Demand Side Management: A Survey of SPT & TOU

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Abstract : Modern power system have large amount of generation from fossil fuels which provide high degree of reliability and sustainability but produce carbon and pollute the environment from green-house gasses. Distributed generation (DG) is the best alternative to reduce such problems but DG installations have their own problems of reliability and installed near consumer end need bidirectional power flow. Smart grid provides the solution by controlling the power consumption through Demand Side Management (DSM). Demand Side Management (DSM) is much needed requirement to control the consumption at distribution side, objective of the paper is to compare the two latest technologies of DSM through literature review, which are Time-of Utilization (TOU) and Stepwise Power Tariff (SPT). TOU is the methodology used to reduce the difference between peak and normal hour power consumption and STP is divided the power consumption in several parts and reduce the cost. Both these methodologies are used together for better results as future scope.

Index Terms **– demand side management (DSM); time of utilization (TOU); stepwise power tariff (SPT); renewable energy sources (RES); DG's; demand management**

I. INTRODUCTION AND MOTIVATION

Consumption of electrical energy is increasing day by day, all the consumers take the advantage of electrical equipments for their luxury and time saving property of equipment's. Worldwide electricity consumption will estimate to escalate by 93 % from 20.2 TkWh (Trillion kilowatt hour) in 2010 to 39 TKWh in 2040. Most of the energy is generated by fossil fuels but emit CO2 and green house gasses. Introduction of distributed generators (DG's) are give the way to reduce the problem of environmental pollution created by fossil fuels. Generation of energy from DG's is increasing and to manage the generation and consumption in smart manner need a smart grid. The smart grid is an intelligent node that can operate, interact and communicate to make the power system efficient and procure economical energy for their consumers [2]. To get the more flexibility in operation microgrid is introduced. A microgrid is cluster of small scale controllable and non-controllable micro size generating sources connected at consumer end [3]. To properly utilize and to save the energy, demand management (DM) is needed. The objective of demand management is to embolden the consumers for shift their load to normal generation hours from peak hours. DM can be classified into 2 main categories demand response (DR) and demand side management (DSM) Demand response is compassionate method to encourage the consumers to demonically shift their electric demand as per the signals provided by utilities, such as emergency request. Mainly this technique is used in emergency or used to avoid blackouts. Other side DSM is an approach has the objective to make our consumers energy efficient for long term. DSM can be designed to control the electricity consumption of individual users. Demand can be managed by reducing the cost of electricity during low load period but if all consumers shift their load in low price duration unfortunately a new peak is generate during normal hours [4]. Electricity consumption is charged as per the flat rate tariff, various tariff arrangements are available to encourage the society to reduce the cost such as TPT (Two Part Tariff), TOU (Time of Use) and SPT (Stepwise Power Tariff) etc. TPT divides the overall tariff into two parts, capacity price and energy price it enhanced the load rate and reduce the difference between peak and normal load [5]. TOU is an impressive model to eliminate the peaks it is an effective method of DSM (demand side management) [6]. The approach encourages the consumers to manage their load from peak to normal hours and reduce the peak hour duration [7]. SPT demarcate the electricity consumption into various step based on constraints and give the premium for different consumers [8].

II. SYSTEM MODEL

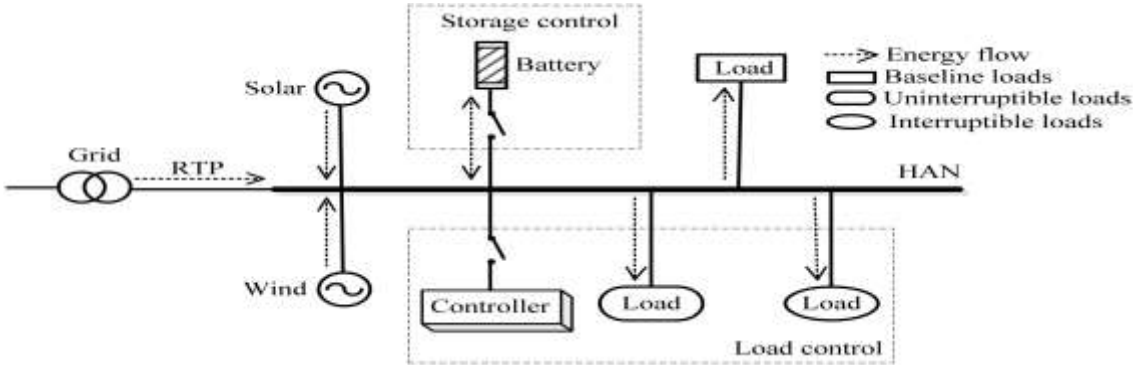

Fig-1 Domestic energy system with DGs and Storage (Ref.-9)

The renewable energy sources such as small scale solar and wind based generators will supply to consumers at vary less per unit cost. Fig 1 illustrate the household model of energy generation and consumption consist of DG's i.e. solar and wind generation, storage units, and domestic appliances such as washing machine, refrigerator, air conditioner under demand side management.

Operation patterns can be categorized into three types Baseline load, uninterrupted loads and interrupted loads. Baseline loads are not properly scheduled and required immediate supply whenever is needed such as lighting, uninterrupted loads can't be stopped once they started such as dish washer, refrigerators and interrupted loads can be interrupted and any instant of time such as air conditioners [9]. The basic requirement of the real time pricing is to schedule the slots of all loads properly but the limitations of the methodology is that it need the online support at all instance to aware the consumers.

III. STEPWISE POWER TARIFF

STP is also called progressive electric tariff system. Electricity consumption from different loads is divided in N number of steps which include the electrical appliances worked in one step and unit price charge for that particular step. The objective function of SPT is to maximize the energy saving during a day. If average peak is generated at 6 o'clock in the evening the interrupted loads will manage at different times of extra stored energy is supplied during these hours. The method will finalize the cost of consumption based on constraints, if the DGs are used as constraints consumer will aware about the DG installation.

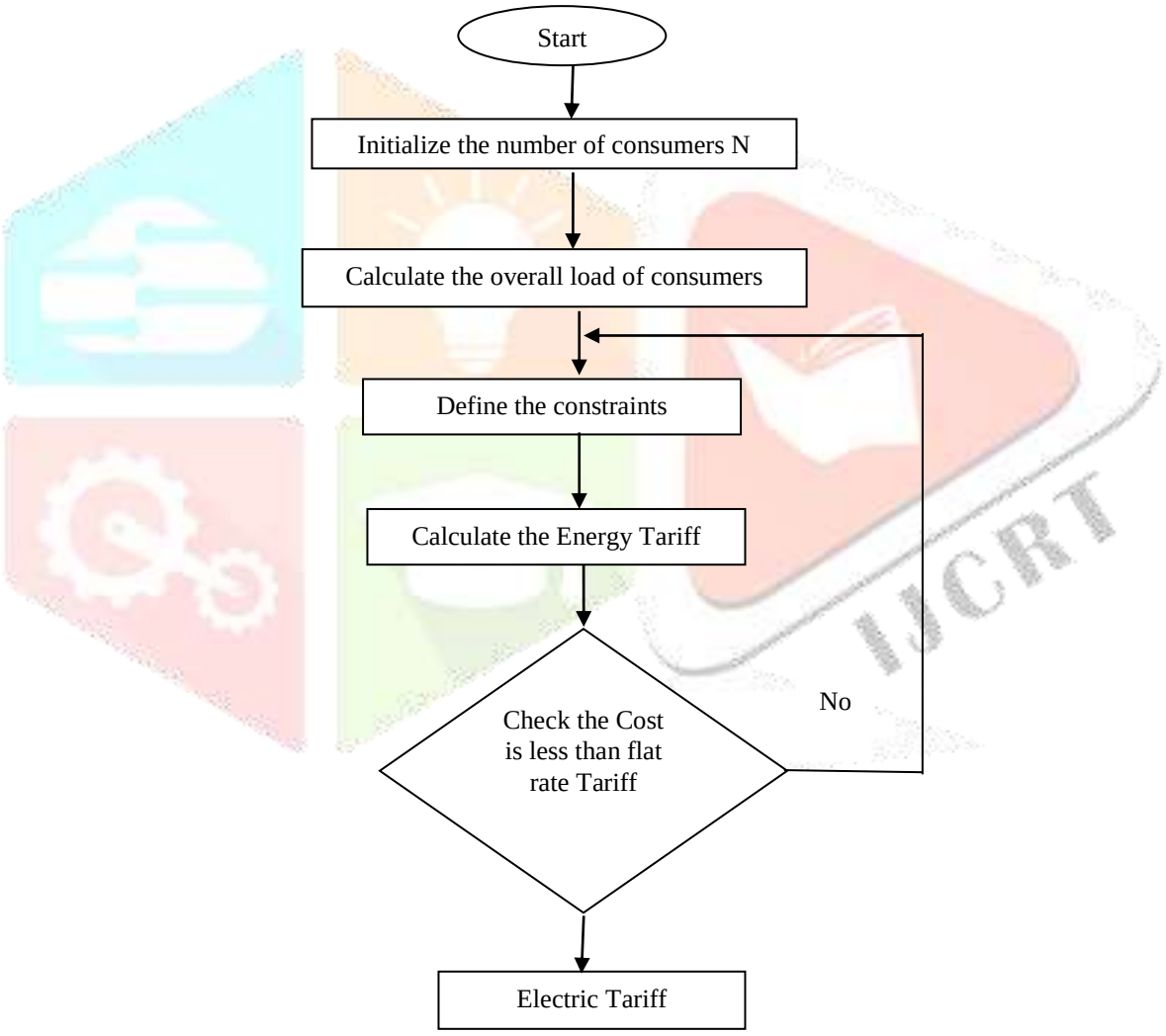

Fig-2 Flowchart for stepwise power tariff

Step1: Initialize the number of consumers are connected in a microgrid.
Step2: Calculate the load of different households.
Step3: Define the constraints for stepwise power tariff and divide consumption in steps.
Step4: Calculate the energy cost for overall microgrid.
Step5: If calculated cost is higher than the flat rate tariff, reschedule the load profile.

IV. TIME OF UTILIZATION

TOU is the method based on rescheduling the load timing from peak hour to normal hours. The loads of all consumers are divided into three categories baseline load, uninterrupted load and interrupted load. Interrupted loads are the target load to reschedule through TOU. Shiftable loads can be start early or late from their schedule time to reduce the peak. The method is used to reduce the peak hour generation as well generate the profit for consumers. Per hour cost is Calculate from the Scheduling compared with flat rate tariff and if the per hour cost is less use the methodology otherwise again reschedule.

Step 1. Figure out the shiftable loads (Interrupted Loads)
Step 2.Specify the earlier start time and late start time of the equipments
Step 3: Check whether the loads can be shifted
Step 4: Shift the loads if possible and calculate the savings

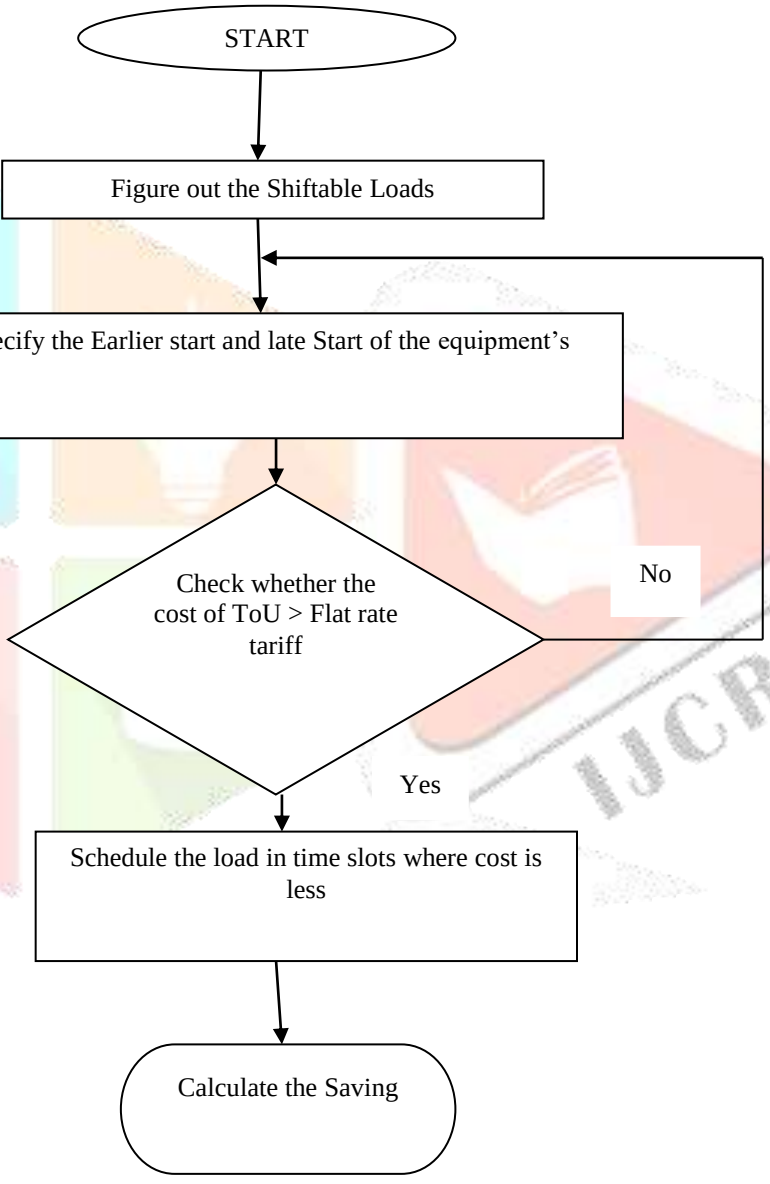

Fig.-3 Flowchart for Time of utilization

V. CONCLUSION

In some regulated markets, SPT is adopted with increasing stepwise electricity tariffs to encourage the residents to use electricity efficiently for the simple fact that the more the electricity consumption, the higher the electricity bill payment. Furthermore, the practice of TOU could reduce the difference of electricity demand between peak and valley periods, and is therefore an effective way for valley filling and peak shaving. For example, TOU tariff may bring about higher average electricity consumption and lower payments by residential consumers while SPT brings about the opposite effects. Both these techniques are provided for better

utilization of electric energy and try to use most of the generation through DG's if future if both methodologies used simultaneously to reduce the reliability on fossil fuels it may give better results.

REFERENCES

[1] U.S. Energy Information Administration, "International energy outlook 2013," Nov. 2013. [Online]. Available: http://www.eia.gov/forecasts/ieo/pdf/0484(2013).pdf.

[2] A. Talwariya, D. Sharma, A. K. Pandey and P. Singh, "An execution of smart grid with game theory," *2016 International Conference on Recent Advances and Innovations in Engineering (ICRAIE)*, Jaipur, 2016, pp. 1-4. doi: 10.1109/ICRAIE.2016.7939503

[3] K. Dehghanpour; H. Nehrir, "Real-Time Multiobjective Microgrid Power Management Using Distributed Optimization in and Agent-Based Bargaining Framework," in *IEEE Transactions on Smart Grid* , vol.PP, no.99, pp.1-1 doi: 10.1109/TSG.2017.2708686

[4] Finn, P., Fitzpatrick, C.: 'Demand side management of industrial electricity consumption: promoting the use of renewable energy through real-time pricing', *Appl. Energy*, 2014, **113**, pp. 11–21

[5] G. Ji and G. Yang, "Capacity manipulation and menus of two part tariff contract in supply chain, service systems and service management," in Proc. 6th Int. Conf. (ICSSSM '09), Xiamen, China, 2009

[6] G.Yang, G. Tang, and A. Nehorai, "A game-theoretic approach for optimal time-of-use electricity pricing," IEEE Trans. Power Syst., vol. 28, no. 2,pp. 884–892, May 2013.

[7] B. Lin and X. Liu, "Electricity tariff reform and rebound effect of residential electricity consumption in China," Energy, vol. 59, pp. 240–247,Sep. 2013.

[8] Pushpendra Singh, D.P. Kothari & Mool Singh, "Smart Grid Integration for demand side management" vol. 12, issue no. 03, pp. 49-52, June 2010 – August 2010, International Journal on Electronic & Electrical Engineering (IJEEE).

[9] Qiang Yang, Xinli Fang, "Demand response under real time pricising for domestic households with renewable DGs and storage" *IET Gener. Transm. Distrib.*, 2017, Vol. 11 Iss. 8, pp. 1910-1918 ISSN 1751-8687