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Demand Response Program considering availability of solar power

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Abstract: *Energy is the index of a country's development and it is required in all spheres of life, like cooking, to provide light and heat, to propel vehicles and to drive machinery in industries. For the development of the country, demand of the energy increases, as energy is proportional to the progress. With the increasing need, the demand of energy too is increasing day by day, however no major integration of renewable energy sources can be made out. The rate of consumption of energy has become infinitely large to the rate of replenishment. Moreover we largely depend on fossil fuels. These not only cause pollution but are also exhaustible and their disappearance can have serious repercussions on the country's economy. So there is a pressing need to implement innovative Demand Response Management System, Optimum utilization of existing resources and hence bridge the gap between demand and supply. Demand Response is essential for balancing the supply and demand relationship by shifting electricity demand from peak demand periods to off peak demand periods and hence minimizing the electricity generation from fossil fuels and protect the environment. Mixed Integer Linear Programming method is used to minimize the cost for optimization of appliances schedule. Shifting of the load is done by considering Priority of load, Time of Use tariff, Flexibility and Availability of Solar.*

Keywords—Demand Response, Home Energy Controller (HEC), Time of use (TOU), Grphical user Interface (GUI), Home Area Network (HAN)

I. INTRODUCTION

Demand Response (DR) can be defined as "changes in electric usage by the end user consumers 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 in danger [1]."

By implementing DR, consumers can shift their shift able loads themselves or by the utility, at peak demands. Peak shaving during peak demands helps utility reduces outages, expenses on installation, running costs and alleviate major grid failures. With the advanced Information and communication tools and software, two way communications is possible which helps the consumer to manage their load to reduce the energy cost.

Following Technologies are used in Demand Response:

Home Energy Controller (HEC): Energy controller provides the on off status of the appliances according to the considering Priority of load, Time of Use tariff, Flexibility and Availability of Solar.

AMI (Automatic Metering Infrastructure): To optimize the performance of DR, AMI is increasingly being used with demand response because it provides both utilities and end-users two- way communication, live data about loads.

In this paper DR is performed in a home which shows how shift able loads can be shifted to off peak periods for peak shaving considering availability of solar.

There are three main types of load in a residence.

Must-on load: This type of load should remain on and cannot be switched off or shifted to other time period for peak shaving [3].

Controllable load: This type of load has thermostat to control the temperature which ultimately can change the energy consumption [3].

Shift able load: This type of load can be shifted to any other time slot at the time of high energy prices to reduce the energy cost. These types of appliances are used in peak shaving [3].

For shifting the load we have to consider the following parameters:

TOU tariff: TOU tariff is the rate of energy at different time of the day. In our case there are two different rates of energy in a day, Peak period and off peak period.

Priority of load: Consumers decide the priority according to which different shift able appliances should be shifted to any other time slots. The appliances with higher priority should be switched off at last.

Flexibility: In flexibility, consumers specify the time period during which the particular appliance should be switched ON again if it was switched OFF during DR event. This reduces the inconvenience to the consumer due to shifting of the appliances.

Availability of solar: It shows the load should be supplied by the solar power if solar is available and not from the grid. Hence it reduces the cost of energy to the consumer and protects the environment.

II. PROPOSED CONTROLLING SCHEME

2.1. Load Priority: Priority can be decides by the consumer beforehand. It can be changed when consumer wants it to change**.**

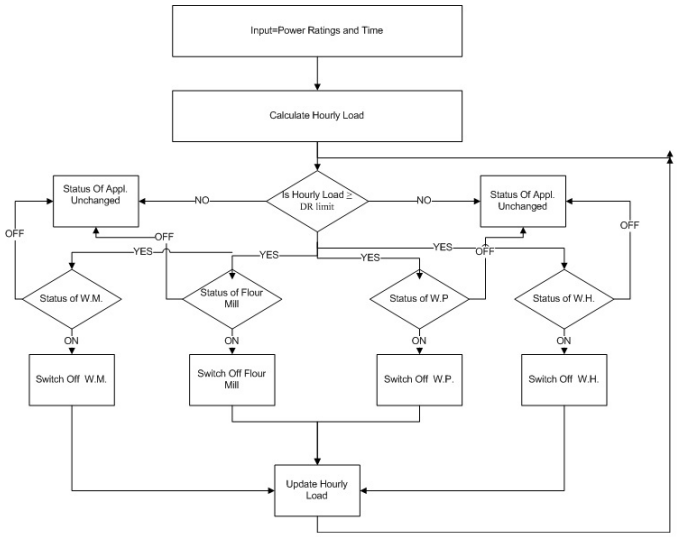

Figure 2.1: Flow chart for operating appliances according to the priority

2.2.Availability of Solar: Load should be supplied by solar when it is available during the day,

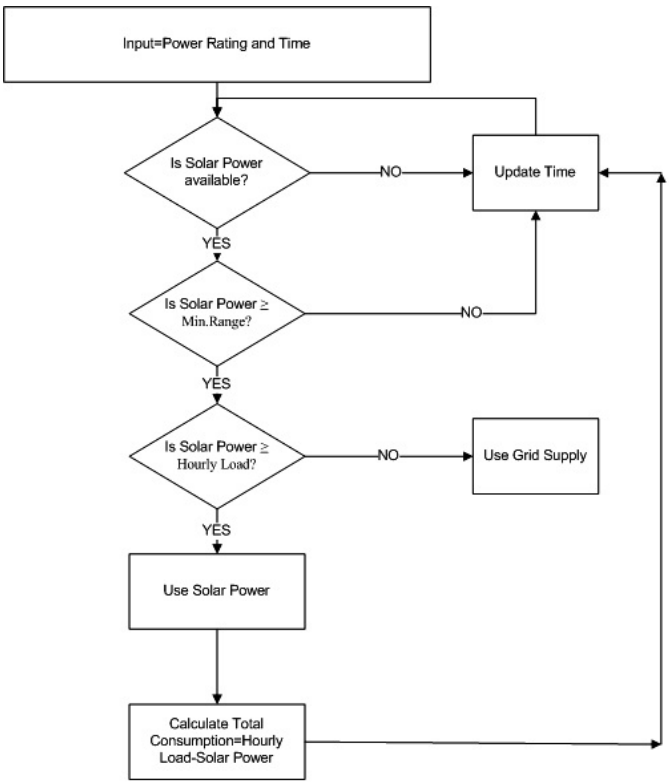

Figure 2.2: Flow chart for operating appliances according to the availability of solar power

2.3. Flexibility: Consumers specify the time period during which the particular appliance should be switched ON again if it was switched OFF during DR event. This reduces the inconvenience to the consumer due to shifting of the appliances.

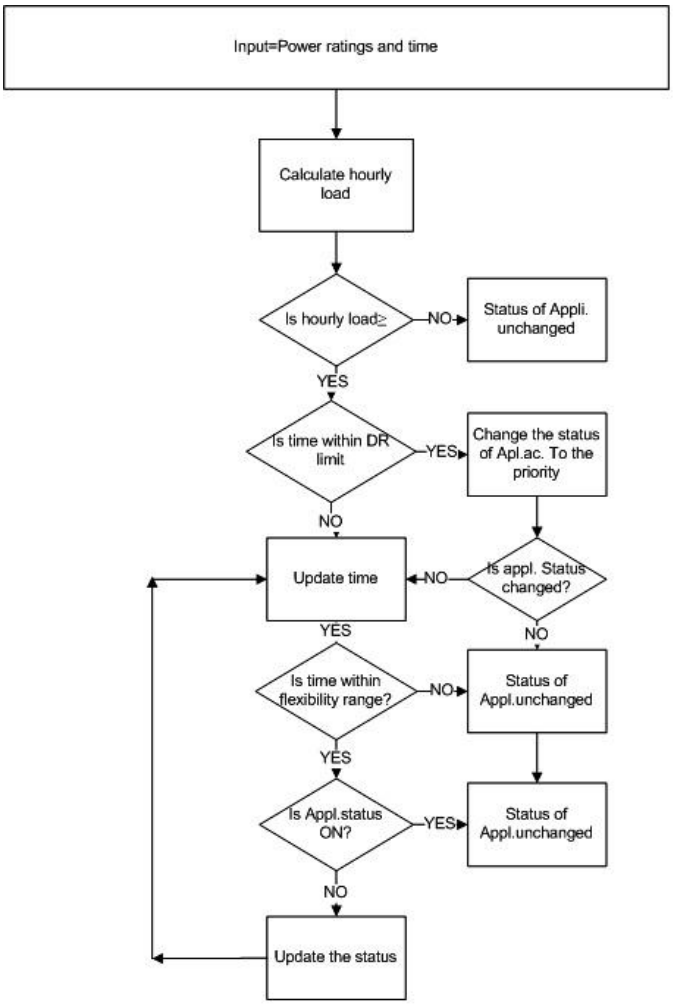

Figure 2.3: Flow chart for operating appliances according to the Flexibility

HEC Load Management strategy:

HEM collects all the information regarding total energy consumption, priority, flexibility and status of the appliances [5]. If total consumption is more than DR limit, then starting from the last priority one by one load are made OFF to make the total consumption below DR limit. We have considered the flexibility customer has provided for shifting the appliances at particular time duration to avoid the inconvenience to the consumer due to shifting of the appliance. To reduce the total energy consumption of home, we have used solar power instead of grid power, which reduces the cost of energy as well as protect the environment.

III.RESULTS AND GRAPHS

3.1 Load with and without DR: Power consumptions of the home appliances are measured every hour, and then constructed the load profile with respect to the time as shown in the graph. The graph shows the comparison between the load with DR event and without DR.

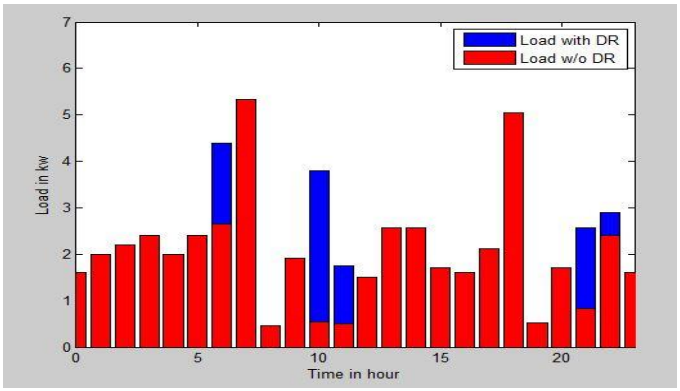

Figure.3.1Comparison between the load with DR event and without DR.

3.2.Load with and without DR considering availability of solar: In this graph availability of solar is considered. Solar power are added to the residential side to achieve further efficient schedule plans in reducing the residential electricity bill. When solar power is greater than hourly load,

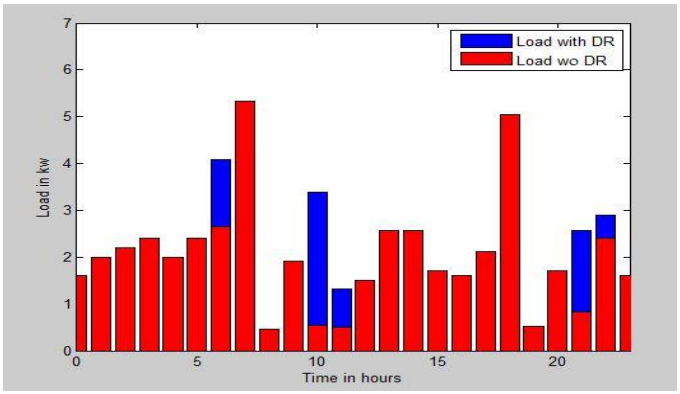

Figure .3.2 Load with and without DR considering availability of solar

3.3.Graph for Load of more than one home: MILP method for Optimization is used for individual as well as total load of the
Residential area. Following graph shows the results of total load before and after the DR program implementation.

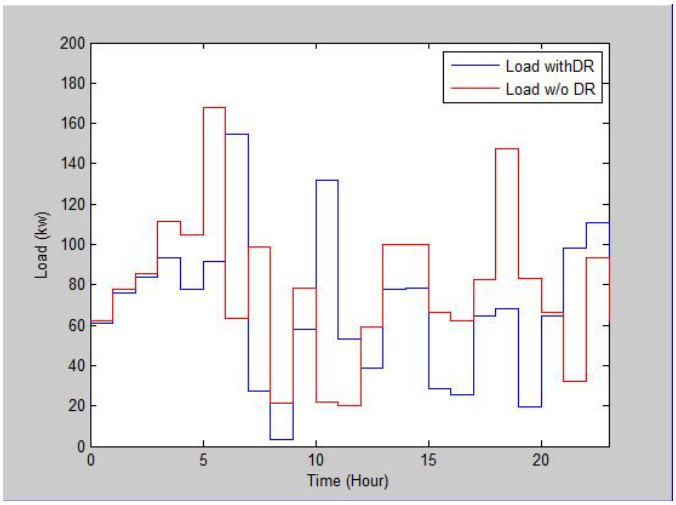

Figure 3.3 Residential load after shifting

Fig.3.3 shows Residential load after shifting. We can see that peak is reduced to and some load is shifted to off peak periods during DR event. This reduces the energy cost to the consumers.

Energy Cost comparison can be summarized in the table below. Energy cost is taken as □: 3/ kwh for off peak period and □: 5/ kwh for peak period.

Table.1

Status of Load	***Supply is taken only from the grid***	***Supply is taken from solar also***
Before DR	□:240.05	□:240.05
After DR	□:189.05	□ 173.49

IV. CONCLUSIONS

By considering the DR limit, Time of use (TOU), priority of load and flexibility, load is shifted to off peak period during DR event and hence peak shaving is done. Energy cost after load shifting is also calculated. Comparison of energy cost before and after shifting of load is as mentioned in the table 1. In this DR program consumers availability of solar is considered to reduce the cost and also to reduce the environmental impact. This type of DR program is useful for deciding TOU tariff as it has taken into account consumers' behavior in response to change in price.

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