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Dynamic pricing strategy for demand response management in smart grid

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Abstract:

As per the flat tariff rates we have been utilising each and every electronic gadgets at the same cost per unit for the whole day, due to this we are not aware about the genuine price for the distribution and the generation of the electricity. The strategy of dynamic pricing is a key for this issue, in which a customer is charged with different rates contingent on the curve of demand response. Many of the latest studies which are related to the dynamic pricing of electricity are being limited to block rating where the price per unit for electricity increments or at times diminishes after utilizing a specific amount of electricity. Even though the electricity utilization of every customer is not equal, yet at the same time the effect of increasing cost because of load fluctuation in case of peak hours influences every customer to the same extent. So to overcome this we are recommending a different dynamic pricing modelling with the help of which the expanded cost would be shared with those consumers, who really take an interest in destabilizing curve of demand response, but not with those users, whose utilization of electricity is almost minimum or underneath normal.
Keywords— **Tariff, Demand response, Dynamic pricing, Load balancing , Smart grid.**

I. INTRODUCTION

Smart Grid is the most recent trend for dealing with the current electric power grid infrastructure alongside creating an automated energy delivery network with the assistance of smart meters to facilitate two-way communication of electricity amongst consumers and suppliers [1][2]. Out of all the main functionality of smart grid, demand response management is one of the significant function, as it provides the communication between the supplier and consumers, which thus, enables consumers to make decisions with respect to their energy utilization, and causes the supplier to decrease the peak load demand and reshape the load profiles [3]. Electricity markets generally offer a flat tariff structure to consumers because of this, consumers are generally unconscious of the genuine cost of generation and distribution of electricity while utilizing their gadgets. Although flat tariff rates offer vulnerability free electricity bills to customers regardless of the gadget utilized or time-of-utilization, it might require expensive capacity addition keeping in mind the end goal to meet the load balance of demand and supply of electricity, the greater part of which are environmentally harmful. Dynamic tariff structures have the potential to flatten demand profiles and along these lines help power suppliers to diminish expenditure on capacity addition and efficiently enterprise electricity generation and distribution .There are distinctive types of dynamic pricing that can be offered to diverse markets and customers. Estimating of demand, furthermore, demand price relationship assume an essential part in determining prices and aides in scheduling load in dynamic pricing environment. Dynamic tariff likewise give each consumer with a chance to lessen his/her electricity bill at a consistent consumption level just by shifting load for a specific time duration of the day when the cost is high [4]. Since the generation of electricity relies on numerous variable sources, subsequently the total generation isn't stable. Contingent on the total accessibility of the electricity for any day, the regulation of costs for a specific day or time should be set [5]. The adjustments in pricing should also be reflected to the smart meters ahead of time, so that consumers can be aware of the high/low costs before utilizing their electronic gadgets [6]. A one-pioneer, N-supporter model utilizing stackelberg Equilibrium can be utilized to give optimal energy demand for every gadget [7]. In case of peak hours, there can be a two way communication between the electricity supplier and users with the goal that user can transfer their unused power back to the supplier so as to adjust the demand supply load [8]. Electricity prices can be extensively classified into two sorts - Static prices that don't change with change in demand and dynamic prices that change with changing demand situation. Different pricing schemes as specified underneath are portrayed by [12-15].

A. Flat Tariff

Price remain static despite the fact that power demand changes. Consumers under such a scheme don't confront the changing cost of power supply with a change in aggregate demand. Consequently, consumers have no monetary incentive to reschedule their energy utilization. They don't confront any threat of high esteem power bills for any unavoidable or impulsive electricity utilization. Consequently this strategy is frequently utilized as a welfare pricing scheme.

B. Block rate tariffs

This strategy differentiates between customers in view of the amount of electricity utilization. The scheme comprises of different levels represented by the degree of consumption. Inclined rate schemes increment the Per-unit rate with increasing consumption and declining schemes do the inverse.

C. Seasonal Tariffs

These strategies observe different rates in various seasons to coordinate the varying demand levels between seasons. Energy is charged at a higher rate during high demand seasons and the price lowers amid low demand seasons.

D. Time-of-utilization (TOU) tariff

These are pre proclaimed tariffs changing amid the different times of the day, that is, high during peak hours and low amid offpeak hours. Such strategies can remain viable for short or long terms. This is otherwise called time-ofday (TOD) tariff.

E. Super peak TOU

It is like TOU but the peak window is shorter in duration (around four hours) in order to give stronger price signal.

F. Critical peak pricing (CPP):

This is a pricing strategy in which consumers are charged a high fixed rate amid peak hours of the day and discounted rate amid rest of the day. It gives an extremely strong price signal and upgrades the decrease of excessive peak load.

***G. Variablepeak pricing** (VPP)*

This is very analogous to CPP with the main contrast that the peak prices are not fixed, and alter from day to day. The consumers are informed about such peak prices in advance.

H. Real time Pricing(RTP)

This is the purest form of dynamic pricing and the strategy with the most extreme vulnerability or threat involved for the consumers. Here the prices change at consistent interims of one hour or less and the purchasers are made attentive of the prices in advance according to the design of the strategy. The alteration in prices in little interims builds the proficiency of the pricing strategy in reflecting the genuine expenses of supply, yet such plans require advanced technology to communicate and deal with these regular changes.

II. LITERATURE SURVEY

Despite the fact that the exiting power system require solid information and communication infrastructure, an alternate and complicated approach is utilized for smart grids, since it works on a larger dimension [1]. Authors address important issues on smart grid technology utilizing information and communication technology (ICT) issues as well as opportunities. The author gives a glimpse at the present scenario in smart grid communication. As indicated by [2], smart grid are utilized to make an automated and distributed network of delivery utilizing smart meters to permit two-sided flow of information and in addition electricity between energy suppliers and consumers. [3] Proposed a generic day-ahead demand side management (DSM) procedure for forthcoming smart grid. In this paper, author makes utilization of load shifting to be utilized by smart grid central controller. Objectives of the demand side management are boosting the amount of renewable energy source assets being utilized, minimizing power obtained from main grid,and bringing down peak load demand. While in [4], demand response strategy of the second sort was considered. Here author concentrated on a particular sort of dynamic pricing known as the day-ahead hourly pricing (DAHP). Under DAHP, the hourly retail prices of electricity are set one day ahead of the actual consumptions, thus giving a price certainty to consumers. DAHP additionally permits day to day adjustment of retailer prices. Additionally, the interactions between a retailer and its customers are also analysed.Authors of [5] specified smart pricing is one of the most proficient technique among DSM tools which can help consumers to consume sensibly. With the expansion in energy prices,users take part in DSM programs and make an endeavour to transfer energy consumption schedule of highload household appliances to off-peak hours to limit cost. In this, authors gave another approach for DSM to expend energy proficiently to accomplish social goals. In any case high computational capacity makes it hard to accomplish them, if all appliances of consumers have joint schedules. Along these lines a top-down approach is given to control it. In [7], author has proposed a regulation pricing index and after that developed a Vickrey-Clarke-Groves system to initiate egotistical operators to genuinely report their private valuations and expenses of regulation. While in [8], author proposed another procedure for load shaping, where a consumer is encouraged to draw a specific quantity of energy (i.e., portion) from the grid. At the point when the actual energy demand is digressed from the quota, the consumer is challenged with a higher electricity cost. With the assistance of energy storage, the consumer can draw less electricity from the grid at a lower cost by discharging energy when the demand is higher than the quota and draw greater electricity from the grid at a lower cost by charging energy when the demand is lower than the quota. In [9], author proposed a demand response algorithm in view of real time pricing for accomplishing optimal load control of devices, A one-pioneer N-devotee Stackelberg diversion is utilized to capture the interactions between them. Linear optimization approach is utilized to decide the real time price. In [10], author proposes a real time price (RTP)- based demand response (DR) algorithm for accomplishing optimal load control of devices. While [11], built up an integrated DR (IDR) program for multiple energy carriers fed into an energy center in smart grid. In this model, the IDR program is formulated for the electricity and natural gas network. The interaction among the S. E. center hubs is demonstrated as an ordinal potential game with unique Nash equilibrium. In [12],[13],[14],[15] the terms identified with dynamic pricing design like TOU, CPP, RTP, flat tariff… .is well described.

III.OBJECTIVE

Different methodologies have been discussed above about the dynamic pricing which, if applied, will influence each consumer similarly regardless of their monthly electricity utilization. We must also take into consideration that the electricity utilization of every individual are not same. There are some consumers whose monthly electricity utilizations is above the average while on the other hand there are some consumers whose use is underneath the average as they barely utilize the appliances which devours substantial amount of electricity. During the peak load we should not increase the price for the consumers whose monthly electricity use is absolute minimum since they are not devouring the amount of electricity which may change the load profiles at any time. Peak load are generally caused by the appliances which consumes a greater amount of electricity which isn't utilized by every class of individuals. We must design the dynamic pricing strategy in a way where the hike in price is shared among just those consumers whose electricity usage is extreme however not whose electricity utilization is absolute minimum. Electronic devices plays a crucial part in the demand response load balancing. We should outline our plan in a way so the gadgets which expend substantial electricity ought to be charged more when contrasted with the one which utilizes less energy. The greater part of the consumers don't utilize overwhelming appliances and thus they must not be sharing the expanded price raised because of the consumers of substantial appliances.

IV. METHODOLOGY

As talked about above, since there can be different sort of electricity consumers so we have ordered them into different classes in light of their monthly electricity consumptions. We have also divided the 24 hours of a day into different time slots lastly we have sorted the appliances utilized in home into three unique classes in light of its power consumptions.

TABLE I
SEGMENTATION BASED ON CONSUMPTION

Class	Consumption
A	1500-2500
B	1000-1500
C	500-1000
D	300-500
E	200-300
F	00-200

We have also divided the 24 hours of a day into different slots as this peak load capacity remains idle amid off-peak periods bringing about lost in opportunity cost and system efficiency. Viable scheduling of electrical load can help consumers to lessen their electricity bills by expanding consumption when prices are low and lessening consumption when prices are high.

TABLE III
TIMES SLOTS OF THE DAY

Slots	Timings
1	6:00-10:00AM
2	10:00AM-4:00PM
3	4:00-11:00PM
4	11:00PM-6:00AM

Legitimate scheduling of devices consumption in a dynamic pricing environment can flatten the load curve to a huge extent. Henceforth we have sorted the appliances in light of its consumptions.

TABLE IIIII
CATEGORIZATION OF APPLIANCES

Appliances Category	Consumption
Heavy	1500-3000
Medium	500-1500
Low	0-500

Consumers need to choose their class before they can utilize electricity using smart grid. The information of the consumers will be stored at the time of installation of the smart grid. The current pricing for a specific hour will rely upon the class of consumer, time slots and the category of appliances being used.

TABLE IVV
DYNAMIC TARIFF SCHEME

Consumer		Price(Per unit)/hour			
Class	Device	Slot1	Slot2	Slot3	Slot4
X	Heavy	P1	P2	P3	P4
	Medium	P5	P6	P7	P8
	Low	P9	P10	P11	P12

An effective algorithm is required to deal with the pricing system in a way where the surplus amount could be distributed according to the excess utilization in case of peak hours. The algorithm should also take care of TOU before it can decide the real time price[p1… .p12] for a specific hour.

V. AREAS FOR FUTURE RESEARCH

There are interesting future research challenges that develop from this investigation. These are noted in this area.

- Understanding the customer's willingness to adopt dynamic tariffs can be extremely useful for further progress in this field. Dynamic prices have never been experienced in numerous electricity markets. Such markets can provide interesting research opportunities for finding consumers' willingness to-pay for electricity inside a dynamic pricing environment. Results from such investigations can help in promoting the plan to more number of consumers and providers.

- Smart grid technology can empower automated scheduling of household load. Automation is conceivable with the advancement of scheduling algorithms. Researchers can keep on growing more realistic scheduling algorithms with various goals for various consumers. On the technological side, the sort of enabling technology required in a specific market and the technological and monetary learning for the same can be studied.

VI. Conclusion

The discussion in this paper reveal the significance of dynamic pricing of electricity and its influence on demand response. The development and testing of empowering technologies is a progressing procedure and there are a several studies that reveal the convenience of such technologies. We highlight some future research opportunities in this field at the end of our study. This paper can help in drawing the attention of policy makers and electricity markets players to the benefits of dynamic and modified pricing, demand mapping, segmentation for electricity markets and automation technologies.

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