AUTOMATIC DEMAND RESPONSE WITH LOAD SHIFTING ALGORITHM USING MATLAB SOFTWARE

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ABSTRACT

Power management in micro grid is very important term to understand to stable the load curve. For stability of load curve we have to manage the demand. For manage the load (demand) we use demand response. The first objective of work is proposing customer participation model for electricity consumption cycle, for better transparency between supply and demand. Another objective is to develop the load shift algorithm and make the mathematical modeling for that. After applying it on different systems check the value of load factor. This work can use for various load shaping objectives peak clipping, load shifting, valley filling etc. work provides customers to have more choices for consumption which leads to better utility of consumer, it also provides generators with better load curve. In this work we make the model of 6 bus system in MATLAB for stability of load curve. After performing that we have more stable load curve. Hence we manage the power according to demand response.

KEYWORDS: *Customer participation model; Load shifting algorithm; Automatic demand response; dispatchable load; non dispatchable load*

I. INTRODUCTION

Demand management is not profound concept. When energy is expensive or the grid is approaching peak capacity, utility can simply shut down the power [1]. 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 n 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. With managing demand we make the power management at input side. To meet supply and demand is very challenging term. Utility company required more generation, transmission and distribution to full fill the peak demand which is grater then average demand. In result it is very costly because of low load factor and underutilized most of time. As example, 55% is US national load factor,10% of generation and 25% of distribution facilities are used less than 400 hours per year,5% of the time[1]. Shifting of demand to reduce the peak and stable the variations can highly improve power system efficiency and huge savings. The other techniques improving efficiency and reducing cost is to fill the supply. Renewable sources like solar and wind power steadily rises, supply of power become is time-varying. To match the supply with demand becomes more effective

and common way to improve system stability, efficiency and cost reduction. Apart from above reasons the major factor which influence the efficiency is customer participation. The demand curve is unstable which proves the inefficiency of system. Customer participation model proposed to highly load profile consumers. Medium and large scale industries required manual control because it is not fully automatic. System requires the flat load curve, take care of mismatch of supply and demand which involves the consumers at each level for domestic to large scale industries for more transparency to improve the consumer satisfaction. So we can improve the efficiency and stability with implement of customer participation and automatic demand response. Objective of the work is proposing the consumer participation model for them in electricity consumption cycle. So that it has better transparency between supply and demand. Second objective is to develop load shifting algorithm to shift the demand for improving the reliability, efficiency and stability. Also we can improve the load factor and reduce the cost. This work used for various load flatting objective like peak valley filling load shifting. This method provides better choice and economic utility for consumers. This is starting step of ISO (Independent system operator) in looking into level of distribution network for demand response. This method can be applied for more number of buses which improve the load factor of the system and also increase the efficiency of the system. Also we can reduce the cost by managing the demand, so we can make the load curve stable.
The paper is organized as: Theory of demand response, Customer participation model, Classification of load, Load shifting algorithm, Results and explanation

II. DEMAND RESPONSE

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

2.1 Consumer 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.

2.2 Classifications of Loads

There are two types of loads

(1) Non-dispatchable load and
(2) Dispatchable load

From their expected consumption, consumers reduced in the consumption in electricity. It used to refer to peak clipping emergency measures and was confined to a limited number of hours per year.

Below are the example of dispatchable load and non dispatchable load. Dispatchable load example: Washing machine, Agricultural motors, Inverters, ACs, Microwave, Plug-in Hybrid Vehicles (PHEV), Refrigerator, Flour mills, Pumped storage, Industrial Machines' shift, Dish washer etc.

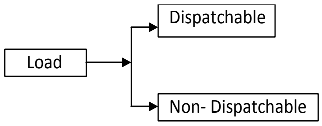

Figure. 1 Types of loads for demand response period

There are two type of demand response loads.

(1) Dispatchable demand response
(2) Non-dispatchable demand response
Dispatchable demand response includes direct load control of customer appliances (e.g., air conditioning and water heating), directed reductions in return for lower rates (interruptible rates), and a variety of wholesale programs offered by RTOs/ISOs that compensate participants who curtail load when directed. **Non-dispatchable demand response** is also referred to as the "retail price-responsive demand" in which customer decides whether and when to reduce consumption based on a retail rate design that changes over time, e.g., dynamic pricing programs.

2.3 Modeling of Consumer's Participation Based on The Automatic Demand Response

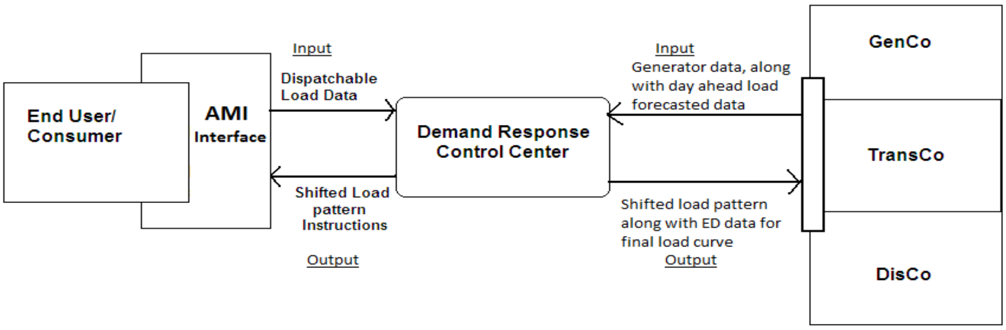

Figure 2. Conceptual Model for Automatic Demand Response

Below some point are given which are considered to developed model of automatic demand response.

(1) Day ahead load forecasted curve
From the given total load forecasted curve, calculation of forecasted curve for non-dispatchable loads has been done assuming the ratio of total dispatchable load to total load, at each hour, constant i.e.

TOTAL LOAD (TL)= NON-DISPATCHABLE LOADS (NL) + DISPATCHABLE LOAD (DL) (1)

$$\frac{DL_t}{TL_t} = \frac{DL_{total}}{TL_{total}} \quad (2)$$

Where, DL_t =DISPATCHABLE LOAD AT HOUR t

TL_t = TOTAL LOAD AT HOUR t

DL_{total}=TOTAL DISPATCHABLE LOAD FOR THE DAY

TL_{total}= TOTAL LOAD FOR THE DAY

(2) Generator limits and it's fuel cost data

$P_{gi,min}$ And $P_{gi,max}$ can deliver once they are chosen and switch ON after the unit commitments. These 2 data are used to perform the economic dispatch for the given load level at P_{gi} each hour.

Cost Fun. of a Generators is given by:

$$F(P_{gi}) = f_c({}^{\gamma}{}_iP^2{}_{gi} + {}^{\beta}{}_iP_{gi} + \alpha_i),\ such\ that\ P_{gi,min} \leq P_{gi} \leq P_{gi,max} \quad (3)$$

WHERE ,

f_c REPRESENTS THE FUEL COST

(3) customer preference data for the dispachable loads

All consumers used below data for dispatchable load and all are shown in figure 3

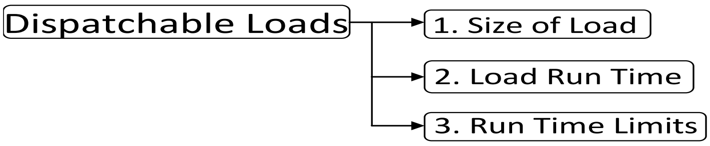

Figure 3. Parameter of Dispatchable load

III. ALGORITHM OF AUTOMATIC DEMAND RESPONSE

Taking above given values, we need to distribute the dispatchable loads according to consumer preference, so as to have a flatter load curve and to have minimum incremental cost of generation at allocation of each dispatchable load. Represented in Fig 4.

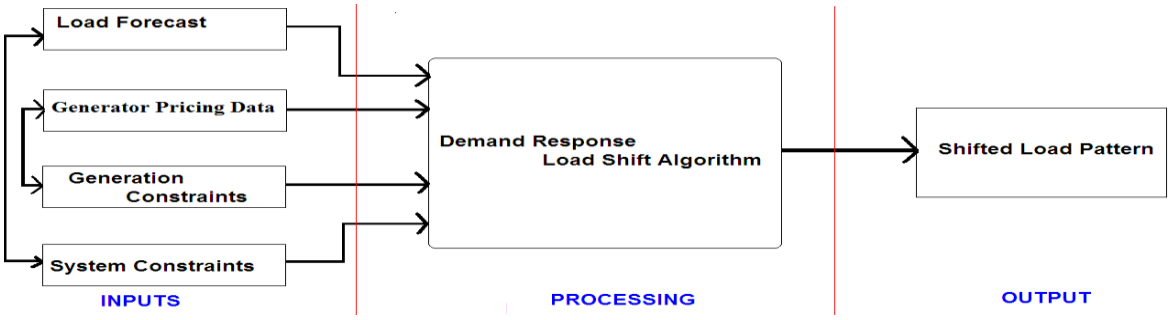

Figure 4. Basic Input / Output Model for Customer Side ADR

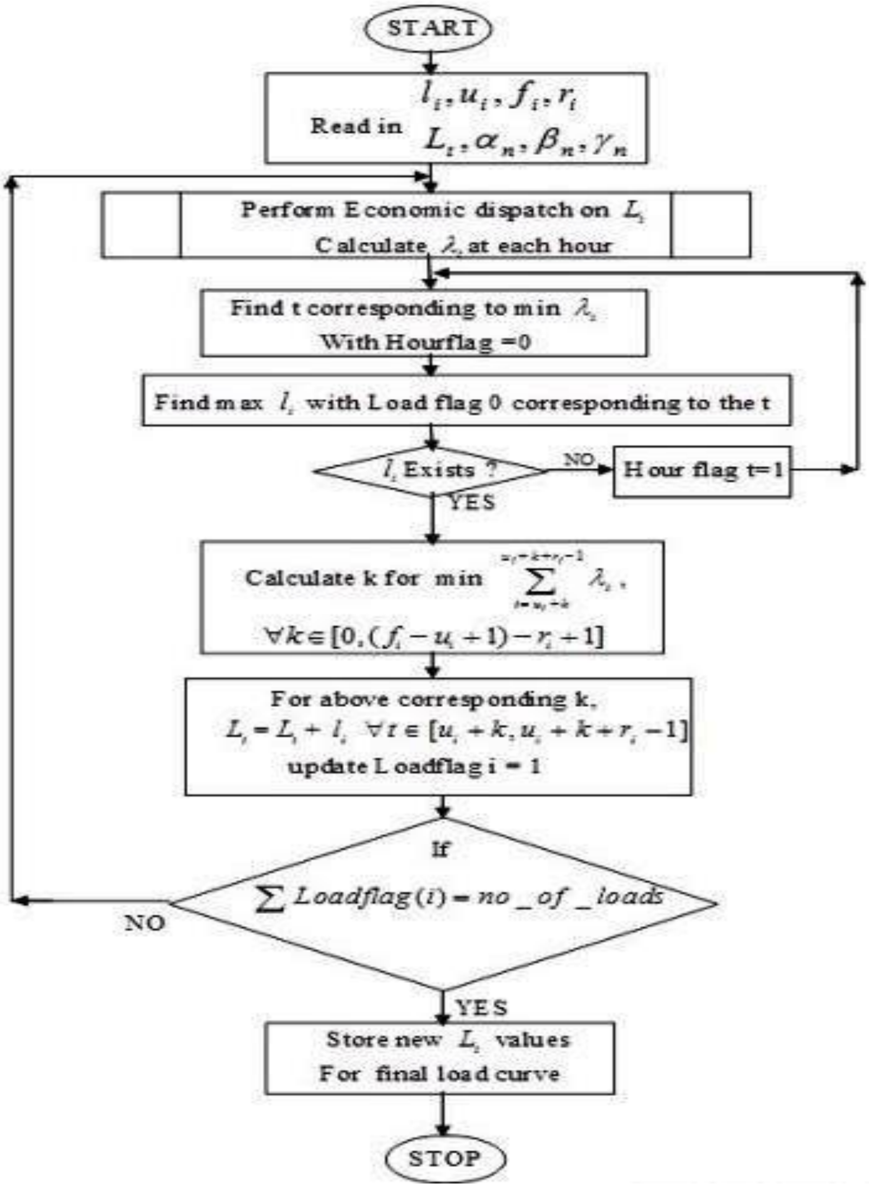

Figure 5 Algorithm of AD

IV. ECONOMIC LOAD DISPATCHES IN THE POWER SYSTEM

For profit maximization, economic operation is most important for power systems. If our power system gains maximum efficiency than it reduces the unit power cost to the customer and also reduces generating cost of power for the company. Economic dispatch is one type of method for determining the most efficient and reliable operation of the power system. The main objective is to minimize the total cost of generation.

$$F(P_{gi}) = f_c({}^{\gamma}{}_{i}P^2{}_{gi} + {}^{\beta}{}_{i}P_{gi} + \alpha_i) \quad (4)$$

Where,

$F(P_{gi})$ = cost of producing power at generator *i*

α_i, ${}^{\beta}{}_i$, ${}^{\gamma}{}_i$= Constants

f_c= fuel cost

The generating unit has incremental fuel cost denoted by, which is defined by

$$\lambda_t = \frac{dF(P_{gi})}{D(P_{gi})} = 2^{\gamma}{}_i P_{gi} + {}^{\beta}{}_i \quad (5)$$

There are represented in the form of lower and upper bounds of the power generated at the Unit.

$$P_{gi,min} \le P_{gi} \le P_{gi,max}$$

Where,

$P_{gi,min}$ and $P_{gi,max}$ = minimum and maximum limits imposed on the real power output of the generator at the bus.

Power balance constraints:

The power generated has to meet the power demanded and the transmission loss imposed by the network.

$$P_D = \sum_{n=1}^{k} P_{gi} \quad (6)$$

Where,

$P_D = \sum_{n=1}^{k} P_{gi}$ = total power received by the loads

The objective fun. Is the sum of the generating costs at each plant.

$$F = \sum_{i=1}^{k} ({}^{\gamma}{}_i P^2{}_{gi} + {}^{\beta}{}_i P_{gi} + \alpha_i) \quad (7)$$

The economic dispatch problem is to minimize the total generating cost under the above mentioned constraints.

V. RESULT OF 6 BUSES, 3 GENERATOR SYSTEM

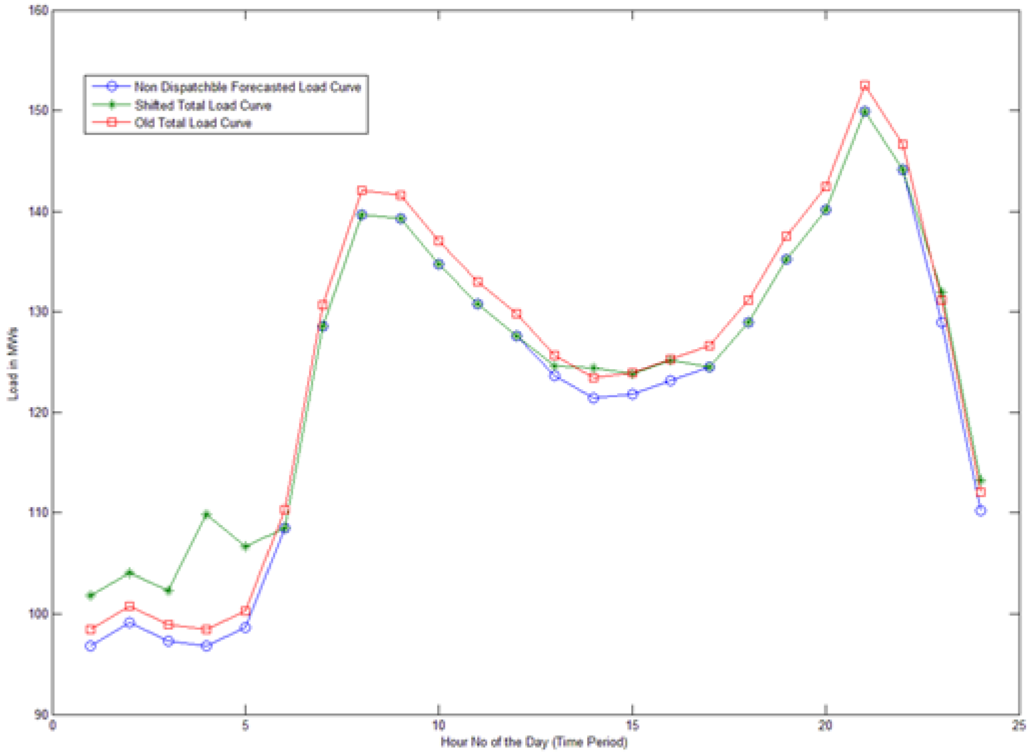

Table 1 Data of Six bus and three Generator System

HOUR	INITIAL LOAD(MW)	FINAL LOAD(MW)	GENERATOR 1(MW)	GENERATOR 2(MW)	GENERATO R 3(MW)
1	98.48	101.84	50	35.82	16.02
2	100.76	104.07	50	37.56	16.51
3	98.94	102.29	50	36.16	16.12

4	98.49	109.84	50	42.06	17.77
5	100.30	106.63	50	39.55	17.04
6	110.28	108.44	50	40.97	17.47
7	130.71	128.53	50	56.66	21.86
8	142.06	139.68	50	60	29.68
9	141.60	139.24	50	60	29.24
10	137.07	134.78	50	60	24.78
11	132.98	130.76	50	58.41	22.86
12	1290.80	127.63	50	55.97	21.67
13	125.71	124.62	50	53.61	21.01
14	123.44	124.39	50	53.43	20.96
15	123.90	123.83	50	53.00	20.83
16	125.26	125.17	50	54.04	21.13
17	126.62	124.51	50	53.53	20.98
18	131.16	128.97	50	57.01	21.96
19	137.51	135.22	50	60	25.22
20	142.51	140.13	50	60	30.13
21	152.50	149.95	50	60	39.95
22	146.60	144.15	50	60	34.15
23	131.16	131.97	50	59.35	22.62
24	112.10	113.23	50	44.71	18.52

The load levels of initial load more than 98 mw and final load more than 100 mw. Generator 1 operates on 50 mw load which is its maximum limits, while generator no. 2 operates at its maximum capacity for few hours. But every hour variation occurs at generator no. 3. At generator no. 3 variation occurs, so operating cost come down.

Table 2 Allotted Start Hour for Various Loads

Load number	**Load value, l_i (*10 W)**	**Up time u_i**	**Down time f_i**	**Duration r_i (hours)**	**Allotted star hours**
1	5	1	10	4	1
2	8	2	12	2	4
3	3	10	24	2	23
4	2	12	20	3	14
5	1	8	16	2	13

Table 3 Comparison between new load curve and old load curve given in below table for six buses.

	Maximum load(MW)	**Minimum Load(MW)**	**Hour for Maximum load**	**Hour for Minimum load**	**Average Load(MW)**	**Std devn.**	**Load Factor**
Six bus (new)	149.95	101.86	21	1	125.00	13.88	0.83
Six bus (old)	152.50	98.5	21	4	125.00	16.5	0.82

VI. CONCLUSION

By using automatic demand response we fit the load curve by shift the demand with the help of load shifting algorithm. We make the load curve more stable than the old one, as well as we improve the efficiency of the system and also improve the load factor. Hence we can manage the power by using automatic demand response. In this work we make the programming for different system and according to that we had been seen that we can improve the load factor which improves the efficiency.

VII. FUTURE WORK

By using demand response we can manage the load or we can shift the load and make load curve stable. This can be used in the controller of smart meter which improves the efficiency of system.

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BIOGRAPHY

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