Recent Trends in Intensive Computing
M. Rajesh et al. (Eds.)

doi:10.3233/APC210304

Demand Side Management for Commercial Area Using Teaching Learning Based Optimization

Dhanshri Narayane [a,1], Amarjeet S Pandey [a], D B Pardeshi [a], Renuka Rasal [a]
[a] *Department of Electrical Engineering, Sanjivani College of Engineering, Kopargaon, Maharashtra, India*

Abstract: In Smart Grid Demand side management (DSM) plays a crucial role which permits customers to form educated selections concerning their energy consumption. It allows the strength to companies lessen the height load call for and reshape the burden profile. Most of the present demand aspect management ways utilized in ancient energy management system is with specific techniques and algorithms. In addition, the present ways handle solely a restricted range of governable a lot of restricted varieties of loads. This paper covers a requirement aspect management strategy supported load shifting technique for demand aspect management of future sensible grids with an outsized range of devices of many sorts. The day-in advance load shifting technique is proposed and mathematically formulated as a minimization problem. Teaching Learning Based Optimization (TLBO) is an efficient optimization is proposed. Considering Smart Grid with commercial customer, Simulations has been carried out. The respective results emphasis that the considered demand side management strategy attains substantial savings, whereas suppresses the mark of load demand of the smart grid. The outcome is by improve in sustainability of the smart grid, in addition to reduced standard operational value and carbon emission levels. The proposed algorithms can be easily applied to various optimization problems.

Keywords: Commercial, Demand Side Management, Smart Grid, TLBO, Simulation, Demand Response.

1. Introduction

Modern electrical power systems are continuously fulfilling the demand of power consumption with a satisfactory level of reliability, environmental friendliness and quality. Though, meeting these challenges has become more and more difficult due to the increase in electricity demands caused by population and industrial growth. In addition to this difficulty, the infrastructure investments required to guide the growing worldwide power demand for might be large due to the fact growing older strength machine additives will need to get replaced.

Accordingly, the same old practices geared toward balancing energy supply and demand must to be tested carefully. Power price varies in accordance with real-time electricity needs. Especially, increases charges boom as demand for rises and vice versa.

[1] Dhanshri Narayane, Department of Electrical Engineering, Sanjivani College of Engineering, Kopargaon, Maharashtra. Email: narayanedhanshrielect@sanjivani.org.in.

The administration of power systems is classified into supply-side management and demand-side management (DSM). Both approaches are useful for reducing possibilities, to boost network loading capacity and shorten peak loads. Smart Grid plays vital role in Demand Side Management that supervises the load on customer side which targets on efficiency and sustainability. Modern conversation technology has expedited the productive implementation of smart grid (SG), that aims at plans of demand aspect management (DSM), consisting of demand response (DR). The major ambition of sensible grid is to fulfill the forthcoming power demands. these days sensible grid is one in all the goodly trends within the wattage business and has achieved acceptance in several application departments.

The consumer's demand for energy is altered in DSM through monetary incentives. Demand Side Management processes the choice; planning, associate degreed implementation of measures designed to own an importance on electricity demand on the customer-side of electrical meter, that the utility be able to either management directly or stirred up indirectly. Due to supply-demand gap of electrical Energy is continuously increasing thanks to such technologies which will support to meet the target in nearby future. Underneath such situations, Demand side management is applied to manage the load demand and cut down the energy consumption. The most acquainted motivation for DSM within the power sector is that the most value effectiveness to cut back the electricity demand instead of increasing the ability offer generation or transmission. Application of DSM benefits the customers to adopt electricity with more efficiency. The load profile of the consumer can be flattened that improves the efficiency of various end-uses.

2. Demand Side Management

Deregulation in the world's energy market is experiencing vast changes, based on the real time data of electrical consumption new avenue has been created. To ensure a balanced and reliable market the commitment for balance between electrical offer and demand is critical. To try and do this there are 2 ways that, initial is that the Supply-side Management that adds the accessibility once demand is high and therefore the alternative is DSM that curtails the system need as per the availability.

In offer Demand Side Management, it's impracticable to fulfil the demand because it takes a while for the unit to begin and meet the demand like a shot. So, to fulfil this growing demand the demand facet management will be enforced and additionally helps to economic balance. In DSM designing, implementation and watching of utility activities are provided to manage end users which will end in sizable changes within the utility's load form, i.e., modification within the time pattern and value of a utility's load.

For many years, Demand Response (DR) or Demand-Side Management (DSM) is being thought-about because the "Holy Grail" of competent power generation. For the classical orienting downside DSM is essentially recognized because the fruitful answer, those facts this power system will be designed to carry peak however not the typical demand.

Generous quantity of the system capability is wasted once demand fluctuates considerably over a period. the most effective aim of DSM is thus to interrupt the burden interval by victimization "splintering the crests" and "filling the cribs" or, in numerous words: to transfer as Associate in Nursing awful ton of the bendy demand as

possible far from peak time into intervals of lower pursuit. A dependable and resourceful approach would make rational for existing generation substructure without ill effect on load side. The system improves with weather parameter.
The conventional thanks to perform DSM is via rate incentives, i.e., by means that of lowering tariffs from time to time whereas the aggregative necessitate is expected to be at a lower place common, therefore on inspire the stop person to shift versatile lots nearer to those periods. thanks to generation barriers and absence of automation, such laws have up to currently been terribly coarse-grained and regularly static (e.g., "day-charge" vs. "night-charge"), as a minimum within the customer market the client marketplace.

3. Teaching Learning Based Optimization

The TLBO technique is predicated on the impact of the sway of a tutor on the product of aspirants in a very category. Here, output is taken into account in terms of output. The tutor is usually thought of as an extremely student World Health Organization (WHO) shares the data with the beginners. the standard of a tutor affects the result of aspirants. It is evident that a good tutor or mentor put hard efforts to improve the results. Moreover, beginners learn with collaboration more, which additionally improve the output.

Basic

Assume 2 completely different tutors, *T1* and *T2*, tutoring a theme with same curriculum to an equivalent benefit extent aspirant in 2 completely unlike categories.

Fig. 1 reveals the nature of marks scored by aspirant. Curves 1 and 2 represent the output by *T1* & *T2* tutors. With observation skewness nature has been showed.

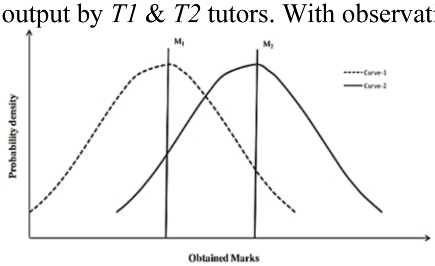

Figure 1. Distribution of grades obtained by the aspirants taught by of two different tutors

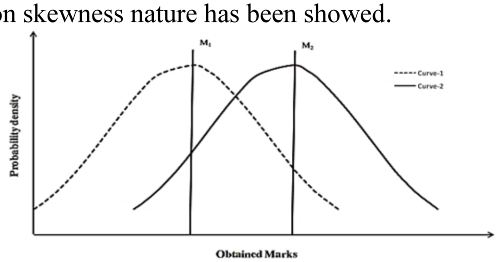

Figure 2. Model for obtained marks distribution for a group of aspirants.

It has been observed from Figure. 1 that curve-2 has more improved output than curve-1 and so it proves that tutor *T2* is better than tutor T1 in the form of coaching. The point which differs the output is mean (Curve-2 has *M2* and curve- 1 has *M1*), i.e., worthy tutor makes more impact when collaborative teaching approach is defined.

From figure. 2 represent that A-curve having mean M_A. Tutor is taken into account as a learned human and best candidate is mirrored like tutor, and this can be shown by tantalum the tutor efforts to unfold data among the aspirants which is able to successively increase the data level of the total group and facilitate aspirants to urge smart marks or grades. Therefore, a tutor will improve the mean of the category per his or her potential.

In tutor to move mean towards their own level in step with his or her potential, thereby increasing the aspirants' level to a brand-new *M2* mean. *T1* Tutor can place most effort into educating his or her students; however, students can gain data in step with the standard of coaching delivered by an educator and also the quality of aspirant's gift within the category. The standard of the aspirants is arbitrated from the average of all. Tutor *T1* work hard for improvement in the standard of the aspirants from *M1* to *M2*, at that stage the aspirants need a replacement tutor . Hence, the choice will be tutor *T2*.

Like different nature-inspired algorithms, TLBO is additionally populations primarily build technique that uses a population of answers to proceed to the world solution. As per TLBO algorithm is concerned, the population is taken into account as a bunch of aspirants or a category of aspirants.

In improvement procedures, the population be made up of varied vogue parameter. In TLBO, altogether totally different vogue variables square measure similar to different cases proposed and among which 'fitness' act as novel technique. The tutor is taken into consideration as a result of the most effective resolution as per the condition. Reveals the nature of marks scored by aspirant. Curves 1 and 2 represent the output by *T1* & *T2* tutors. With observation skewness nature has been showed.

The tutor is taken into account because the best answer obtained up to now. TLBO flow chart is as shown in Figure 3.

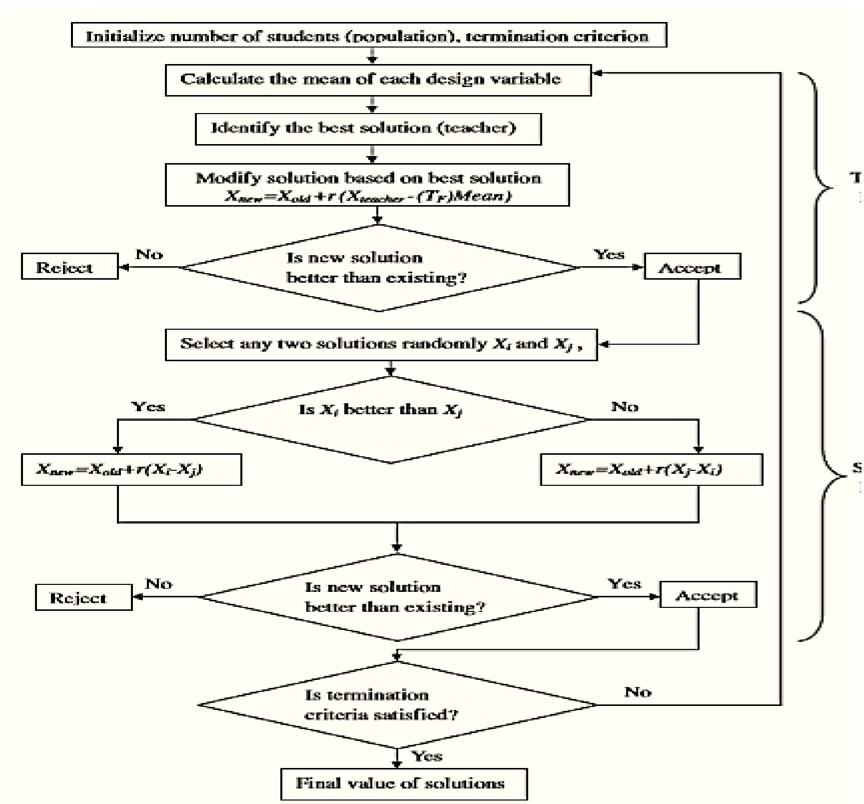

Figure 3. TLBO Flowchart

Tutor Phase

The tutor hard efforts result into improvement of M_1 mean (i.e. T_A) (to his or her level. However, a lot of its unfeasible and a coach can move the mean of the class house money supply to the opposite value cash in hand that's best than money supply relying on his or her potential of the class. This follows a random technique relying on varied factors.

Suppose M_j be the mean and T_i be the tutor at any i iteration. As per eqn.1, T_i selected as M_{new} and also the difference between the prevailing mean and new mean.

$$Difference\_Mean_j = r_i(M_{new} - T_F M_j) \qquad (1)$$

where, represent teach factor clarify the mean change, and is the random number in the range [0, 1]

Value of is either one or a pair of that may be a heuristic step or it's determined indiscriminately with equal likelihood as shown in eq. (2)

$$T_F = round[1+rand(0,1)\{2-1\}] \qquad (2)$$

The coaching issue is generated randomly as per eqn. 1-2, within which one corresponds to data level increment and a represent pass on of data. The in between values indicate quantity of transfer level of data. Basis on aspirant ability the transfer level of data is define. As per equation 2, one or two reckoning data is recommended. Consideration of 1-2 any price of T_F for *Difference_Mean*, the present resolution is updated as per equation (3)

$$X_{new,i} = X_{old,i} + Difference\_Mean_i \qquad (3)$$

Aspirants Phase

As per eqn. (3), the aspirant enhances their data by mutually interaction. As per system demand the interaction prevails cluster interaction for better output among aspirants. Additional data help for new learning.

Mathematically, it can be expressed as,

For i = 1: Pn

Randomly select another aspirant *Xj*, such that

$i \neq j$

if $f(X_i) < f(X_j)$

$X_{new,i} = X_{old,i} + r_i(X_i - X_j)$

else

X_{new}

$i = X_{old,i} + r_i\,(X_j - X_i)$

end if

end for

Accept X_{new} if it gives a better function value.

4. Problem Formulation

In this analysis work we tend to square measure reshaping the particular load curve just about objective load curve by minimizing peak demand supported the target the target as below.

A. Objective function

$load_i$ be the Initialization of load or load curve with forecasting. The advantage of this curve is depending upon the system the curve parameter will change. Implementation of DSM occurs when $load_f$ will be modified.

$$Minimize: f_1: max(load_f)$$

Consider $max\ load_f$ as load curve peak which will decrease within system.

For Optimization of final loaf curve function $load_f$ is created.

B. Constraints

Considering subsequent constrains for minimization problem in which area unit will be positive in all time instant for number of devices of any sort.

$$X_{kh} > 0 \qquad \forall\, k,h$$

5. Results and Discussion

The parameter values of TLBO improvement are listed in Table 1. In TLBO aspirant count (20) will be proportion to size of population, Subject count of 3 will be proportion to style parameter or variable, improvement ways of iterative variety will be 35.

Table 1. Parameter values for TLBO with DSM Technique

Parameter Value	
Parameter	Value
Ending Criterion	35
Subjects Count	3
Aspirants Count	20
Rand	0 to 1

The hourly forecasted load for the commercial area is shown in Table 2. The hourly Wholesale cost of electricity in cents/kWh. The time take daily based in hours and accordingly wholesale price is mentioned with respect to time. As shown in Table 3. Hourly forecasted load is given with respect to hours.

Table 2. Forecasted Load Demand and Wholesale Energy Costs of Commercial Load

Hour	**Wholesale Price**	**Hourly Forecasted Load**	**Hour**	**Wholesale Price**	**Hourly Forecasted Load**	**Hour**	**Wholesale Price**	**Hourly Forecasted Load**
1	12	923.5	**9**	16.42	1558.4	**17**	8.65	404
2	9.19	1154.4	**10**	9.83	1673.9	**18**	8.11	375.2
3	12.27	1443	**11**	8.63	1818.2	**19**	8.25	375.2

4	20.69	1558.4	**12**	8.87	1500.7	**20**	8.1	404
5	26.82	1673.9	**13**	8.35	1298.7	**21**	8.14	432.9
6	27.35	1673.9	**14**	16.44	1096.7	**22**	8.13	432.9
7	13.81	1673.9	**15**	16.19	923.5	**23**	8.34	432.9
8	17.31	1587.3	**16**	8.87	577.2	**24**	9.35	663.8

Figure 4. Shows Forecasted Load Hourly and Objective curve Load Hourly without DSM. Hourly forecasted load is at peak . The aim is to minimize hourly forecasted load to hourly objective load curve. This result obtained is without implementing DSM.

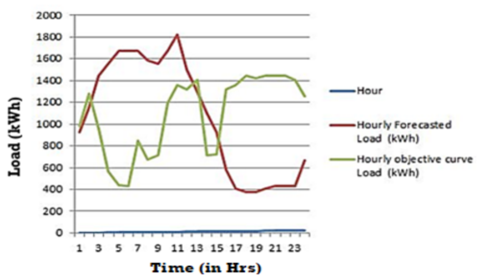

Figure 4. Forecasted Load Hourly and Objective curve Load Hourly without DSM

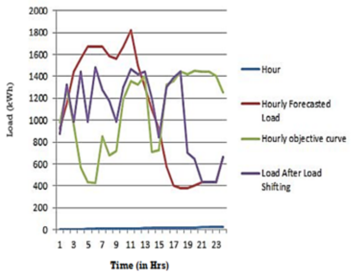

Figure 5. Forecasted Load Hourly and Objective curve Load Hourly with DSM

After implementing DSM, hourly forecasted load curve is altered as shown in Figure 5. There is a decrement of 353 kW considering difference of first & second row.

Table 3. DSM Strategy

Parameter Name	Value
Peak Load Without DSM	1818.2
Peak Load With DSM	1465.2
Peak Reduction	353
Percentage Reduction	19.41480585

6. Conclusion

Due to Demand Side Management the whole sensible smart grid, DSM is gaining a great deal. It decreases the excess power requirement during peak hours and also decreases the consumer utility bill. One of the unique features for future smart grid has been successfully implemented in this paper. For different sorts of commercial load TLBO methodology has an outsized variety significance for shifting of load. TLBO method can be used for residential and industrial consumers too.

It has been mathematically developed as a minimization downside. Mathematical approach could be considered as a minimization downside. TLBO algorithm has start off with minimization of peak demand and monetary benefits in utility consumption. The experimentation has done on commercial area load for smart grid.

References

[1]. Thillainathan Logenthiran, Dipti Srinivasan, and Tan Zong Shun, "Demand side management in smart grid using heuristic optimization," ‖ IEEE transactions on smart grid, Vol. 3 Issue 3 pp. 1244–1252, 2012.

[2]. Ishan Gupta, G.N. Anandini, Megha Gupta "An Hour wise device scheduling approach for Demand Side Management in Smart Grid using Particle Swarm Optimization," IEEE Transaction, pp. 4799-5141, 2016.

[3]. Dhanshri A. Narayane, Prof. Kishor C. Muley, "Statistical Study of Microgrid Based on Object Oriented Usability Indices," IJRECE Vol. 7 Issue 1 ISSN: 2348-2281 pp. 2350-2353, 2019.

[4]. Oprea, S.V. Bâra, A.; Ifrim, G., "Flattening the electricity consumption peak and reducing the electricity payment for residential consumers in the context of smart grid by means of shifting optimization algorithm," Vol. 122, pp. 125-139, 2018.

[5]. Lizondo, D.; Rodriguez, S.; Will, A.; Jimenez, V.; Gotay, J., "An Artificial Immune Network for Distributed Demand-Side Management in Smart Grids," Inf. Sci., Vol. 438, pp. 32–45, 2018.

[6]. Hussein Jumma Jabir, Jiashen the "Impacts of Demand-Side Management on Electrical Power Systems: A Review", Energies, Issue 11, Vol. 1050, 2018.

[7]. Q. Li and M. Zhou, "The future-oriented grid-smart grid," J. Comput., Vol. 6, Issue 1, pp. 98–105, 2011.

[8]. Rao, R.V., Savsani, V.J. & Vakharia, D.P, "Teaching-learning-based optimization: A novel optimization method for continuous non-linear large-scale problems," Information Sciences, Vol. 183, Issue 1, pp. 1-15, 2012.

[9]. Di Santo, K.G.; Di Santo, S.G.; Monaro, R.M.; Saidel, M.A., "Active demand side management for households in smart grids using optimization and artificial intelligence," Measurement, Vol. 115, pp. 152–161, 2018.

[10]. Rao RV, Patel V, "An elitist teaching-learning-based optimization algorithm for solving complex constrained optimization problems," Int J Ind Eng Comput Vol. 3, pp. 535–560, 2012.

[11]. Rao, R.V.; Savsani, V.J.; Vakharia, D.P., "Teaching-learning based optimization: A novel method for constrained mechanical design optimization problems," Comput.-Aided Des., Vol. 43, pp. 303–315, 2011.

[12]. Rao RV, Patel V, "An improved teaching-learning-based optimization algorithm for solving unconstrained optimization problems," Sci Iranica D Vol. 20, Issue 3, pp. 710–720, 2012.

[13]. Khan, B.; Singh, P. Selecting a Meta-Heuristic Technique for Smart Micro-Grid Optimization Problem: A Comprehensive Analysis. IEEE Access, Vol. 5, pp. 13951–13977, 2017.