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Demand Response Management for Residential Smart Grid

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Abstract: *In the past, energy was relatively inexpensive. Efforts to control the efficient use of electrical energy are less important, and in many cases were limited to initial architectural and design considerations. Cost-effective and widely available energy brought unprecedented economic growth, but costs and risks are rising: fossil fuel costs, environmental costs and overseas delivery risk. Smart grids are more efficient and reliable than today's grids and are expected to reduce the economic and environmental problems of traditional fossil fuel power generation. The two basic functions of a smart grid are efficient demand response management and flexible use of renewable energy. Real-time control of electricity prices has proven to be effective for providing efficient demand management. Demand response is an important element of DSM. In this paper, we proposed the DRM method and built a test-bed for a smart home for an individual home to execute the proposed method. In the proposed DRM method, we propose two different types of royalty plans, environmental burden and environmental plan, and a design algorithm based on two user discomfort indexes for evaluating DRM to reduce peak load. The test-bed checks the effectiveness and efficiency of the projected DRM scheme.*

Keywords: *Smart grid, peak load reduction, customer engagement plan, demand response, energy management service (EMS), implementation.*

I. Introduction

The Federal Energy Regulatory Committee calls Demand Response (DR) as changing the power consumption of end users from normal consumption patterns in response to changes in electricity prices over time or sometimes a decrease in power consumption when the wholesale price is high or the reliability of the system is compromised [2].

In other words, Demand Response (DR) is a method of manipulating customer loads during peak demand or when demand is low. This reduces the peak demand of the network and also lowers the price on the customer side. DR can be used for both private and industrial loads. There are three different concepts. Reduction of energy consumption, shifting to low or high demand and efficient use of the energy storage system. It will manage DR to reduce peak load and make more efficient and systematic use of existing infrastructure [2].

Demand Response Management (DRM), based on real-time electricity price management, is an important element in the realization of the future smart grid. Properly designed real-time pricing schemes can lead to a "triple win" solution: A consistent load requirement increases robustness and lowers power generation costs for the grid. Lower production costs lower wholesale prices, increasing retailers' profits. Users can reduce the electricity bill by responding to prices that change from moment to moment. This paper describes how to design real-time rate plans to lower peak and average load rates, maximize revenue for each user, and maximize retailers' profits. In particular, we formulate the real-time pricing scheme as a two-stage optimization problem [3]. In the lower tier, each user maximizes this payment in response to the price. This is the difference between the quality of use and payment to retailers. In the above phase, retailers set real-time prices according to the responses to maximize expected user revenue [3].

II. Technical Concept/ Research Methodology

In smart homes, there are many burdens such as heat load, electric cars, smart appliances, etc. that can contribute to the efficient use of electrical energy. Intelligent control of behavior behind the scenes or together can save energy and costs.Heat loads such as air conditioning, electric heating and hot water supply can be controlled with a "smart" thermostat. Unlike traditional thermostats, which operate on the hysteresis principle, advanced thermostats like Nest have learning capabilities that can be automatically learned from users' behaviors. The thermostat then adjusts the room temperature efficiently by Z. For example, the heater schedules automatically according to arrival and departure times and detects when the user is not present. These strategies help to reduce energy consumption, especially when conventional thermostats or programmable thermostats are not set properly or users can not recognize that they are not present. By the detailed control of the burden of the household, the inherent thermal inertial force of the intelligent housing inventory can be used for energy storage.

The controller can "learn" the thermal response of the enclosure, including such factors as weather forecasts, weather observations, and load levels from monitored devices. The resulting model will better predict the future load. It can be used locally or the utility can be aggregated to schedule short-term control options. For example, the smart home controller may cool the house in the morning before the maximum load on the system and reduce the load on the air conditioner when a signal is sent by the utility.
Plug-in electric vehicles including hybrid cars are expected to account for 1.7 to 3.5% of all American small cars by 2025. They use technologies from the car to the house, for example, when the power supply can be more expensive and the battery can cover part of the total demand, while the peak demand or when the battery charge is lower you will reach the threshold. The adjustment of the charging plan to the mains supply conditions offers further possibilities. The usefulness of such a distributed memory can be improved when used with distributed power supplies such as solar panels[1] [2].

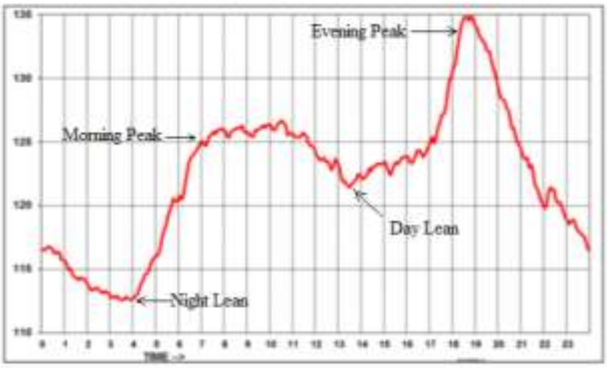

Fig 1: A Typical All India Daily Load Curve [11].

Household loads such as electronic devices, solid state lighting, variable speed motors, etc. are designed for DC powering inside. Figure 1 shows a typical full daytime Indian load curve. Most distributed decentralized renewable energy sources generate direct current. It must be converted to AC power for the mains connection. Several recent studies are considering a distributed home-based storage system to provide local backup power and ancillary services. The convergence of these sources and loads offers an interesting opportunity to improve detailed control of the load and penetration of small DC power elements [4] [5].
Smart Home can also integrate a low voltage DC bus. Renewable resources, battery storage and possibly charging cars can be interconnected on the DC bus. The DC bus is integrated into one point, and many inverters and converters become DC-DC converters. If mass production lowers costs, this simplification can lower costs and improve the efficiency of renewable systems, solid state lighting and electronic loads. However, this paradigm shift poses challenges for electrical protection, rewiring and standardization. Currently, the EMerge Alliance is developing standards for the distribution and use of DC power, including 24V and 380V distribution systems. Although the use of DC distribution continues to be a problem in refurbishing existing US property portfolios, researchers are investigating the AC / DC coupled to the power supply using existing building cabling [5].
Home appliances also have the potential for smarter energy consumption. Dishwasher, washing machine and clothes dryer can be booked in advance. The user does not have to manage directly. The start time can be delayed by several hours as long as the cycle ends when the user requests it for the first time. A similar strategy can be used to control the refrigeration and freezing circuits to reduce peak load by coordinating their operation. After all, many other burdens, such as sunlight intensity, adaptive lighting, and automatic blinds that rely on autonomous sweepers, can provide resources for intelligent energy use and enhance user comfort. These devices will use the capabilities of the sensors that make up the wireless sensor network, and the widespread use of intelligent and adaptive actuators, possibly controlled by learning algorithms [5] [6].

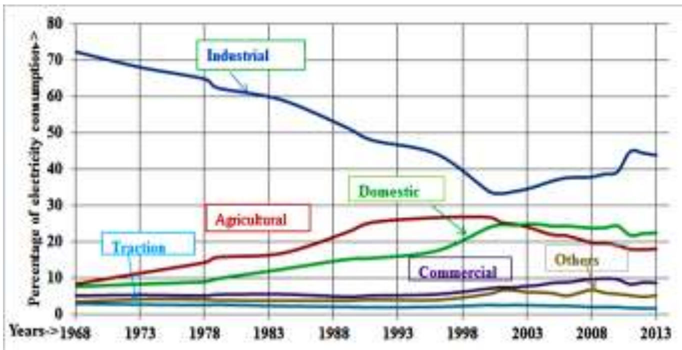

Fig 2: Percentage of Electricity Consumption By Various Sectors [11]

It can provide intelligent controls for almost all loads, from the simple on / off of state lighting to sophisticated controls for photovoltaic systems, car chargers, air conditioners and other heavy loads. With appropriate standardization and capacity increase, a practical and cost-effective communication system can connect most loads to a central home automation system. The controller can provide residents with detailed monitoring and control. With a suitable AMI interface, houses can group resources for system usage that are requested by service providers. Figure 3 shows a block diagram of the centralized smart home and its components [8].

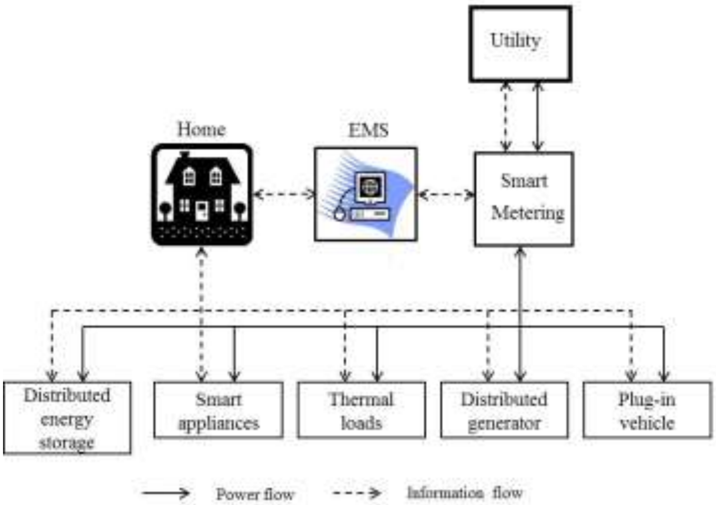

Fig 3: Schematic Diagram of A Centrally Controlled Smart Home

III. System Model

None of the implemented DSM techniques (Demand Side Management) can lead to any of the following forms of power reduction: peak clipping, savings and load shifts. To achieve this, the following techniques are used in the current smart home.
Direct load control
Load limiters
Real time use of pricing
Smart energy meters
Smart appliances

Current research and work in this field is being done using DSM techniques with the use of smart energy meters and artificial intelligence, which can be found here.

A. Demand response and Smart grid

However, considering the DR and smart grid technologies in the current smart home, the electricity providers see DR as a choice of viable assets, which has been enhanced by the modernization of the network. The current example is included. Sensor networks that recognize the problem of maximum load and can take control of key ranges through programmed changes eliminate excessive load and power outages. The advanced smart metering framework extends the range of time-based charging programs that can be offered to consumers.

For example, smart consumer frameworks, such as home displays and smart area networks, reduce the need for consumers to change their behavior or reduce peak loads due to data on energy use and costs. Finally, further studies are being conducted on whether artificial intelligence technologies such as game theory and neural network are used in the current Smart Home DR and Smart Grid program [6].

B. Arduino based models

The prototype used in this study was an Arduino UNO microcontroller with IoT. We've studied how this hardware has been used in smart home applications so far. Studies have shown that home automation is an important application. Other applications include temperature control, energy metering, remote management such as Wi-Fi and GSM, and the control of smartphones with custom applications [7] [9].

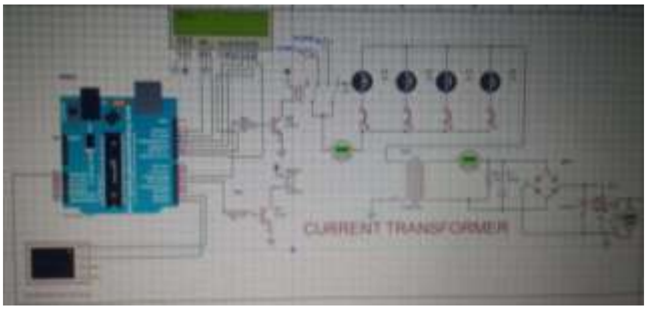

Fig. 1. Proposed System Model of The Prototypes Operation

Smart homes smart grid technology can reduce traditional investments with a demand-response system. It is implemented by a utility that intelligently turns on and off intelligent power plugs throughout the home based on the main and auxiliary times through the Smart Grid communication. In order to allow consumers to move loads during peak periods and non-productive times, you need a power supply for the equipment that can operate autonomously based on the wireless signals received from utilities. The appropriate user connects the appliance to these connectors by giving priority to using the appliance and creating their own hierarchical system. However, as concerns must be expressed that the end user may be caused by the installation of a smart power plug at home, e.g. the practical idea of the demand response and the separation of the top options as well as the demand management The system is added. This allows the user to set the date and time of the wireless smart plug automatically and manually. Fig. 4 shows a simple system model of the prototype operation based on the above description.

IV. Simulation Result

In this section, we present simulation results on demand-response mode, show the performance of an energy-efficient future smart home that can save energy with the proposal system for the future smart grid and monthly expenses, while saving energy I will rate it.

Table 1: Simulation Result Analysis for DRM scheme

Lamp Load				Current (A)	Source		Load	
1	2	3	4		A	B	Base	Over
Off	Off	Off	Off	0	✓	-	✓	-
On	Off	Off	Off	225	✓	-	✓	-
On		Off	Off	446	✓	-	✓	-
On	On		Off	642	-	✓	-	✓
On	On	On	On	815	-	✓	-	✓

We start by assessing the load that the network has to cope with over a 24-hour period for a specific region, in this case, 10 house groups. Next, we compare it to the result when you use an energy-efficient system. How does this reduce the network load? In this case, the demand-response system reduces power consumption at peak and high prices.

V. Conclusion

Through a new intelligent way of efficiently producing, distributing and managing electricity, we have come to a new mindset in this time. In this article, we examined the impact of demand-response systems and demand-side management systems in smart homes by using future communication technologies for smart grids. The use of the prototype not only saves energy but also shows that it is possible to reduce consumers' monthly expenses.

Smart Home relies on a range of implementation technologies in both power and consumer electronics. To spread Smart Homes, technologies need to be standardized and matured in each of these areas. Given that the buy-in of users is the key to setting smart homes, rigorous consumer testing needs to be integrated with the smart home design process. Without a comprehensive interdisciplinary assessment of smart homes, expensive systems can run counter to expectations. Research in this field has clearly unresolved research topics.

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