronic Engineering (ICEEE), Ankara, pp. 104-107, April 2017.

[16] Saber Chenari, Kazem & Abghari, Hirad & Tabari, Hossein. “Application of PSO algorithm in short-term optimization of reservoir operation,” Environmental Monitoring and Assessment, 188. 10.1007/10661-016-5689-1, December 2016.

[17] I. Gupta, G. N. Anandini and M. Gupta, "An hour wise device scheduling approach for demand side management in smart grid using particle swarm optimization," 2016 National Power Systems Conference (NPSC), Bhubaneswar, pp. 1-6, February 2016.

[18] Y. del Valle, G. K. Venayagamoorthy, S. Mohagheghi, J. Hernandez and R. G. Harley, "Particle Swarm Optimization: Basic Concepts, Variants and Applications in Power Systems," in IEEE Transactions on Evolutionary Computation, vol. 12, no. 2, pp. 171-195, April 2008.

[19] N.Gooda, Keith A. Ellisb, and Pierluigi Mancarellaa, “Review and classification of barriers and enablers of demand response in the smart grid,” Elesvier-Renewable and Sustainable Energy Reviews, vol. 72. No. 72, pp. 57–72, May 2017.

[20] B. V. M. Vasudevarao, M. Stifter and P. Zehetbauer, "Methodology for creating composite standard load profiles based on real load profile analysis," IEEE PES Innovative Smart Grid Technologies Conference Europe (ISGT-Europe), Ljubljana, pp. 1-6, October 2016

[21] I. Prahastono, D. King and C. S. Ozveren, "A review of Electricity Load Profile Classification methods," 2007 42nd International Universities Power Engineering Conference, Brighton, pp. 1187-1191, September 2007.

[22] A. Malik and J. Ravishankar, "A review of demand response techniques in smart grids," IEEE Electrical Power and Energy Conference (EPEC) , pp. 1-6, October 2016.

[23] P. Khajavi, H. Abniki and A. B. Arani, "The role of incentive based Demand Response programs in smart grid," 2011 10th International Conference on Environment and Electrical Engineering, Rome, pp. 1-4, May 2011.

[24] J. Andruszkiewicz, J. Lorenc And P. Piasecki, "Estimation Of Electricity Value For Households Participating In Demand Response Programs," 14th International Conference On The European Energy Market (Eem), Dresden, , Pp. 1-6, July 2017.

[25] Albadi, M. H., & El-Saadany, E. F. “Demand response in electricity markets: An overview,” In 2007 IEEE Power Engineering Society General Meeting, June 2007.

[26] E. Moreno, O. A. Gonzalez and A. Pavas, "Demand flexibility assessment for residential customers," 2017 IEEE Workshop on Power Electronics and Power Quality Applications (PEPQA), pp. 1-5, Bogota, June 2017.

[27] Xiandong Tan, Baoguo Shan, Z. Hu and Sizhu Wu, "Study on demand side management decision supporting system," 2012 IEEE International Conference on Computer Science and Automation Engineering, pp. 111-114, Beijing, June 2012.

[28] S. R. Konda, L. K. Panwar, B. K. Panigrahi and R. Kumar, "Investigating the Impact of Load Profile Attributes on Demand Response Exchange," in IEEE Transactions on Industrial Informatics, vol. 14, no. 4, pp. 1382-1391, April 2018.

[29] A. Asadinejad, K. Tomsovic and C. Chen, "Sensitivity of incentive based demand response program to residential customer elasticity," 2016 North American Power Symposium (NAPS), Denver, CO, pp. 1-6, September 2016.

[30] S. Kwon, L. Ntaimo and N. Gautam, "Optimal Day-Ahead Power Procurement With Renewable Energy and Demand Response," in IEEE Transactions on Power Systems, vol. 32, no. 5, pp. 3924-3933, September 2017.

[31] H. Du, S. Liu, Q. Kong, W. Zhao, D. Zhao and M. G. Yao, "A microgrid energy management system with demand response," 2014 China International Conference on Electricity Distribution (CICED), Shenzhen, pp. 551-554, September 2014.

[32] IEEE Guide for the Benefit Evaluation of Electric Power Grid Customer Demand Response," in IEEE Std 2030. , vol.6-2, pp.1-42, 16 December 2016.

[33] P. Ballenger, Anna & Herath, Pramod & Navarro Caceres, Maria & Venayagamoorthy, Ganesh & Corchado Rodríguez, “Influencing behaviour of electricity consumers to enhance participation in demand response,” pp.1-6. 10.1109/NAPS.2017.8107300, September 2017.

[34] R. Sharifi, S. H. Fathi, A. Anvari-Moghaddam, J. M. Guerrero and V. Vahidinasab, "An economic customer-oriented demand response model in electricity markets," IEEE International Conference on Industrial Technology (ICIT), Lyon, 2018, pp. 1149-1153, February 2018.

[35] L. Liu, B. Wang, Z. Wang, F. Wang and K. Li, "Recognition model of air conditioning electricity consumption behaviors for demand response based on k-means clustering," 2017 Asian Conference on Energy, Power and Transportation Electrification (ACEPT), Singapore, pp. 1-7, October 2017.

[36] S. Bahrami and A. Sheikhi, "From Demand Response in Smart Grid Toward Integrated Demand Response in Smart Energy Hub," in IEEE Transactions on Smart Grid, vol. 7, no. 2, pp. 650-658, March 2016.

[37] S. Sebastian and V. Margaret, "Application of demand response programs for residential loads to minimize energy cost," 2016 International Conference on Circuit, Power and Computing Technologies (ICCPCT), Nagercoil, pp. 1-4, March 2016.

[38] A. Etxegarai, A. Bereziartua, J. A. Dañobeitia, O. Abarrategi and G. Saldaña, "Impact of price-based demand response programs for residential customers," 2018 19th IEEE Mediterranean Electro technical Conference (MELECON), pp. 204-208, Marrakech, May 2018.

[39] S. L. Arun, A. A. Raj and M. P. Selvan, "Demand response in smart buildings through time-varying priority of household appliances," 2017 IEEE Region 10 Symposium (TENSYMP), pp. 1-5, Cochin, July 2017.

[40] M. Muratori and G. Rizzoni, "Residential Demand Response: Dynamic Energy Management and Time-Varying Electricity Pricing," in IEEE Transactions on Power Systems, vol. 31, no. 2, pp. 1108-1117, March 2016.

[41] Mahsa Khorram, Omid Abrishambaf, Pedro Faria and Zita Vale, “Office building participation in demand response programs supported by intelligent lighting management”, EnergyInformatics 2018, pp. 1:9, August 2018.

[42] E. Moreno, O. A. Gonzalez and A. Pavas, "Demand flexibility assessment for residential customers," 2017 IEEE Workshop on Power Electronics and Power Quality Applications (PEPQA), Bogota, pp. 1-5, June 2017.

[43] P. Guo, X. Wang and Y. Han, "The enhanced genetic algorithms for the optimization design," 2010 3rd International Conference on Biomedical Engineering and Informatics, Yantai, pp. 2990-2994, October 2010.

[44] N. Pavithra and B. P. Esther, "Residential demand response using genetic algorithm," 2017 Innovations in Power and Advanced Computing Technologies (i-PACT), Vellore, 2017, pp. 1-4, June 2017.

[45] F. Meng and X. Zeng, "A Profit Maximization Approach to Demand Response Management with Customers Behavior Learning in Smart Grid," in IEEE Transactions on Smart Grid, vol. 7, no. 3, pp. 1516-1529, May 2016.

[46] Yi Wang, Qixin Chen, Chongqing Kang, Mingming Zhang, Ke Wang and Yun Zhao, "Load profiling and its application to demand response: A review," in Tsinghua Science and Technology, vol. 20, no. 2, pp. 117-129, April 2015.

[47] J. Soares, S. Ramos, Z. Vale, H. Morais and P. Faria, "Data mining techniques contributions to support electrical vehicle demand response," IEEE PES T&D 2012, vol. 162 FL,, pp. 1-8, Orlando, May 2012.

[48] F. Meng and X. Zeng, "Appliance level demand modeling and pricing optimization for demand response management in smart grid," 2015 International Joint Conference on Neural Networks (IJCNN), Killarney, pp. 1-8, June 2015.

[49] Mohajeryami, Saeed & Schwarz, Peter & Teimourzadeh Baboli, "Including the Behavioral Aspects of Customers in Demand Response Model: Real Time Pricing Versus Peak Time Rebate," North American Power Symposium (NAPS). Pp. 1-6, January 2015.

[50] N. Gonzalez Cabrera and G. Gutiérrez Alcaraz, "Estimation of customer base line and multi-period demand response," IEEE International Autumn Meeting on Power Electronics and Computing (ROPEC), Mexico City, pp. 1-6. November 2013.

[51] K. A. Keitsch and T. Bruckner, "Influence of demand response tariffs on the electrical load of households," 2015 IEEE Electrical Power and Energy Conference (EPEC), London, ON, pp. 215-219, October 2015.

[52] Esther Mengelkamp, Samrat Bose, Enrique Kremers, Jan Eberbach, Bastian Hoffmann and Christ of Weinhardt, "Increasing the efficiency of local energy markets through residential demand response" Energy Informatics, pp.1:11, august 2018.