International Journal of Engineering Technology Science and Research
IJETSR
www.ijetsr.com
ISSN 2394 – 3386
Volume 5, Issue 4
April 2018

Demand Side Management for Industrial Consumer: A Review of Worldwide Approaches

Sanket Gautam
Electrical engineering
MANIT , Bhopal
India

Tripta Thakur
Electrical engineering
MANIT , Bhopal
India

Abstract— *The requirement of demand side management (DSM) is basically to save cost directly or indirectly by applying different approaches. Various methods of optimizations are being implemented, moreover, DSM is integrated in the existing restructured electricity market and it is not linear as we can see by the approaches implemented till now. In addition to DSM base methods, integration of renewable energy is also done to make most out of it. This paper basically focuses on worldwide methods, aspects and research applied in DSM for industrial consumers so that we get better understanding and future work can be done upon this with suitability.*

Keywords— DSM techniques, Fuzzy logic controller, Load Factor, Peak Clipping

I. INTRODUCTION

DSM is the implementation of the process and also the monitoring of the activities of the utility to manage use of electricity according to time and load management according to it so as to get desired peak load reduction. Hence it has attracted all the related power sectors to work upon. Also, smart technology is playing a vital role in making is better. For example Advance metering infrastructure [1] .Hence better control and monitoring is being done by this.

The main benefits of DSM are cost reduction in generation, transmission and distribution infrastructure. Initially focus was on supply side (generation and transmission) management only i.e. methods used were from utilities side and consumer had to do nothing. But now new challenges are there on consumer side and various methods of optimization are being implemented to get better results. This paper emphasizes basically on the consumer end DSM and the new methodologies near around. If we consider scenario of INDIA 17 out of 29 states are deficit in case of Peak Demand Supply [2]. Hence DSM needs to be improved as it further enhances flexibility in power system, where flexibility refers to the management of energy supply balance in network. [3].

However network modelling is a limitation here and a different aspect that has to be dealt with some different scenario.

As we see basically these are the barriers in the implementation of DSM:

1. High cost
2. Technical barriers (High Efficiency of Appliances)
3. Incentive Up to pf 0.85 only
4. Lack of Subsidy .

II. INTEGRATION WITH RENEWABLES AND SMART GRID

The boost we got in implementing DSM is with the renewables and smart grid although we have to deal with 2 main challenges i.e. Variations and uncertainty. Variations are there in the form of fluctuations in the resource and uncertainty is the future scenario i.e. how to predict the future demand.

As we talk about renewable integration we consider the solar and wind energy that supports DSM at the time of peak demand. Hence the main consideration at the time of setup of RE is that range should be high so as to deal with the above two challenges. Hence the need to manage variability and to use forecasting it has become important to minimize unpredictability [4]. Taking the aspect of smart grid the role can be described by these factors:
1. Real time information of the equipment being

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ISSN 2394 – 3386
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used and their compatibility with out implementation module. 2. Two way networking and behavior of customer regarding this. 3 Integration of utility information systems 4.Regulatory changes with time. Smart grid has provided an aid in implementing operations along with reliability.

As we go in detailing, we found that there is focus on working and management of microgrid as we needed to reduce communication overhead. Two basic modules which we work upon are Distributed generation (DG) and distributed storage (DS). As already stated the importance of RE, it is also one of the associated aspect with it.

Figure 1. Benefits with smart grid and AMI [13]

DG comprises of small scale power generators, fuel cell, RES etc. [5] and DS consists of batteries, flywheels and pumped storage. DG solves the problems of transmission network at congestion. So it hits the main challenging area.

Also as far as observation is done from Indian context, DF (distribution franchise) has been a best mode for power distribution because of good effect in reducing loss [6]. Functionalities in the smart grid are AMI, PQM, OMS, PLM, and DG [8].

AMI- Advanced metering infrastructure

PQM- Power quality management

OMS-Outage management system

PLM-Peak load management

DG – Distributed generation

Further the PILOT Projects [8] approved in this context are shown as follows :

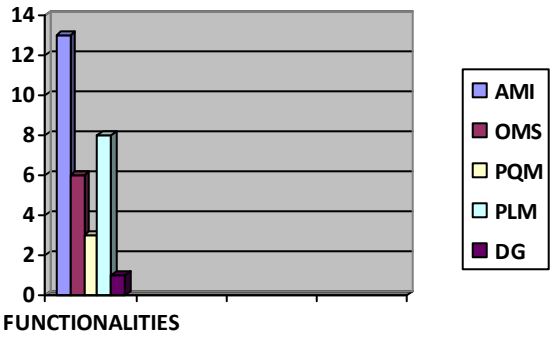

Figure 1.

III. MAJOR TECHNIQUES OF DSM FOR AN INDUSTRIAL CONSUMER

These are the techniques which are applied to the industrial consumer upon which work is being done [7]

(A). Differential Tariff

(B). Load priority and Load shifting

(C). Peak Clipping and Valley filling

(D). Strategic conservation

(E). End Use equipment control .

the load curve has peaks and valleys. So, the supplier is required to install the equipment which can meet the peak demand at consumers end. Also different incentives are given upon usage of equipment at off-peak time and also the punishment is announced if those are being used in peak time. So, rescheduling is required for achieving its result. This is basic overview of differential tarrif

A. Differential tariff

As the load is variable at consumer end in the industries hence the load curve has peaks and valleys. So, the supplier is required to install the equipment which can meet the peak demand at consumers end. Also different incentives are given upon usage of equipment at off-peak time and also the punishment is announced if those are being used in peak time. So, rescheduling is required for achieving its result. This is basic overview of differential tariff.

B. Load priority and Load shifting

In this technique the load is first divided into categories: interruptible and non-interruptible.

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After that the load is prioritized and the non-interruptible load is used as required and interruptible load is shifted to some other time slot so as to reduce peak and valleys in load curve. So for this to be done in the industries different modular sections are required to have close interaction.

C. Peak Clipping and Valley filling

In this technique, load reduction in the peak causes cost reduction and better operation. It is the key factor in DSM. It can be done by DLC (Direct Load Control). The main motive of peak clipping is to avoid costly extra generation and match demand – supply at normal generation.

As we talk about valley filling, the load cut in the peak clipping is operated in light time. It helps us to improve load factor as well as energy efficiency. Hence cost is reduced which is our main aim.

D. Strategic conservation

It is the shift between one type of supply to another with more favorable characteristics. According to this technique we conserve at light time and supply at peak time and taken into consideration the range the implementation of techniques is decided.

E. End Use equipment control

EUEC focuses on consumer side work i.e. proper usage of equipment for better utilization of policies of DSM and optimal use of resources without affecting generation and supply. This is one of the most active technique which is being focused upon and various tariffs are also there so that big industries help out in DSM implementation. This helps in flattening load duration curve and hence reduction in cost.

IV. METHODOLOGIES AND APPROACHES OF DSM

As we already saw the types of DSM, some approaches are required to achieve DSM.

- DSM through ANN (Artificial Neural Network) [12]
- DSM through fuzzy logic controller[7]
- DSM through Multi-objective Genetic Algorithm

1. Artificial Neural Network

It is actually based on connectionist approach to computation. It consist computational model which can be seen as interconnected group of artificial neurons and these neurons use this computational model. ANN or NN can be seen as adaptive system which performs according to the conditions and these conditions are basically information whether internal or external. This information exist in the network.

As we talk about the elements of ANN, the simple nodes are called neurons and these neurons are connected together to form a network of nodes called neural network. Earlier single-layer perceptron network was there which had single layer of output nodes and inputs were fed straightforward in a direct manner.

Next type is multi-layer perceptron which has multiple layer of computational units.

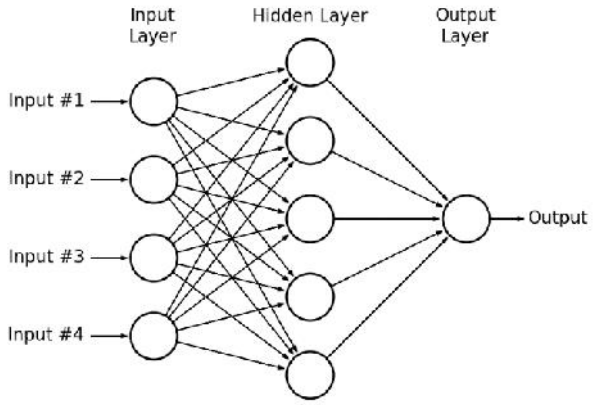

FIGURE 2. LAYOUT OF INPUT OUTPUT IN ANN

2. *ANN Load Controller*

Conjugate gradient back propagation algorithm is used in training of the network. It has input layer, one hidden layer and some output layers. Also it uses log sigmoidal transfer function for hidden and output layers which trains network by mean square error between the desired output and the actual output.

Basically the input of ANN model is load in kW and output switching conditions which can be operated to increase and decrease according to the requirement at peak and off-peak load. Hence it was seen that ANN model can be used very effectively for online controlling.

3. *Fuzzy logic controller*

It is the controller which takes some constraints as input on which the output depends. In our case, maximum times load and time is taken as input and power is taken as output. Apart from input and output some fuzzy rules are specified which make

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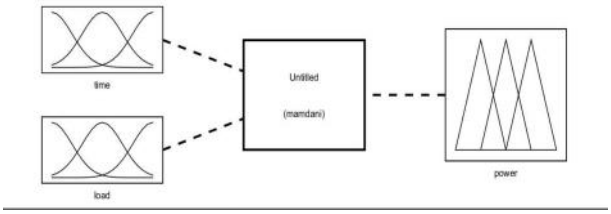
the process special. After taking input values, the controller fuzziest them, and a fuzzified control signal is assigned to controller



In this, we choose the most suitable membership function and these functions are needed for input and output and relationships between the rules are governed by them.

In DSM for industrial consumer, the triangular membership functions are best suitable. In DSM models, the fuzzy controller helps us to shift the peak of industry to the off –peak time. Hence we get a new profile after fuzzification. That helps us to get flattened load profile which reduces peak load demand and increased load factor, thus helping in getting our aim. In [10], we got to know that peaks got shifted after fuzzy controller from 100% to 90.84% which lead to effective DSM strategy.

WHY NEED OF FUZZY LOGIC CONTROLLER?

The disadvantage of ANN include highly computational burden, also delay along with system response and not so friendly with the end-user. [9]

Talking about fuzzy, it has fast calculation, less expensive construction, easily understandable, less complex as compared to others and highly flexible at the time of updation.

Also, FIS (FUZZY INFERENCE SYSTEM) can be even suitable for non-linear function, which increases efficiency for all kinds of complex problems. That's why FIS is better among all methods [9].

4. *Multi-objective genetic algorithm approach*

Earlier single objective of minimizing energy is not feasible for both user and utility. So, as complexity is more in the integrated system hence single objective approach won't be that effective and efficient. Multiple approaches are being used optimization and linear programming [11].

Hence in this method work is done by deploying the technique to minimize the consumer's electricity usage cost along with benefitting the utility as its load factor gets improved by this. Basically, normal distribution curve is used for regional distributions. Hence this technique is both generation management oriented and consumer oriented also. Here mutation and crossover strategies are emulated by application of various operators and fitness function is selected.

Multiobjective GA approach gives us better load scheduling by getting hourly loads near to its mean value, therefore reducing the standard deviation. This leads to improved load factor of consumer appliance giving more efficient working of device.

Further if we use time-based pricing model along with multi-objective approach and monitoring it by normal distribution curve method, we get even better results.

CONCLUSION

As it is seen from different approaches of DSM and by analyzing those methodologies and tools we need to explore some more areas which are unexplored. Although fuzzy logic controller and multi-objective approach are best methods we got but somehow it is required to several modelling tools which can integrate the benefitting part of methodologies along with integration of Renewable energy and DR deserves special attention as it consist of main part i.e., penetration of RE in big industries.

This future aspect of integrated modelling can unveil the more efficient system that will focus consumer as well as generation end along with renewable penetration and this will definitely be a much better approach for us .

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