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Appliance Scheduling Optimization for Demand Response

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Abstract- The main responsibility of the demand response system is scheduling the operation of appliances of consumers in order to achieve a network-wide optimized performance. Each participating electricity consumer, who owns a set of home appliances, provides the desired expectation of his/her power consumption scenario to the demand response system. It is accompanied with time limits on the flexibility of controllable appliances for shifting their operational time from peak to off peak periods. The appliance scheduling optimization for demand response is modeled as an optimization problem. The optimization of the scheduling probabilities is carried out as an economic dispatch problem, which aims to minimize the total network utilization cost. This problem has been studied extensively in the context of micro grids.

Keywords- Smart Grid; Demand Response; Appliance Schedule; Optimization.

I. INTRODUCTION

As per the Ontario government's Green Energy Green Economy Act (GEGEA), conserving energy not only saves money for the consumers and businesses but also lowers the demand on the electricity system and helps reduce greenhouse gas emissions [1].

Importance given to home area network (HAN) layer of smart grid gets more attention when utilities are finding ways to promote small scale renewable energy generations and ways to keep demand response in line with the supply during peak timings of usage.

There are programs that are being worked upon to tie up and motivate the consumers to strictly abide with the program features, which are: 1) Making consumer well aware with the Time of Use (TOU) features and rates, 2) Effective demand response programs to help reduce the consumption during peak demand and 3) Innovative energy efficiency and cost effective programs for residential, commercial and industrial sectors and offering alternative options and incentives to consumers who cooperate with the utility and assists in demand side management (DSM). Therefore, as depicted in Figure 1.1 among the offered applications of smart grid, automatic meter infrastructure (AMI), distributed energy resources (DER), electric vehicle (EV) and storages comes under the umbrella of demand side management (DSM).

Within the concept of demand- side energy management, residential energy management is recently attracting increasing interest from the research community. The traditional grid has demand response programs for large-scale consumers such as industrial plants or commercial buildings; however, it does not have a similar mechanism for the residential consumers mostly due to two reasons.

First, it has been hard to handle the large number of residential units without communication, sensors, and efficient automation tools. Second, the impact of demand response programs has been considered to be relatively small when compared with their implementation cost.

However, in the smart grid, smart meters, low-cost sensors, smart appliances, and communications set the stage for novel residential energy management techniques that involve communications and interaction between consumers, devices, and the grid [7].

Recent advances in smart metering technology enable bidirectional communication between the utility operator and the end-users and facilitate the option of dynamic load adaptation.

Toward this direction, demand-response (DR) programs provide incentives to major consumers of electricity, usually in the form of monetary rewards, to reduce their electricity consumption in peak-demand periods. DR can take place at a very fast timescale, almost real-time; it leads to a more stable power grid system and significantly reduces electricity generation cost and CO2 emissions [1].

Load balancing today occurs primarily via supply side adjustments, whereas demand side opportunities remain under-exploited. Electricity suppliers have for a long time used sophisticated methods to estimate near- future grid loads and correspondingly adapt electricity production across different sites as well as trading electricity across national borders.

Direct response actions on the demand side (called peak shaving or peak clipping) have so far been largely limited to industrial customers.

This approach has some limitations as some industrial processes are harder to turn on or off due to the critical and strategic processes involved and high stakes of financial repercussions. Demand response management is therefore expanding rapidly to encompass further commercial and residential; customers.

In the study of dynamic demand side management, different techniques and algorithms have been proposed, where the basic idea has been to reduce the energy bill corresponding to the TOU and billing incentives offered by the utility [5], [6].

Consumers can also generate renewable energy, consume some portion of it locally, and sell the excess energy to the utility companies. For example, Ontario government's micro feed-in tariff (FIT) program allows home owners to sell locally generated energy [1], [2], [7].

The rest of research paper is design as follows. The demand response scheduling scheme is described in Section II. Section III describes proposed methodology. Result Analyses describe in section IV. Finally, Section V describes the conclusion of paper.

II. DEMAND RESPONSE SCHEDULING SCHEME

A novel scheme for load management in microgrids based on stochastic scheduling of loads under risk-limiting constraints. When trying to enforce adequate power supply in a micro grid, the volatility of renewable resources such as wind energy has to be considered.

In the risk of inadequate power supply, loads have to be scheduled, which can be achieved by directly controlling individual loads or by setting pricing incentives to encourage beneficial behavior of the customers. A common drawback of conventional methods lies in the need of sophisticated control strategies and a significant amount of real-time signaling exchange between the micro grid and the central control unit.

To address these issues, we propose a scheme that does not require a direct control of individual loads. Our method relies on sorting the appliances in the network into groups, and allowing these groups to schedule themselves stochastically according to broadcasted scheduling probabilities.

In this paper, we propose an optimization problem to determine these group scheduling probabilities, as well as for choosing the best utilization of conventional generators, in a day-ahead planning scenario of an isolated micro grid. Using an outage-risk limiting constraint, we control the risk of inadequate power supply causing network outages. The proposed scheme can be easily implemented with unidirectional communication from a central control unit via simple broadcast messages [13].

III. PROPOSED METHODOLOGY

The main challenge for the future smart grid is essentially the optimization of energy consumption. In fact, a smart home system allows customers playing an important role in optimizing the energy consumption and helping to reduce peak demand. In this context, the studied smart home consists of household loads which can be divided mainly into three classes: Non-shift able loads such as televisions and refrigerators which necessitate a permanent power supply during operating, anyway of electricity prices.

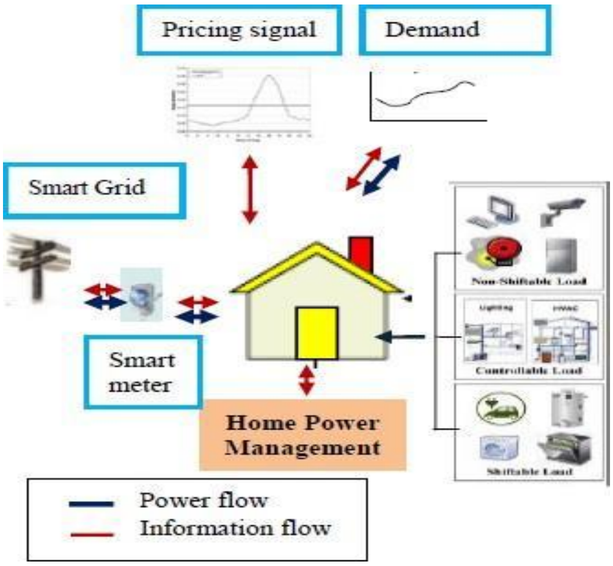

Fig 1. Typical smart home configuration.

Controllable loads such as lighting and HVAC (heating, ventilation, and air conditioning) systems, which can be operated depending on the electricity price and adjusted by dimming, varying the fan speed and thermostatic control. Shift able appliances such us water heaters, dishwasher's washing machines and plug-in electric vehicles: the operation of these loads can be shifted from peak to off-peak hours.

Figure 1 depicts the typical smart home configuration. The studied smart home contains: the daily load power curve, the electricity price signal, a different appliances categories, the home power management and the smart metering devices ensuring the two-way communication between power grid and home users [11].

First, the considered household receives the electricity price curve and the daily load profile using the smart metering infrastructure. Then, the proposed "Demand response strategy for home power management" is applied. The aim of this control is to utilize intelligently the electricity by shifting loads from peak periods to off-peak hours depending on different class of devices ensuring consequently the peak demand minimizing.

IV. RESULT ANALYSIS

Load power before rescheduling is define in figure 2. The load is calculated for 24 hours. In the starting load power 2500 watt. Then it will increases as time increase. Max. Load is 3200 at 20 hours time

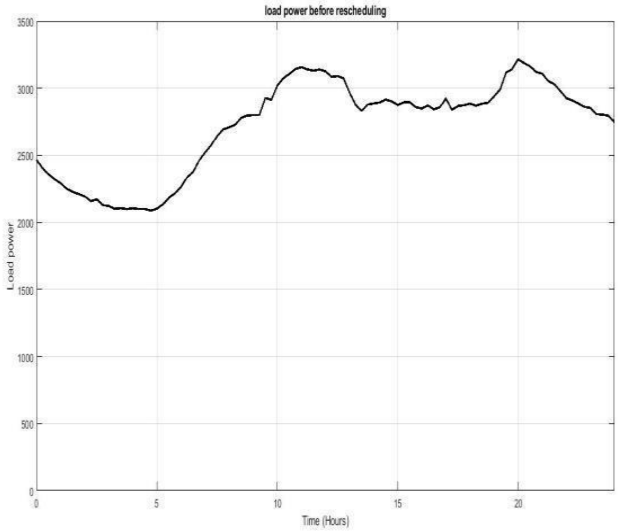

Fig 2. Load Power before Rescheduling.

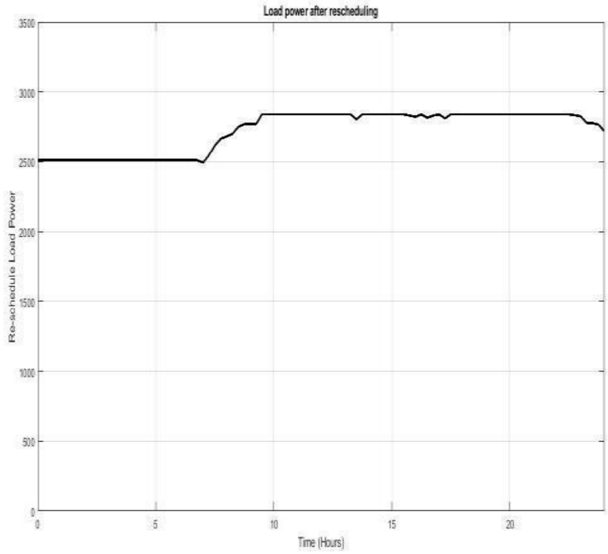

Fig 3. Load Power after Rescheduling.

Load Power after rescheduling is shown in fig 3. The load is flattered from 0 to 7 hours then increase to 2800 watt. Then again flattered with 10 to 24 hours

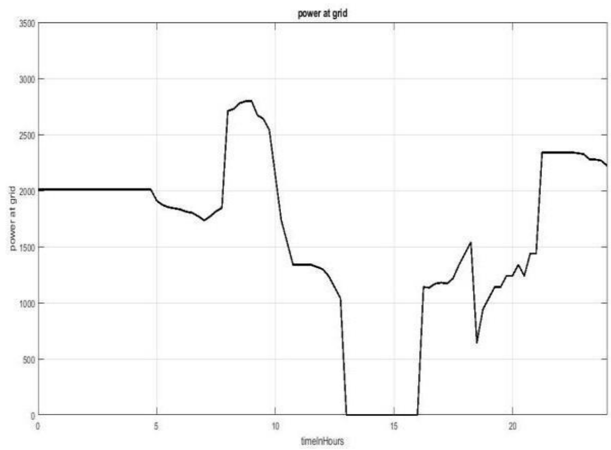

Fig 4. Power at Grid.

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Power at grid generated is shown in fig 4. The power is flattered up to 5 sec. then a dip comes up and it will rise and give maximum load at 8 hour. The power from the grid becomes zero at 13 to 16 hours.

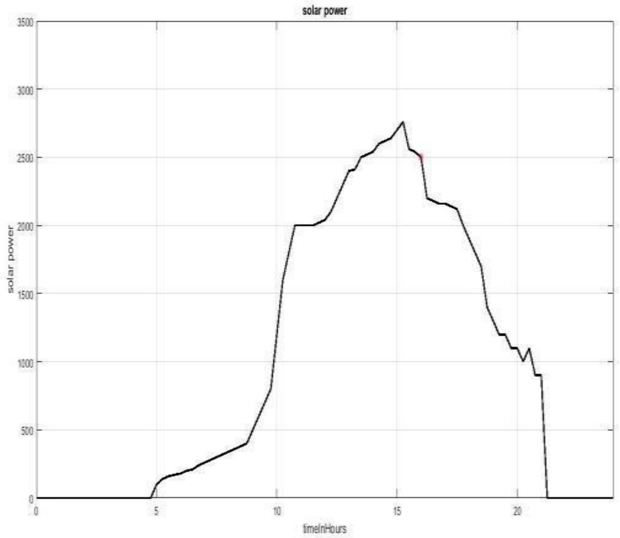

Fig 5. Solar Power Generated.

Solar power generated is shown in figure 5. The power is delivered from 5 to 21 hours .At that time power should be active. Max Power is derived at the mid day of the complete day.

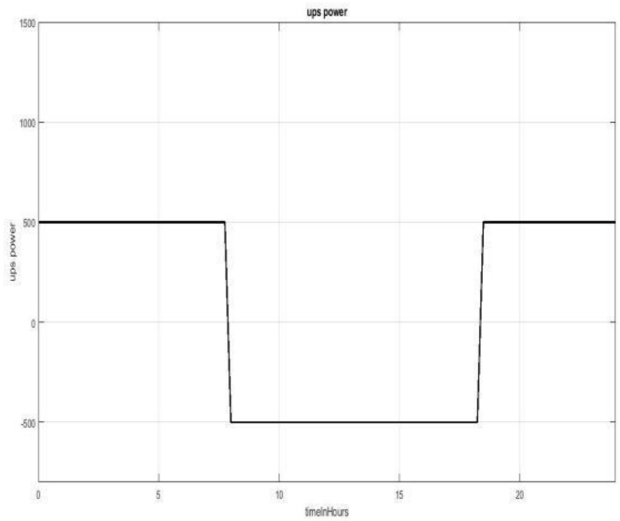

Fig 6. UPS Power Generated.

The UPS Power generated should be constant as 500 watt from 0 to 8 hours. Then it will charge then again 18 hour to 24 hour again power delivered.

The comparative Analysis of UPS power, Scheduled Power, Solar power & Load Power. Is shown in fig 7. Power delivered after rescheduling is more as compare to other sources.

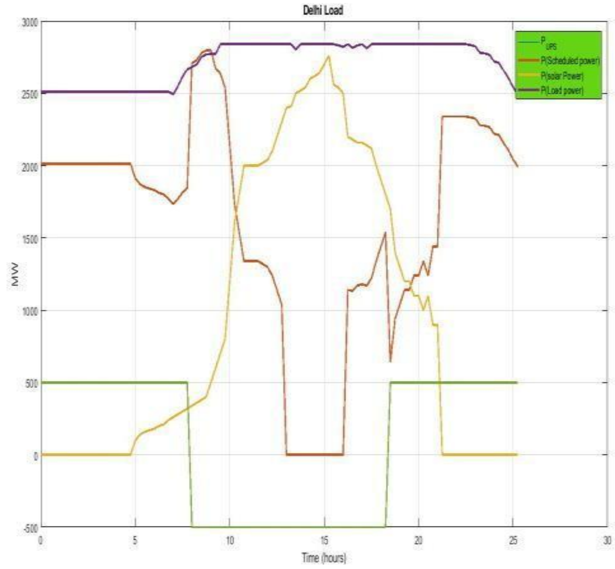

Fig 7. Comparative Analysis of UPS power, Scheduled Power, Solar power & Load Power.

V. CONCLUSION

In this paper, the possibility of reducing peak demand in household by demand response was presented. The main contribution of this study is to develop a supervision algorithm for household power management with respect of the class of appliances and their priority order.

The control strategy of the studied system aims to detect the relationship between electricity price and total load demand in order to shift some appliances form peak hours (high prices) to off peak periods (low prices) ensuring consequently the smoothness of the daily load curve to make it between a limiting power margin without affecting the family lifestyle.

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