Active Demand Side Management in the Residential Sector by using ANN and Genetic Algorithm: A Review

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Abstract

Nowadays, electricity demand is increasing as the cost of fuel is also increasing. It is the need of time to manage the electricity by proper utilization. In this paper, DSM is defined as the modification of consumer demand for energy through various methods such as behavioral change of humans towards use of electricity, financial incentives and automatic control of the household demand in order to achieve savings and higher efficiency in energy use. The combination of DSM with an automatic control of the household appliances and small other loads as per the conditions leads to a new concept called Active Demand Side Management (ADSM).The demand profile can be improve by using ADSM in order to reduce the stress of the electrical system by maximum utilization of load. In this paper ADSM controller based on ANNs is implemented to increase the self-consumption in the residential sector. The distributed control system presented is made up of several ANNs located at the different appliances in a house similarly direct load control technique by using Genetic Algorithm can be used to solve the complex problems characterized by a predominant commercial consumption, by the contribution of the air conditioning systems in the substation loads to minimize the peak the demand.

Keywords: ***Active Demand Side management (ADSM), Demand Side Management (DSM)***

1. Introduction

Demand Side Management (DSM) provides is a effective solution for peak-time power consumption. There are several benefits of the ADSM, such as reduction of losses and load shedding in the grid, reduction in energy bills, demand curve smoothing or reduction in the production cost. There are three main strategies to implement ADSM (i) peak clipping, (ii) valley filling and (iii) load shifting. ADSM has to guarantee the comfort of the users and their preferences without changing their behavior. ADSM can be implemented based on different criteria, such as the price of the energy, maximization of the self-consumption or limiting the maximum power between others. The term self-consumption on distributed generation electric networks focuses on the usage of the own generated energy. This paper focuses on ADSM with peak clipping and valley filling strategy to maximize self consumption.

In this paper a distributed ADSM controller based on ANNs is implemented to maximize self-consumption in the residential sector. The distributed control system presented is made up of several ANNs located at the different appliances in a house. The appliances self-organize in a distributed way and a coordinator corrects their outputs in order to enhance self-consumption. It is expected that ADSM system tries to reduce the consumption of electricity by running the deferrable load in off peak time and off that load in on peak time that is peak clipping and valley filling techniques in DSM so that self consumption could be maximized. Similarly by applying Direct Load Control (DLC) method by using genetic algorithm by minimizing the peak demand in electric systems.

I. System under study by ANN

The ADSM system has been developed by including typical electrical appliances of a highly electrified home: washing machine, dryer, dishwasher, refrigerator, cooking appliances, lighting, computers and entertainment appliances. By using ADSM these appliances will get automatically monitored and controlled for maximum utilization of electric load. In electric utility some appliances are need to use for 24 hour of the day while certain appliances can be run for particular time of the day e.g. motor or washing machine etc. On the basis of this concept all the appliances are divided into Deferrable loads and non deferrable loads. In case of deferrable load the user set up time limits between which tasks has to be carried out and in case of non deferrable Non Deferrable loads the demand is not controllable. It represents the instantaneous appliances, like lights, TVs, fridge etc.

ADSM system tries to reduce the consumption of electricity by running the deferrable load in off peak time and off that load in on peak time that is peak clipping and valley filling techniques in DSM. So in this paper we have considered certain load and try to given in table no.1.which consists of deferrable and non deferrable load and ADSM is applied to control the ON and OFF actions of these devices as per the peak electricity demand by using ANN techniques. Maximum peak demand is taken on basis of maximum demand of the particular feeder. In this paper certain load data for four feeders is collected and on the basis of that Maximum demand is specified for each feeder for e.g. 3000, 5000 or 7000 for each feeder. According to this range ADSM is applied to residential sector by using in ANN.

Sr. No.	Appliances	No. of Equip ments	Ratings	Total Load in Watts
1	LED Bulb	20	10 W	200W
2	Fan	5	75 W	375W
3	Incandescent Lamp	20	100 W	2000W
4	TV	1	150 W	150W
5	Fridge	1	400 W	400W
6	Washing Machine	1	500 W	500W
7	Vacuum Cleaner	1	700 W	700W
8	Water Heater	1	3000 W	3000W
9	AC	3	4000 W	4000W

As aforementioned, the main objective of the ADSM system is to maximize self-consumption. Therefore, the ADSM system must schedule different appliance tasks commanded by the user

throughout the day. Only deferrable appliances can be controlled by the system. However, deferrable and non deferrable appliances are taken into account to analyze and validate the system. To allow the ADSM system to create the scheduling, the user must provide a list with the appliances to be executed within the next 24 h. This list consists of the name of the appliance together with the program variables and the time limits. A summary of these variables is shown in Table 1. Before starting, the ADSM system must obtain the tasks that the user wants to execute and the generation forecast. Once all the information is ready, the system starts scheduling the different tasks according to a specified energy criterion, maximizing self consumption.

II. System Under study by Genetic Algorithm

Direct load control (DLC) plans reduced the peak periods' consumption by directly controlling the natural operation certain devices.DLC programs helps for planning capacity expansion are currently introduced as an appealing alternative in networks and avoid the need for investing in new capacity to supply the demand. Traditionally, thermostatic control applications are used as manageable load in the implementation of these programs. They can be air conditioning equipment, water heaters and heat pumps. In these applications, their operation determines a service – in this case, keeping the users' comfort – regardless their mode of operation.

These qualities are seen particularly in areas that have essentially commercial consumptions. The generality of the algorithm presented in this research makes it possible to apply it to any set with characteristics similar to the zone under study. The demand prediction models as such demand a complex investigation. A first contribution of this research consists on the development of a simple, but effective load prediction method that is based on finding the optimal match between the past and future temperatures for a specific day to forecast, in order to estimate its energy demand. The assumption behind this search defines that if two days are similar in their temperature dynamic behavior, their energy consumption profiles will also be alike.

Modeling of the equipment operation

A CAC piece of equipment has three circuits that allow refrigerating or heating an environment, depending on the requirements . This dual operation is due to the equipment capacity to extract heat from one place to transfer it through a flow to another zone. The mode of operation is therefore defined by the direction of this energy transfer.

The first cycle determines the heat exchange between a low boiling point cooling liquid that circulates through the CAC and a water flow that is pumped toward the zones that must be conditioned. In this cycle, the thermal balance is achieved when a constant cold-water output temperature of 6.6º is obtained, independent from the temperature of the flow that enters into the equipment. This exchange is called electric differential, because the balance must be maintained and restored by means of electric power.

The second cycle is generated between the cold water pumped from the equipment and the air that passes through the fan systems. This exchange is called thermal differential, because the disparity between the temperature of the water that enters and the one that goes out from this zone is defined by the thermal requirement of the area that is being conditioned.

The third cycle is established between the cold air that is exhausted by the fans and the air in the zone to be conditioned, that ultimately is the one that determines the comfort conditions. Hence, the balance is defined at the moment in which the thermal and electric differentials coincide, a scenario that must be maintained to ensure the sensation of comfort.

Results

After applying ADSM in residential sector as per the maximum power demand the deferrable loads will get turn ON and OFF i.e. when the shown in fig.2 when there is peak demand on the certain feeder during that periods all the deferrable loads will get OFF and during OFF peak demand that load will run if user has already kept it on for use. By applying this type of system we can provide peak clipping and valley feeling strategy for maximumutilaization of electrical energy and reduce the load demand at a particular hour and hence reduces the generation cost also.

Sr. No.	Appliances	No. of Equipments	Ratings	Total Load in Watts	Before	After
1	LED Bulb	20	10 W	200W	ON	ON
2	Fan	5	75 W	375W	ON	ON
3	Incandescent Lamp	20	100 W	2000W	ON	ON
4	TV	1	150 W	150W	ON	ON
5	Fridge	1	400 W	400W	ON	ON
6	Washing Machine	1	500 W	500W	ON	OFF
7	Vacuum Cleaner	1	700 W	700W	ON	OFF
8	Water Heater	1	3000 W	3000W	ON	OFF
9	AC	3	4000 W	4000w	ON	OFF

We have developed a control system using ANNs to implement an ADSM system for the residential sector. Results show that ANNs are able to implement an ADSM system that meets the user requirements and schedules the tasks for the next day to improve the electrical local behavior. This concept is related to the idea of the self-consumption of the local energy.

Conclusion

In this paper required data is obtained through the constant monitoring of the energy flow of the electrical system. After obtaining required data the maximum peak demand is find out with the help of load curve and ADSM is applied to the all appliances in the residential sector by using ANN for controlling and monitoring. ADSM applies ON and OFF control on the devices as per the load demand results reduced load demand during peak time and improving load demand during OFF peak time.

These techniques also benefit the grid, reducing the transportation losses and load shedding because of the self-consumption of local energy. Results shows that ANNs are able to implement an ADSM system that meets the user requirements and schedules the tasks for the next day to improve the electrical local behavior. By using this ADSM technique it is possible to manage the supply side also by reducing the generating cost. This concept is related to the idea of the self-consumption of the local energy. The ADSM system inherits the properties of the applied algorithms.

This research has developed a generic technical – practical tool to exert a control of equipments to minimize the peak demand in the commercial based on DLC programs applied to CAC equipment in office buildings. Different from research made previously, the fully generic solution can be used in different types of zone like industrial or residential etc. with similar electric demand

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