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Smart Grid System -Tariff Based

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Abstract — ***This Paper investigates the concept, implementation, and impact of Tune of Day tariff and other tariff based incentives / disincentives. The paper covers specifically following points. Design of 'Time of the Day' (ToD)/ 'Time of Use' (ToU) tariff structure for industrial consumers encourages consumers to shift their energy usage. Under To D tariff, consumption during different hours (period) of the day is charged differently. All the consumers are not aware about this type of tariff structure.***

1. Detail study of ToD tariff structure applied to different industrial consumers and its effect. 2. Study of different incentives/disincentives given to these consumers such as power factor incentive, load factor incentive, power factor penalty etc. 3. Approach of ToF towards this tariff structure. The cost incurred by utility for this purpose is recovered from different consumers by applying a suitable tariff. Load curve of Indian utility is peaky in morning and evening hours. Differential between demand and supply is increasing day by day. Naturally cost of generation will also increase in order to meet the peak demand. To reduce this difference it is necessary to shift the load of certain consumer categories to off peak hours. The demand for electricity in India is increasing every day. As per consumer demand, utility is required to generate, transmit and distribute electricity among different consumers. The major load on utility system is industrial, and hence if industries would take initiatives for flattening the load curve by shifting their loads from peak hours to off peak hours, it will be profitable to both, utility and industry. To motivate consumers towards this goal is a challenging task.

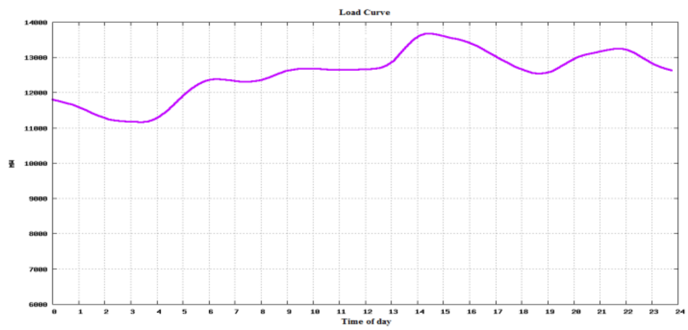
Keywords - Off-Peak Load, Smart Grid , Demand Side Management, Peak Load, Tariff Incentives And Disincentives, Smart Tariff,

I. INTRODUCTION

In order to encourage the consumers to take active part in load shifting (load curve flattening) technique, some demand side management(DSM) programs are required to be implemented. DSM involves co-operative action by the utility and consumer to modify the consumer load curve resulting in savings to the consumer, utility and society. Also load leveling would result in improved capacity utilization. Demand of electricity is increasing every day. Also there is large variation in demand at different time periods of the day. The load curve of Indian utility normally has morning peak and evening peak. Differential between demand and supply is increasing day by day. In this scenario, in order to meet peak demand, if generation capacity is increased, the cost of generation will also increase. In an existing shortage situation, the peak power available is significantly costlier than off peak power and availability of power during peak hours is also limited. For reducing the cost of generation, it is necessary to reduce burden on the system and hence steps are to be taken for flattening of the load curve i.e. to distribute the load (power demand) evenly through out the time period of the day. Load leveling could be promoted by use of one of tariff related DSM options like time of day/time of use tariff (ToD/ToU) in which consumption during different hours (period) of the day is charged differently. The major load on utility is industries and hence industries have to take major part for flattening the load curve. ToD tariff structure is hence implemented for industrial consumers. Switching from flat rate tariff to ToD tariff, it is possible to have reduced electricity bill provided industries take benefit of this tariff structure by suitably modifying their load pattern. In order to reduce cost of power and to create awareness among consumers about such tariff structure, it is necessary to study overall philosophy behind ToD/ToU tariff structure. The paper specifically covers the tariff structure. The paper describes the concept, implementation, and impact of ToD tariff on utility's load curve, approach of regulatory commission towards this tariff structure.

II. TOD A KEY DSM OPTION

Load curve of the Indian utility varies from different time periods of the day. A typical load curve of Gujarat is shown in. fig 1



Based on the results of this HT consumer survey, if peaking power generation plants are built they remain idle for the off peak periods and do not earn returns during those hours. Hence the cost of this option to reduce the peak load should be taken in account before building such plants. Alternatively shifting peak load to off peak hours can produce desired result. This can be done by some DSM options in which one of the options is *ToO/*TaU tariff. The results of the survey shows that if DSM programs are implemented, utility saves money in terms of operating costs of fuel for power generation and investments are saved through reduced new capacity requirements. Out of all DSM programs considered in the above study, ToD was found to be the major contributor in savings. They also pointed out in survey results that the tariff needs to deal with at least eight hours duration of off-peak hours and not more than three to four hours of peak period. A suggestion was made by the group that the maximum demand charges should reflect the cost of demand at least in peak period and therefore there should be different demand rates for different time periods.

Results of the survey also show that due to implementation of this tariff to industrial consumes, industries would get reduced electricity bill, Some industries could shift there production in night time period, and shift industries who have their production in two or three shifts, could change their shift timings in order to get ToD tariff benefit in their electricity bill. Results further show that if sufficient incentives are provided to them, and if some awareness programs are arranged then more amount of load can be shifted from peak to off peak time period. Load leveling would result in improved capacity utilization and also results in sufficient flattening of the load curve. From their analysis, consumers would save 2,235MW of power out of which 761MW power can be saved due to ToD tariff which acc~nts for one third of the saving i.e. 34.1% of total saving.

III. TOD TARIFF

Construction of new power generation plants and supply the power at reasonable cost are the limiting factors of Supply Side Management, hence introduced ToD tariff structure for the first time in all HT industrial consumers.

In this type of tariff structure, had introduce 5 slots of a day in which units for different time periods of day will be charged at different rates. Commission introduced some charges along with base charges in this design. It means that along with the base rate tariff for per power consumption there is some concession provide commission for every unit power consumption in night period from 10 pm to 6am (off peak time). and use of peak during morning and evening time periods i.e. from 9 am 1 pm (morning peak) and 6 pm to 10 pm (evening period industries would have to pay extra charges for each remaining time span, rates are base rates. This type of structure would encourage the industries to shift their from morning and evening peaks to off peak time period to get them reduced electricity bill and also to get new flatten load curve.

While implementing this type of tariff for HT consul commission adopted following approach:

HT tarifff in order to bring tariff closer to the average cost of supply; HT tariffs required to be reduced. The average HT tariff (compare both demand and energy charges) was higher than the cost of supply, and the demand charges do not reflect the fixed incurred in supplying electricity and the energy charges considerably higher than the variable cost of electricity supply hence the commission had started different tariff compare with their respective costs. Accordingly there was increase demand charges while decrease in energy charges for a consumer categories.

To restructure HT tariff, the commission intended toward 'ToD' tariff as a critical tool for DSM

Commission expected HT industrial consumers to aware this facility by shifting consumption from peak to off peak period. This would not only be beneficial for industries but also helps in flattening the load curve.

The increase in demand charges increases the electricity bill of the consumers hence commission helped the industrial consumers in shifting the demand and in flattening the demand curve. Therefore, the Commission had decided and revised the definition of billing demand.

It is seen that various large scale industries are going for capative power generation, as well as some consumers entered in to open access. This created pressure on commission as well as on utility to lower the tariff so as to attract more number of consumers towards the implementation of the ToD tariffs commission has increased the difference in the ToD rates from peak and off-peak times.

Along with implementation of ToD tariff to HT consumers, commission also provided them some incentives such as power factor and load factor incentives and disincentives such as power factor penalty. Some of them as applicable in tariff order are describe as follows:

A. *Power factor incentive*

Whenever the average power factor is more than 0.95, an incentive given is at the rate of 1% of the amount of the monthly energy pill (excluding Fuel adjustment cost, demand charge. and electricity duty) for every 1% improvement in the power factor above 0.95. For PF of 0.99, the effective incentive amounts to 5% reduction in the energy bill. For unity and leading PF effective incentive would be maximum 7% reduction in the energy bill.

B. *Loadfactor incentive*

Consumers having load factor in between 0.75 to 0.85 are entitled to a rebate of 0.75% on the energy charges for every percentage increase in load factor from 0.75 to 0.85. Consumers having a load factor above 0.85 are given a rebate of 1% on the energy. charges for every percent increase in load factor from 0.85. The total rebate for this is subjected to a maximum of 15% of the energy charges for that consumer.

C. *Power factor penalty*

Whenever the average PF is less than 0.9. penalty charges shall be levied at the rate of 2% of the amount of the monthly bill including energy charges. for the first 1% fall in the power factor below 0.9. beyond which the penalty charges shall be levied at the rate of 1% for each percentage point fall in the PF below 0.89.

IV. ANALYSIS OF TOU TARIFF

The ability to implement a profitable TOU rate option is not unique to this situation. Any region with a high differential between the peak marginal cost and the off-peak marginal cost, and the average rate between the two levels, has the potential for a profitable TOU rate option. In hot climate and high usage of air conditioning, but another area, even one that is winter peaking and driven by another end-use such as heating, could potentially have a profitable TOU rate option. However, the opportunity would be reduced in moderate climates that do not have a sharp marginal cost peak above the customer's average rate.

Table 1 shows the TOU rates and marginal cost for each TOU period. During the on and partial-peak periods the TOU rate exceeds the standard residential rate, thus inducing customers to reduce consumption during the high marginal cost TOU periods. Since the TOU rate is less than the marginal cost in on-peak periods, this reduction leads to utility cost savings. In addition, since the off-peak rate is lower than the standard residential rate, customer's bills are reduced in the off-peak period.

Since there can be extremely hot days when peak demand spikes sharply, the TOU rate option contains a dispatch energy charge of max/kWh, which could be applied during very high cost hours by sending a signal over the network to each customer's smart meter.

Table 1
TOU rate option design

TOU period definition	Marginal cost (Rs/kWh)	TOU rate (Rs/kW
On-peak: 4–5 pm (weekdays, Jun–Sep)	8.25	7.35
Partial-peak: 1–4 pm and 6-7 pm (weekdays, Jun–Sep)	9.45	5.25
Shoulder: 1–7 pm (weekdays, Oct–May)	1.20	3.15
Off-peak: Remaining hours	1.20	2.50

V.LOAD IMPACT

The survey results indicate that customers change their consumption behavior in response to the high on-peak and partial-peak rates. The customers make the change by programming without adversely altering their lifestyle. This led us to believe that the TOU rate option can shift consumption from the high-cost periods to the low-cost periods. The results from a regression analysis of the load data confirmed our belief.

Fig. 2 reports the average summer weekday and weekend load shapes with and without the TOU rate option in place. A customer with the rate option has a higher load during hours outside the on-peak and partial-peak periods and a lower load during the on-peak and partial-peak periods. This confirms the survey result that customers program the air conditioning to pre-cool their house before the high-price hours begin and to remove heat build-up during the low-price hours. The comparison also shows that customers use more energy on the weekends when the low off-peak TOU rate applies. A reduction in the load of non-participating residential customers, as well as a reduction in commercial and industrial load, offset this effect in the area. Proper design of the TOU rate that considers the impact on the total area load can minimize the rebound problem.
Fig. 3 shows the TOU option's weekday impacts computed from Fig. 1 as the difference between: (1) the load profile without the TOU rate option in place; and (2) the load profile with the TOU rate option in place. Fig. 3 shows that the average impact is 1.95 kW during the onpeak hour, which is larger than those reported. This finding can be attributed to: (1) the large price differential between the on-peak rate and the off-peak rate; and (2) customers' response through programming the operation of their air conditioners.

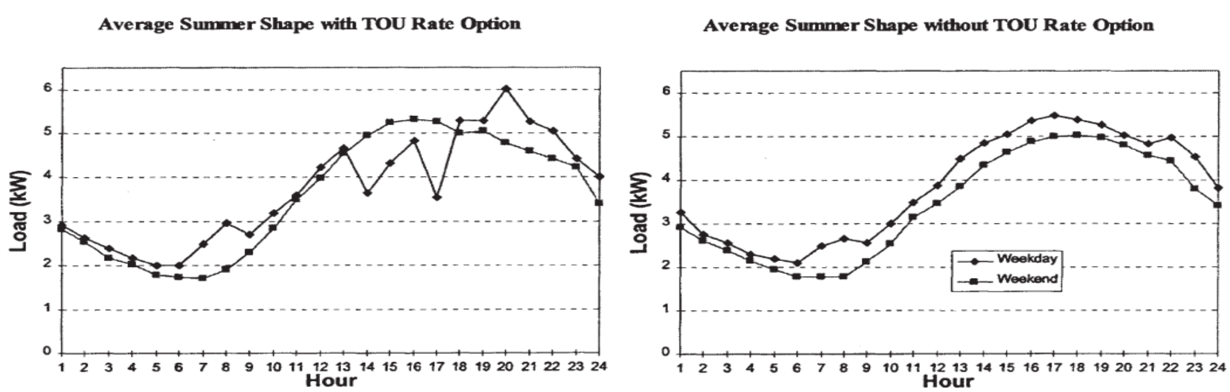


Fig. 2. Comparison of load shape with and without TOU option. The lines with the diamonds indicate the weekday load shape (kW) and the squares indicate the weekend load shape (kW). The chart on the left shows the average summer shape for customers with the TOU rate option, and the chart on the right is the average of customers without the TOU rate option.

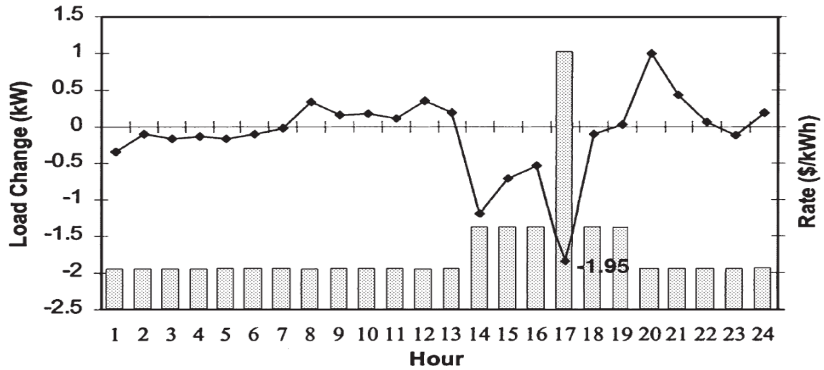


Fig. 3. Load impacts and TOU rates per customer on average. The line indicates average load change of participants (kW) and corresponds to the left-hand axis, and the bars indicate TOU rate ($/kWh) on the right-hand axis.

The high average peak load reduction seen in Fig. 3

VI. FINANCIAL IMPACT

Customer response to the TOU rate option financially affects both customers and the utility. We compute the bill savings of an average customer as a weighted average of the difference between: (1) the bill without TOU rate option in place; and (2) the bill with TOU rate option in place for each of the customer segments. We also compute savings to the utility. It is the weighted average of the difference between: (1) the incremental cost serving the before-TOU load; and (2) the incremental cost of serving the after-TOU load. The option's effect on the utility's profit is the cost savings less the bill savings.

Table 2 summarizes the energy savings and financial impact of the TOU rate option. The TOU rate option produces a net of 107 kWh of energy savings per year per customer. Consumption is higher during off-peak periods, and lower during on-peak periods. The customer's annual bill savings are 3850rs and cost savings to the utility is 6700rs per customer. This results in an annual gross profit of 2850rs per participating customer.

Table 2
Summary of economic impacts per customer

Figure 1.	Figure 2. sum mer	Figure 3.	Figure 4.	Figure 5. winter	Figure 6.	Figure 7.
Figure 8.	Figure 9. Peak	Figure 10. Part ial peak	Figure 11. Off-peak	Figure 12. Shoul der	Figure 13. Off-peak	Figure 14. Ann ual total
Figure 15. Ener gy savings (kWh)	Figure 16. 171	Figure 17. 219	Figure 18. (304)	Figure 19. 100	Figure 20. (79)	Figure 21. 107
Figure 22. Bill savings (Rs)	Figure 23. (3550)	Figure 24. (230 0)	Figure 25. 9600	Figure 26. (2050)	Figure 27. 215 0	Figure 28. 3850
Figure 29. Cost savings (Rs)	Figure 30. 3800	Figure 31. 330 0	Figure 32. (400)	Figure 33. 100	Figure 34. (100)	Figure 35. 6700
Figure 36. Utili ty profit (Rs)	Figure 37. 7350	Figure 38. 560 0	Figure 39. (100 00)	Figure 40. 2200	Figure 41. (225 0)	Figure 42. 2850

VII. CONCLUSION

First, the utility can realize additional cost savings from automatic meter reading and other services such as customer messaging, outage and tampering detection, and remote activation of service which are possible once a smart meter is installed. Second, the utility can charge the participating customers a portion of the program cost. Third, the utility can use the program to enhance its customer relationships, thereby retaining the customer if deregulation and retail access should occur. Finally, state regulators often allow the program costs to be passed on to all customers. As well, legislation on deregulation and competition often provides funding to promote DSM programs

The small financial risk, however, should not discourage a utility from offering a program for several reasons.

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REFERENCES

[1] Potuganti Prudhvi, Dhruv Bhalodi, Manikant Manohar, Vamshi Padidela, Sudarshan Adapa "A Smart Energy Meter Architecture in Indian Context" in IEEE-2012

[2] Anmar Arif, Muhannad AI-Hussain, Nawaf AI-Mutairi, Essam AI-Ammar,Yasin Khan and Nazar Malik "Experimental Study and Design of Smart Energy Meter for the Smart Grid" in *IEEE-2013*

[3] Kamat V.N. Dr. On the Implementation of an Appropriate Tariff System for better Energy Management in Rural and Urban Areas , 1997.

[4] Fawzi Al-Naima and Bahaa Jalil "Building a prototype prepaid electricity metering system based on RFID" in *International Journal of Electrical Engineering,ISSN:2277-7040*, volume 1, Issue 1

[5] Nabil Mohammad, Anomadarshi Barua and Muhammad Abdullah Arafat, "A Smart Prepaid Energy Metering System to Control Electricity Theft" 2013 International Conference on Power, Energy and Control

[6] National Electricity Policy. [Online). Available: http://"www.powermin.nic.in/indian_electricity_scenario/national_electricity_policy.htm

[7] B.Rajesh kumar, G.kiruthika,"RFID Based smart grid with Power Factor Maintenance in Load Side" international journal,vol.2,special issue 1,March 2014

