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An Efficient Load Management System for Smart Homes Using Renewable Energy Resources

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ABSTRACT

Demand Side Management (DSM) will play a significant role in the future smart grid by managing loads in a smart way. DSM programs, realized via Home Energy Management (HEM) systems for smart cities, provide many benefits; consumers enjoy electricity price savings and utility operates at reduced peak demand. In this paper, Evolutionary Algorithms (EAs) (Binary Particle Swarm Optimization (BPSO), Genetic Algorithm (GA) and Cuckoo search) based DSM model for scheduling the appliances of residential users is presented. The model is simulated in Time of Use (ToU) pricing environment for three cases: (i) traditional homes, (ii) smart homes, and (iii) smart homes with Renewable Energy Sources (RES). Simulation results show that the proposed model optimally schedules the appliances resulting in electricity bill and peaks reductions.

Keywords– Appliance Scheduling, Binary, Particle Swarm Optimization, Genetic Algorithm, Cuckoo Search Algorithm, Energy Management System, Electricity Pricing, Smart Grid.

I. Introduction

Global energy demand is increasing rapidly in comparison to the steady growth of energy generation and transmission setups. In traditional grids, utilities cater this situation by increasing the total generation capacity as a function of peak demand. However, the resulted system (generation and distribution) by a large part is unutilized. Recently, two parallel approaches are developed to handle such situations: (i) using and promoting energy efficient technologies to reduce the aggregated power consumption, and (ii) developing strategies to control the aggregated power demand. Collectively, the two parallel approaches make DSM whereas the later approach is known as Demand Response (DR) .

United States household electricity usage data show that 42% of energy is consumed by household appliances . Major forces are creating a new paradigm on residential electricity markets as energy optimization becomes an increasingly important challenge in our society. New technologies are being deployed, including advanced meters, controllable appliances distributed energy generation and storage systems, i.e., plug-in hybrid electric vehicle batteries,

A DR strategy coordinates the requirements between the energy provider and the customer. On the utility side, by reducing high peaks, DR programs are helpful in protecting grid from the risk of outages, reduce the usage of spinning reserves during peak load periods, balance the supply demand ratio, and improve the grid reliability. Further DR benefits include:

(i) lower electricity price in wholesale market,

(ii) adequacy saving and operational security,

(iii) integrated resource planning studies, and
(iv) improved choice for using DR.

II. Literature survey

Grid of the future

This [Smart grid] transformation will be necessary to meet environmental targets, to accommodate a greater emphasis on demand response (DR), and to support plugHin hybrid electric vehicles (PHEVs) as well as distributed generation and storage capabilities On one hand, the transition to a smart grid has to be evolutionary to keep the lights on; on the other hand, the issues surrounding the smart grid are significant enough to demand major changes in power systems operating philosophy.

Smart metering, sometimes called advanced metering infrastructure (AMI), which usually includes control and monitoring of devices and appliances inside customer premises Smart pricing

III. Proposed And Optimize Energy Consumption

An optimal approach for scheduling the power usage of smart appliances in a home is proposed based on the pricing scheme. Accurate and reliable load management are a key element of the automation. Whereas, automation of appliances is a critical aspect of energy management in the residential sector,

especially in the smart grid environment. The concept of load scheduling approach to monitor the electricity usage of appliances is introduced.

Transmitting and distributing direct energy supply from renewable such as solar and wind when and where needed in the grid is a real challenge. Through our client engagements, it is clear that the renewable integration focus is shifting to the “mid-grid” where renewable generation meets medium voltage apparatus in a new, smart distribution system.

A. CONCEPTUAL MODEL

Fig. 1 shows a graphical representation of the proposed model that serves as the basis for the development of optimization algorithm. It consists of integrated power & renewable energy utility that is interested in serving all types of residential or commercial loads. The respective power grid and on-site RES act as a single node. The optimization program dispatches power to residential loads and storage system that could be utilized during high demanding hours. The energy demand of residential load is directly fulfilled by using grid energy, direct renewable energy or storage systems depending on the electricity price in particular hours..

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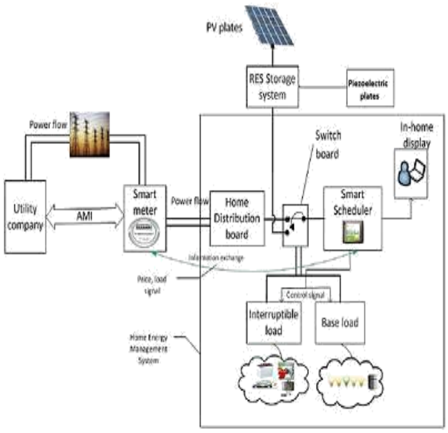

fig 1. block diagram

B. Advance Metering Infrastructure

Rather than a single technology, advance metering infrastructure is an integration of multiple technologies such as smart metering, home area network, software interfaces, and data management applications. Along with these technologies, two way communication, sensors, and distributed computing make it feasible for both end users and independent system operators. The system composed of these technologies leads to make intelligent decision making, reliability, safety and ease of use . Regarding home area network, system includes smart meters, communicating thermostats, back-haul communication network, data centers, and data integration into new and old application platforms. According to Fig. 1, smart meter is located between home area network and utility which forwards aggregated load demand to utility via smart meter.

Traditional users- this class of users is non-price sensitive, thus have no HEM architecture in their homes. *Smart users*- this class of users has HEM architecture but have no on-site energy generation system. *Smart Prosumers*- this type of users not only consume the grid energy but also produce some energy from the RES system and have HEM architecture and RES generation along with storage system in their homes.

D. Renewable Energy Generation

energy crises and environmental concerns, much attentions are given to the integration of renewable energy resources. Among all renewable energy sources, solar energy is most abundant and easily accessible. However, its unpredictable nature poses many questions)to energy retailers and prosumers. A study conducted in shows that Earth receives 174,000 terawatts solar radiations and approximately 30% are reflected back to atmosphere. Then based on solar radiations, the total energy (kW) obtained from solar panels.

C. User Categorization

In this work, a new approach is proposed that autonomously generates energy consumption pattern for each appliance based on the electricity price tariff. First, we categorized the energy consumers into three categories; traditional users, smart users and smart prosumers.

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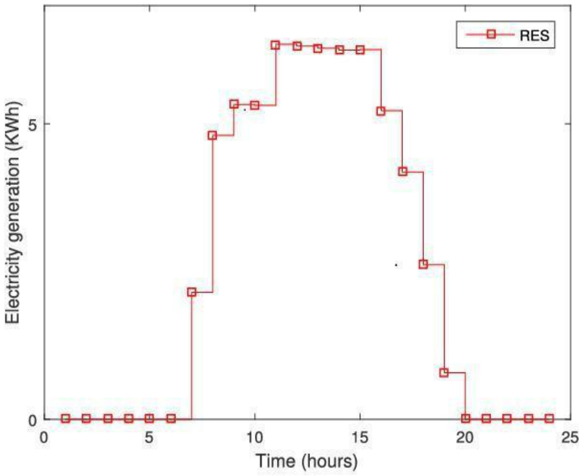

fig 2. Energy generation from solar panel

This information addresses the recent trends in renewable energy integration into a smart home to lower electricity bill along with grid stability.

IV. Results and Discussion

To evaluate the performance of the proposed appliance scheduling schemes, we simulate daily energy use of a set of household appliances. The attributes; number of appliances, Operation Time (OT) and the power rating of the appliances are shown in table 1. Simulations are performed for three main cases: i) Traditional homes (without HEMS), ii) Smart homes, iii) Smart homes with RES system. Peak shaving was realized by load adjustment of devices with soft schedules. Shiftable appliances requests were altered by systematically switching them off and on.

A. Electricity traiff

The ToU pricing policy is used for billing of the energy users. ToU pricing establishes a variable price structure for high peak, shoulder peak, low peak and off peak hours. These prices are typically established well in advance by the utility grid. The ToU pricing provides financial benefits to the users who take part in DR program for shifting their load from high peak to off peak hours. In ToU pricing scheme, the cost of electricity is charged at different rates during different time horizons.

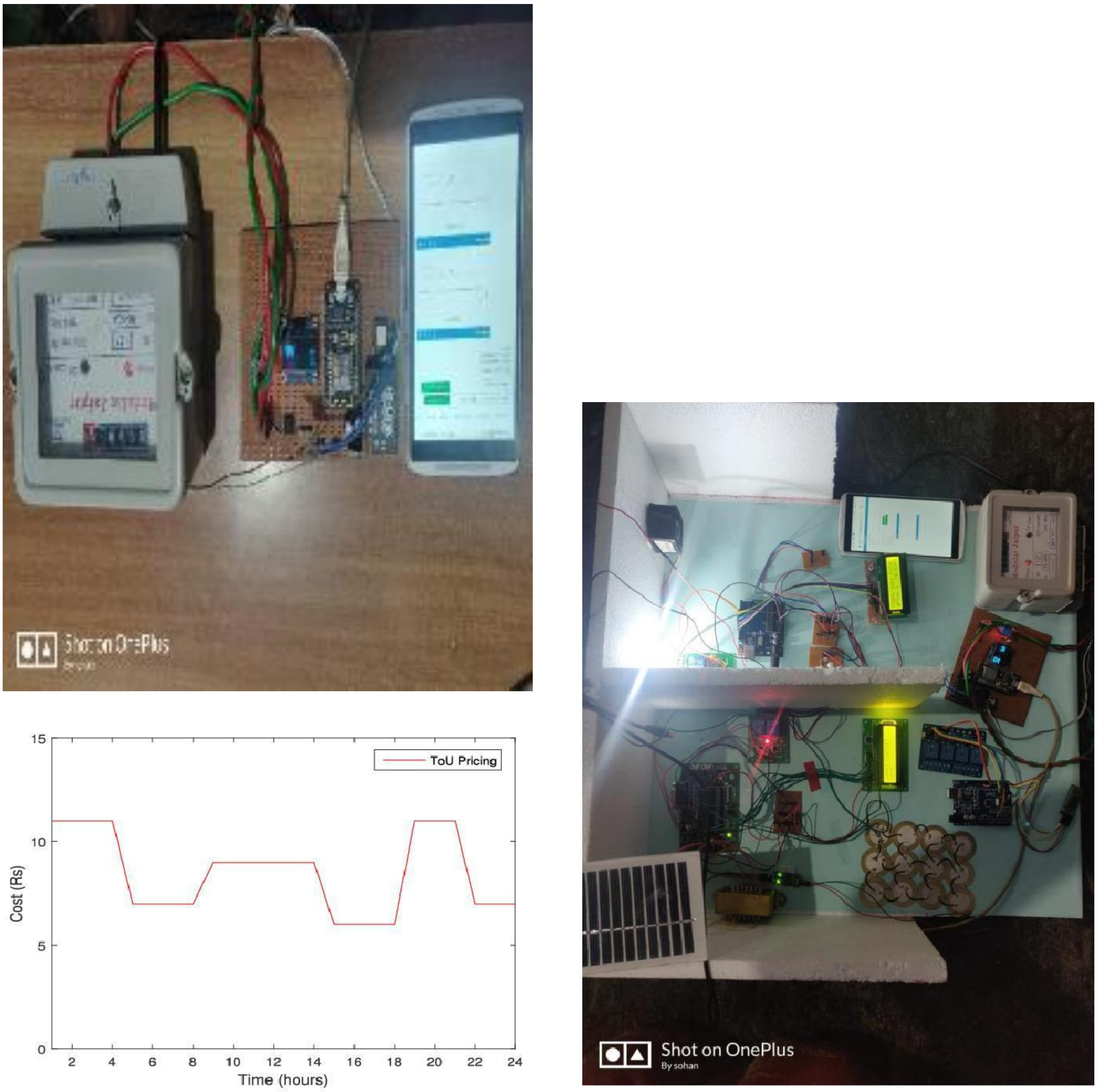

fig 3. ToU Pricing Scheme

V. Conclusion and future work

This paper presented a new HEM model based on ToU pricing scheme with and without RESs. In order to optimally consume grid and RES energy. The results obtained from the simulations revealed that cost saving is achieved in terms of minimized user electricity bill. By using BPSO algorithms, the proposed model significantly reduced the electricity bill and high peaks. In the future, we will investigate other optimization techniques for further reducing the electricity bills of end uses.

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