Automatic Demand Response Controller with Load Shifting Algorithm using MATLAB Software

Ankush P. Dhansande[1], Pavan A. Pise[2], Chandan P. Takarkhede[3], Mayuri S. Nagapure[4], P. K. Khedkar[5]

[1,2,3,4]Student, P. R. Patil College of Engineering & Technology, Amravati, India
[5]Professor, Dept. of Electrical Engineering, P. R. Patil College of Engineering & Technology, Amravati, India

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***Abstract –** Load demand management in electric network is very important term to study to stable the load curve. For stability of load curve we have to manage the demand. The first objective of work is proposing customer collaboration model for electricity consumption cycle, for better limpidity between supply and demand. Another motto is to develop the load shift algorithm and make the mathematical modeling for that. This work can use for various load shaping objectives peak clipping, load shifting, valley filling etc. work provides consumer to have more choices for consumption which leads to better utility of consumer, it also gives generation with better load curve. In this work we make the model of 8 bus system in MATLAB for stability of load curve. After performing that we have more stable load curve. Hence we manage the load power according to demand response.*

Key Words: load shifting, Demand side management, Automatic load Controller, etc.

1. INTRODUCTION

Demand Side Management involves planning, analysis and implementation of utility activities to influence customer load shapes. Implementation of such a load shaping options as a load management, strategic conservation, and selective load growth can results in a efficient use of resources and reduced cost to both the customer and the utility. The most important problem with electric power today is energy efficiency and to manage the system with proper reliability it is very important to study and analyze the distribution system. Electric utilities have to deal with many such problems as high capital costs for installing new power plants and decrease in economical performance. By convincing the consumer to shift their load in off peak periods when their will be the situation of over loading this help us to minimize the energy cost for utility sectors and consumers. With help of load shifting algorithm we can shift the load to its convenience and it also will improve the reliability and stability of the system [1].

Demand management is not profound concept. When energy is expensive or the grid is approaching peak capacity, utility can simply shut down the power. It happened in California and it called rolling black outs [2]. For manage the power we have to reduce demand on grid, it is not easy and it is costly also. But using Modem control techniques there is way to perform demand management is called automatic demand response (ADR). ADR is the ability of buildings, home to lower electricity consumption in response to peak demand condition on the grid. Now Demand Management can be most efficient only when there is a high level of involvement from the source generating the demand, which in our case is the customers or the consumers, and this involvement is called Customer Participation. Through this, customers can become aware about their consumption level, can know the price they are paying and hence can take their own wise decisions to consume electricity efficiently and have more and more benefits in monetary terms, and also, because of the transparency that will creep in, the utility (satisfaction) level of customers can be raised to a very high point. Using load shifting algorithm we can shift the load up to its convenience and improve the load factor, which improve the stability of the system. Shifting of demand to reduce the peak and stable the variations can highly improve power system efficiency and huge savings.

1.1Concept

To create this study, we will propose an analysis of an intelligent net, with distributed production (DP). An operator manages the whole network and, therefore, we will call it the aggregator. As presented in figure 1, this network consists of residential, commercial and industrial customers. Some of these clients have energy production in units, which enabled some of these customers to enter into energy sales contracts with the aggregator. The aggregator also has a wind farm and a solar park giving it a significant energy production capacity.

Where:

1) Command Aggregator Center
2) Wind Farm
3) Solar Park
4) Industry
5) Trade
6) Customer with Production
7) Customer with DR
8) Customer without production and DR

Due to the high productive capacity, the aggregator wants to become as self-sufficient as possible. Thus, it intends to incorporate a system of Demand Response (DR) so that in periods when production approaches consumption (but it is not enough to satisfy all Demand) through DR, loads are under ballasted, reducing consumption to levels equal to those produced.

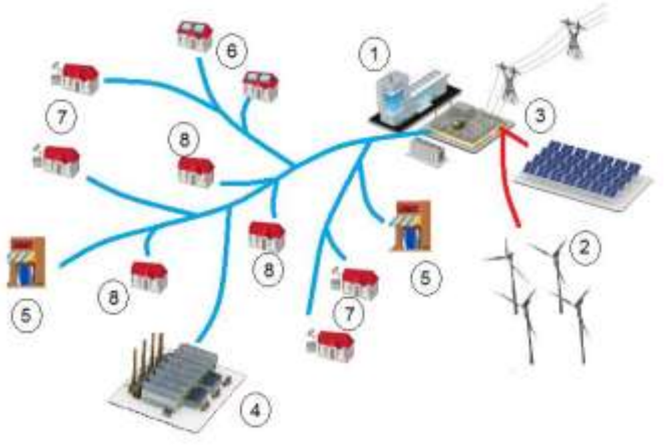

Fig. 1: Aggregator Smart Grid.

1.2 Demand Side Management

DSM is focused on minimizing peak load. End-users are willing to reduce their electricity bills but also to maintain comfort in this process. Waiting reflects user comfort for DSM, and it is desirable to keep it as short as possible. Expensive power generation can be avoided by shifting electricity usage from peak periods to off-peak periods. [5].

The LA receives time-varying price information from an advanced metering infrastructure (AMI) and sends the price with reserved appliance information to the demand response manager (DRM). The DRM receives the previous user pattern from the database (DB), and then the DRM sends an optimal scheduling result and rescheduling request to the load controller (LC). The LC also receives a real-time monitoring scheduling request. Moreover, in the end, the LC sends a signal that turns smart appliances on. Simulation in MATLAB 2016a shows that the load balancing algorithm shifts time to avoid peak load and reduce the electricity bill.

It can display actual consumption of the controlled load on the display interface, e.g. Local Display, Touch Screen and Web server. The user plugs a home appliance into the socket with the actuator creating a hierarchy of importance of the appliance used. In this example, during peak periods, the first device that disconnects is the oven, which is considered least important by the user. The second device that will disconnect is the washing machine and finally the microwave that is considered most important by the user. The user can reactivate the disconnected device by using the actuator push button or the touch screen. In this case, if a pick period still exists, the central unit will disconnect another load according to the hierarchy of importance of the used appliance that is set by the user [6].

2. METHODOLOGY

2.1 Demand Response (DR)

According to the Federal Energy Regulatory Commission, demand response (DR) is 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." It will be developed to reduce electric consumption or a on load peak period to off load peak periods depending on a consumer. Demand response activities are defined as "actions voluntarily taken by a consumer to adjust the amount or timing of his energy consumption". Actions are generally in response to an economic signal (e.g. energy price, or government and/or utility incentive). By developing demand response we can easily reduce the peak load demand or save electricity.

There are three type of demand response.
(1) Emergency demand response
(2) Economic demand response and
(3) Ancillary demand response

2.2Automatic Demand Response (ADR)

Demand Response (DR) is one mechanism which manages customer consumption of electricity in response to supply conditions, i.e. change in electricity usage by end users from their normal consumption pattern in response to changes in market prices, or when system conditions changes, or network reliability is jeopardized [1]. The system conditions include the price of production of electricity or the occurrence of any state which can lead the system into contingency. Demand response also includes actions taken by utility to respond to a shortage of supply for a short duration of time in future and response given by the consumers to the above actions.

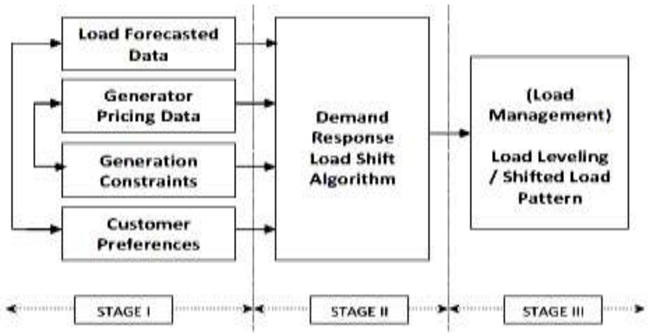

Fig.2: Basic working model of Automatic Demand Response

Fig.2 shows the working of the basic model of Automatic Demand Response (ADR). There are three basic stages in the model of Automatic Demand Response.

Stage 1:- involves taking in all the constraints and preferences from the generating side and the customer side. In this stage, the customer preferences are obtained from the load forecasted data, while the generator pricing data and constraints are fed to the DR program in Stage 2.

Stage 2:- is the taking in of all the inputs supplied at stage 1 and then performing load scheduling process according to the system constraints. In this stage, the load shifting algorithm of the DR using the four inputs from stage 1 provide a schedule and a shifted load pattern to the consumer.

Stage 3:- finally takes the shifted load pattern from stage 2 and dispatches appropriate signals to both the generating side and the consumer side respectively.

2.3Consumer Participation

A significant problem for most electricity markets in the world has been the lack of substantial, timely demand-side participation. While some jurisdictions have provided customers with a choice of suppliers, since most suppliers continue to offer fixed-price contracts and assume the risk of variations in wholesale costs, that choice is a very blunt instrument. Furthermore, many of those customer choices are not conscious, but rather are a consequence of automated controls triggered by temperature, time or motion. With the proper real-time price incentives many of those controls could be programmed with an Automated Demand Response (ADR).There are many issues involved in consumer's participation.

2.4 Energy Management Controller

The controller must operate by considering relevant parameters such as utility tariff and peak, off-peak times. The controller should able to connect to and get such information for intelligent coordination of distributed resources in a smart grid, particularly in competitive market environments. Local controllers should manage devices such as

- Distributed generation
- Storage
- Responsive load
- Smart switch controls

Together these components, under coordinated operation by the Energy management controller, (Master controller) assure continuous supply to critical loads while achieving economic operation of local sources (e.g., generation, storage, and responsive loads). The controller manages the operation of a portion of the power system to achieve customer-configured preferences. The controller has to coordinate the set points for local distributed generation and storage devices and provides an interface to the supply system for electricity market participation [7].

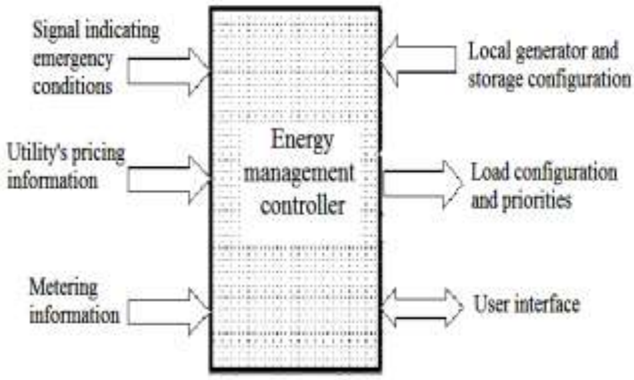

Fig 3: Energy Management Controller

4. WORKING

Demand Management can be most efficient only when there is a high level of involvement from the source generating the demand, which in our case is the customers or the consumers, also termed as Customer Participation. Through this, customers can become aware about their consumption level, can know the price they are paying and hence can take their own „wise decisions‟ to consume electricity efficiently

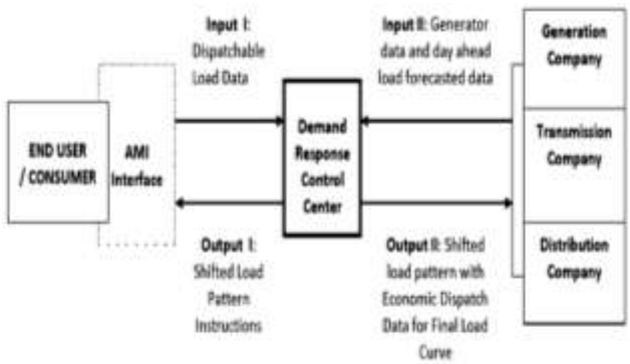

Fig.4: Block Diagram of proposed work

Fig.4 shows proposed model of automatic demand response. The data from the AMI is then sent as an input to DR control centre with/without AMI communication channel, and then processed with all the data collected from all the customers, along with the day ahead load forecasted curve, so as to have a new load curve which is much flatter and better than the previous one. DR control centre will then generate the consumption pattern signal for the AMI, and also the generation schedule for the generating units as outputs. Presently, the working of this process was been tested and implemented only for 24 hour day ahead scenario taking 1 hour as the least quantization of time, but it could be implemented for lesser time periods as well with appropriate modifications. The processing at DR control center involves, allocating the loads one by one to different hours according to total marginal cost of production at each hour and the hours within the run time limits so as to have the minimum total cost of production required for allocating that particular load. [5].

This data is taken to demand response control center through Advanced Metering Infrastructure (AMI), where this data, along with other data of system constraints is operated so as to have an optimum load schedule instructions to be sent back to AMI.

4.1 Model diagram

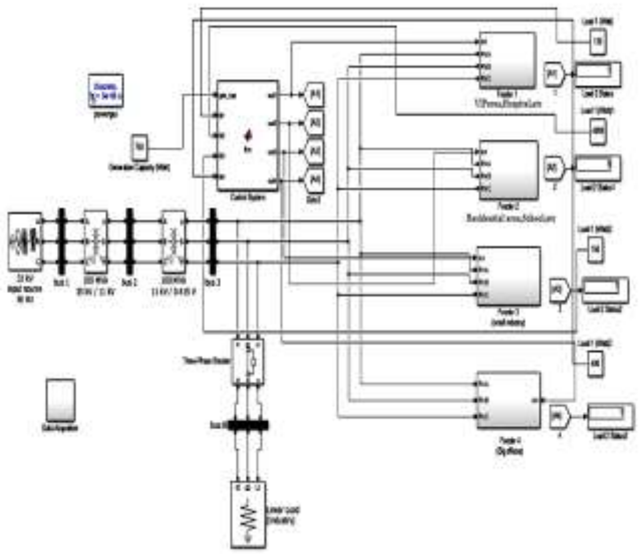

Fig 5: Main Simulation Model

4.1 Mathematical Modeling

Simulation process of load shifting algorithm
Step1:- Start.
Step2:- Monitor and collect generation capacity.
Step3:- Calculating demand from end user/customer.
Step4:- If total demand is less than generation capacity then all loads are **ON.**
%priority load shifted from load1 to load2 to load3 to load4.
Step5:- If load1is less than or equal to generation capacity and total load demand is greater than Generation capacity then load1 is **ON. (%base as load1)**
% shifted to load2.
Step6:- If remaining capacity is greater than load2 then load2 is **ON,** otherwise **Off.**
% shifted to load3.
Step7:- If remaining capacity is greater than or equal to load3 then load3 is **ON,** otherwise **Off. % shifted to load4.**
Step8:- If remaining capacity is greater than or equal to load4 then load4 is **ON,** otherwise **Off.**
Step9:- Else if load2 is less than or equal to generation capacity and total demand is greater than Generation capacity then load2 is ON. **(% base as load2)**
% shifted to load1
Step10:-If remaining capacity is greater than or equal to load1 then load1 is **ON,** otherwise **Off. % shifted to load3**
Step11:- If remaining capacity is greater than or equal to load3 then load3 is **ON,**
otherwise **Off. % shifted to load4**
Step 12:- If remaining capacity is greater than or equal to load4 then load4 is **ON,** otherwise **Off.**
Step 13:- Else if load3 is less than or equal to generation capacity and total demand is Greater than generation capacity then load3 is **ON.(% base as load3)**
% shifted to load1
Step 14:- If remaining capacity is greater than or equal to load1 then load1 is **ON**, otherwise **Off. % shifted to load2**
Step 15:- If remaining capacity is greater than or equal to load2 then load2 is **ON**, otherwise **Off. % shifted to load4**
Step 16:- If remaining capacity is greater than or equal to load4 then load4 is **ON**, otherwise **Off.**
Step 17:- Else if load4 is less than or equal to generation capacity and total demand is Greater than generation capacity then load4 is **ON.(% base as load4)**
% shifted to load1
Step 18:- If remaining capacity is greater than or equal to load1 then load1 is **ON**, otherwise **Off.**
% shifted to load2
Step 19:- If remaining capacity is greater than or equal to load2 then load2 is **ON**, otherwise **Off.**
% shifted to load3
Step 20:- If remaining capacity is greater than or equal to load3 then load3 is **ON**, otherwise **Off.**
Step 21:- Else if each load is greater than generation capacities then all loads are **Off.**
Step 22:- Else total load is less than generation capacity then all loads are **ON.**
Step 23:- Stop.

5. CONCLUSION

We conclude that this model is very efficient and important for the consumer and also for the utilities. Because day by day, load shedding problem occurred in many of the area, we cannot fulfill the demand of last consumer and maximum losses present in area. That's why we discussed, analyzed and surveyed the distribution system and made this model. This model is beneficial for consumer and economical. This model very effective, useful and easy to handle. It is seen that many accident happen in distribution system while shifting the load. In this model load shifting is automatic so there is no chance of accident. When load shifting is applied to the peak hours is utilized in the valley hour. The load shifting model is very effective used in peak time. If one feeder is having maximum load as compare to other feeder then that load is shifted to other feeder.

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