A Survey on Demand Response Management - an approach for load balancing in Smart Grids

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ABSTRACT-With modernization of grids issues related to electric power sector like Demand Response Management (DRM), theft detection, outage management etc. can be effectively solved. Out of these, demand response is essential characteristic that affects the overall grid stability. Demand response is, rearrangement of the users' energy consumption pattern in response to the utility's incentive and pricing scheme thereby reducing the operating expense of generators. DRM deals with managing of load in smart grid (SG). This paper explores various ways of performing DRM to for load balancing in grid. Finally, based on the survey conducted, outline of future approach in the context of demand response, for load balancing in SG is presented.

Keywords—Demand Response Management (DRM), Smart Grid ,Load Balancing, Home Devices,Utility Server, Enery Consumption.

I. INTRODUCTION

One of the key issues in electrical power System is managing Demand response in grids. Modernization of Grids has lead to explore new ways for demand response mangaement so as to provide load stability on the grid. Due to raise in the demand-supply gap, management of the demand has to be done in such a manner that it complies with the supply. Using Internet and other communication technology (ICT), smart devices can exchange their information with grids; this in turn helps to control the demand response of the home devices in minimizing the demand-supply gap. DRM shapes the electricity load profiles of user's with an aim to get better reliability, economy, efficiency, protection, sustainability, and environmental friendliness of the grid.

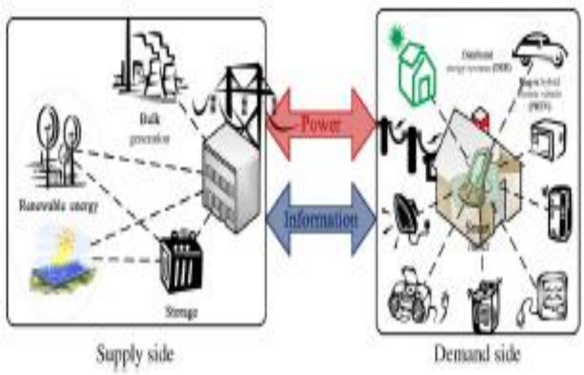

Fig.1. Demand Response Management

The demand response mechanism involves interaction between the supply and demand side to exchange demand and pricing information. It is a bidirectional flow of information and power as illustrated in Fig.1. From the perspective of smart grid, demand response is a means of reordering the energy consumption thereby reducing the operating expenses of the users'.

Demand response can be categorized into the following aspects (as illustrated in Fig.2).

1) ***Peak clipping:*** reduce the peak energy consumption, prohibiting the load from exceeding the supply capacity of distribution substations, or the thermal limit of transformers and feeders. Peak clipping reduces some of user's demand, thereby affecting their comfort and satisfaction.

2) ***Valley filling:*** is showcasingthe off-peak energy consumption through energy storage devices, such as rechargeable batteries and plug-in hybrid electric vehicles (PHEVs).

3) ***Load shifting***is shiftingof the energy consumption over the time horizon, e.g., shifting the demand from on-peak to off-peak time periods, without reduction in the total energy consumption of the users' within a day.

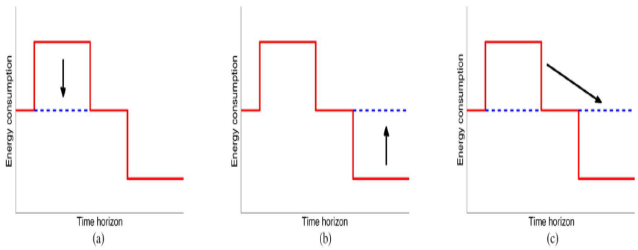

Fig.2. illustration of demand response functions i) peak clipping; ii) valley filling; iii) load shifting.

II. MOTIVATION OF DEMAND RESPONSE MANAGEMENT IN SMART GRIDS

Due to raise in the demand-supply gap, it has become important for managing the user's demand in a way that it adhere to the supply, which has been a main concern in all developing countries where the power needs of the user's is not satisfied by the existing infrastructure. The modernization of power sector, has lead the focus to be shifted from conventional grids to smart grids (SGs).

Motivation for demand response is its following benefits:

- The need for building new power plants can be postponed by reducing in long term the system peak load using DR
- Transmission system operator can be benefit from DR. Improved reliability of transmission network, results in reduced probability of outages when system reserves fall below desired levels.
- Distribution System Operator use DR for managing network constraints at the distribution level, Simplifying outage management and improved quality of supply. DR relieves the network

components from stress during congestion or peak periods.

- The impact of DR on electricity markets leads to financial benefits of the utility and the consumers.

III. EXISTING APPROACHES ON DRM –A LOAD BALANCING APPROACH IN SMART GRIDS

A. Demand Response implementation for improved system efficiency in remote communities.

This paper [4] asses the performance of Demand Response (DR) system, used to manage poor fuel efficiency and reduce the fuel consumption at peak loads. In this work, linear regression model for load prediction and historical data averaging for measuring DR rebound and shed were developed. The work presented here demonstrated the utility of minute-level power metering for assessment and evaluation of the results for DR. Prediction models using linear regression performed inadequately when compared to models based on historical averaging. The cause for this was that the heating system responds to changes in outside temperature with different time constants, but the basic linear regression takes into consideration immediate response time. The models based on averaging were found to produce more accurate results.

B. Load Management in Smart Grids: A Decentralized Framework.

In this paper [5], the author proposed an approach for management of loads of individual homes using decentralized approach in smart grids. The author proposed this approach with an intention to reduce the total cost without disrupting the user's comfort. The Home load management (HLM) modules, are agents in the proposed framework that are embedded in customers' smart meter, with which the energy service provider iteratively exchangesload information to achieve his desired load profile(Fig.3.). Oneach iteration, the utility server announces the system load profile to HLM modules. The modules, send back the load reschedule proposal to modify the system load profile keeping in mind keeping in mind their own comfort and financial constraints .The proposals received are then judged to check whetherthey improve system load profile or not. HLM modules apply their accepted proposed schedules and modified load profile is released. HLM modules' new proposalsare gathered and judged again. This process is repeated until a point after which no improvements in system load profile are experienced.

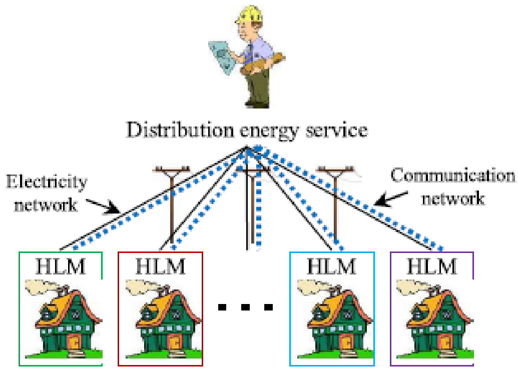

Fig.3. Smart Distribution System

C. System Architecture for Autonomous Demand Side Load Management in Smart Buildings.

This [6] author used a mixed integer linear programming technique of solving the load managing problem for controlling the smart devices so as to reduce the total cost of the. This paper presents the layered architecture for management of load in smart buildings, depicted in Fig.4. The system contains communication interfaces for exchange of information between appliances and grid. The emphasis is on management of optimal energy consumption and appliance operation control. To switch on the new load the predefined constrains are to be set. This approach is capable of handling energy consumption management of systems with dynamics in multiple time-scales and the support for incorporation of techniques for optimal scheduling, online operation control, and dynamic pricing.

This approach does not address the issues related to modeling appliances, communication delays.

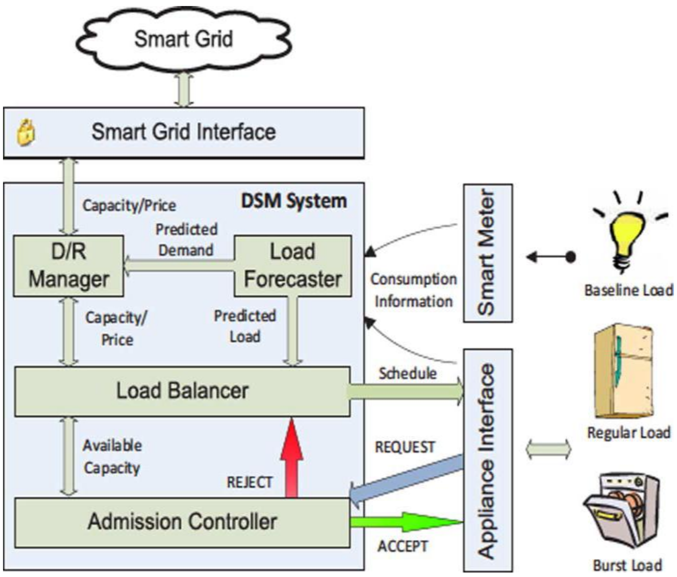

Fig.4. demand side load management-layered architecture

D. An Algorithm for Intelligent Home Energy Management and Demand Response Analysis.

The paper [7] presents a Home Energy Management (HEM) system (Fig.5.) for managing the load of appliances in the home consuming high power, according to the priority set by the user. Load was turned off based on this priority whenever the demand in home exceeded the limit. When the demand limit is low, it results in creation of new peak during off-peak causing an adverse effect. The HEM algorithm takes into consideration the load priority and customer comfort level settings and showcases its applicability to perform DR at an appliance level.

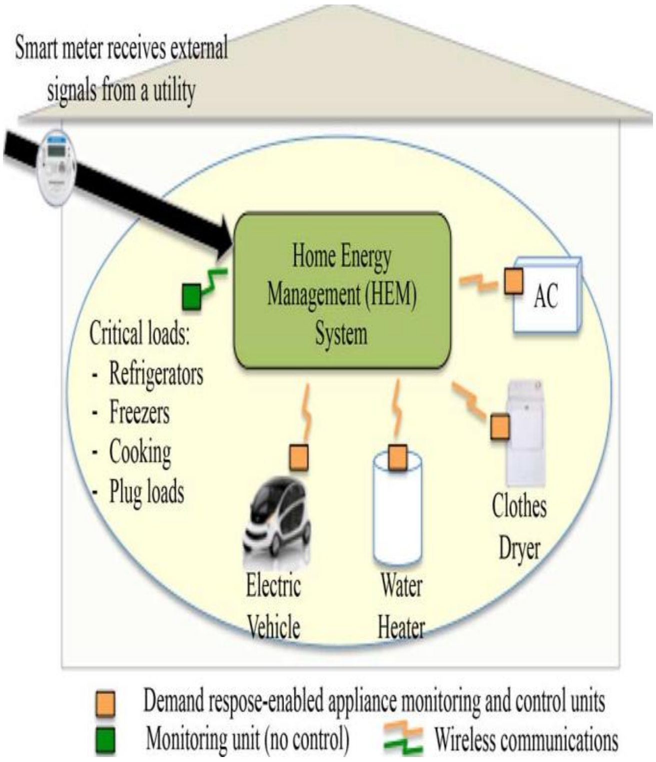

Fig.5. the HEM architecture

E. An Intelligent Home Energy Management System to Improve Demand Response.

This approach [8] proposes a scheme for home energy management with a focus to improve the demand response management of homes. Here branch and bound technique for scheduling the devices based on the consumers load profiles predicted was proposed. The DR expands to residential loads by dynamically scheduling and controlling appliances in homes. The schedule is communicated and executed by appliance control interfaces over a home energy network. To predict, the schedules for appliance run times with an aggregator a predictor is developed which also accumulates predicted demand from residential customers.

IV. PROPOSED SYSTEM

The existing approaches providevarious demand response mechanisms for load balancing in smart grid. None of these approaches utilize the historical data gathered from smart devices. If this data is analyzed effectively,it can provide ways of gaining knowledge to achieve load stability and demand response in smart grids.
The proposed system uses a historical data analysis approach of managing demand response in smart grids, which is a two-stage approach
1. Find the users which are overloading loading the grid using the SVM classifier.
2. For each users identified, perform data analysis to trip or reschedule the load to maintain SG stability.

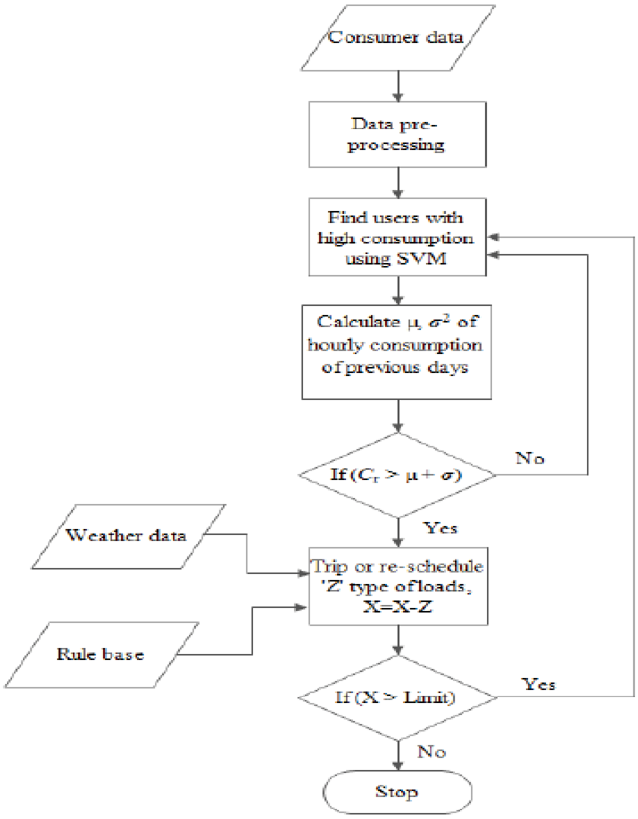

Fig.6. Flow chart of proposed system

V.CONCLUSION

It is learnt from the survey that the various schemes described above for load balancing in smart grid, do not take advantage of using the historical data of smart devices in homes. If this data is analyzed it can open new ways of gaining knowledge to achieve load stability and demand response in smart grids [9] .Our proposed systemenhances the capabilities of smart grid without installing a new infrastructure by using data analytics to identify homes overloading the grid and balancing the load using gathered data.

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