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Conceptualization Of an Intelligent Energy Monitoring System for The Home in Smart Grid

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ABSTRACT

In the context of a smart grid, a conceptualization of an intelligent energy monitoring system (CIEMS) system is essential for implementing residential Demand Response programmes. It gives a homeowner the capacity to carry out intelligent load controls automatically depending on utility signals, client preferences, and load priority. Analysis of the CIEMS's residual energy usage and communication time delay for load control. Designing how each load behaves when it is regulated by the CIEMS unit and taking electrical measurements for various loads are the key objectives. Demand response (DR) is the process through which demand-side resources alter their usual patterns of energy consumption in response to changes in the cost of power. The CIEMS system consists of a CIEMS unit that gives homeowners monitoring and control capabilities, as well as load controllers that collect information on electricity consumption from a set of appliances and carry out local control in response to commands from the CIEMS system. An interface between a utility and the database that tracks electrical use can be provided by a gateway, like a smart meter.

Keywords: Demand response, Residual energy, Intelligent energy monitoring system, Electricity consumption

INTRODUCTION

A perfect storm of economic, social, and environmental pressures on finite energy supplies could result from the world's expanding population and escalating energy demand. Researchers predict that in almost every nation, current energy production capacities won't be able to keep up with rising demand without the development of new energy sources, such as new power plants. These supply-side remedies, however, disregard a more alluring option, which is to reduce or slow down energy use by using technology to significantly improve energy efficiency.

Utilizing electric power generating and transmission resources inefficiently has long been a concern in many regions of the world. For instance, only 5% of the generation assets in the Dominion

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Virginia Powers service area are utilized. Demand response at client locations has helped to address this issue to some extent by obtaining a more precise control over the resources available. The usage of a Home Energy Management (CIEMS) system can make it possible to deploy a completely automated DR solution, or auto-DR, in order to realise the requested DR feature.

Interest in CIEMS systems has considerably increased in recent years. Different CIEMS systems have been developed based on various communication protocols, including ZigBee and power-line carrier. A CIEMS system that can provide data on the energy consumption of particular appliances is suggested. To further reduce energy costs and peak loads, an in-home energy management (iHEM) system is suggested. Focus is also placed on scheduling and managing in-home appliances to offer financial benefits for domestic energy management. Another CIEMS system implementation can control power-hungry loads to lower peak household demand while taking into consideration user preferences for comfort and load priority.

Inefficient utilisation of electric power generation and transmission infrastructure is a long-standing issue in the United States and other regions of the world. In the service region served by Dominion Virginia Power, for instance, only about 20% of the generating capacity is utilized at any given moment. Demand side management, first implemented in the 1980s, has helped alleviate this issue to some degree. The advent of the smart grid has made it possible for customers to engage in demand response on their own property, giving CIEMS greater control over their utility usage .

LITERATURE SURVEY

When discussing the Internet of Things (IoT) in the context of a monitoring and automation system, ***Twinkle et al. (2016)*** emphasise the advantages. The goal is to use a smartphone as a universal remote for controlling electronics throughout the house, with Wi-Fi as the underlying network and an arduino-uno as the brains of the operation. Remote access to home appliances is possible through computer or mobile device, using the same web-based interface. The system also provides extensive smart environment condition and monitoring via a multitude of sensors, which provides the data necessary for the autonomous detection and correction of any device difficulties.

Vinay et al. (2015) detail the system's design, which includes a wide variety of sensors. The Intel Galileo uses its Wi-Fi module to establish a network connection to the internet, after which it can begin to collect information from its sensors. The next step is to fine-tune the sensor thresholds. The data collected by the sensor is sent to a web server and eventually saved in the cloud. These data can be analysed whenever and wherever is most convenient. An alarm will sound and corrective action will be taken if sensor readings fall outside of a specified tolerance zone. This variety monitors the house for gas leaks, temperature changes, and motion. Data like as temperature and motion detection readings can be saved via cloud computing. In response to a temperature rise above the predetermined threshold, the cooler will activate and remain on until the temperature drops below the threshold. An alert will go off if there is a gas leak. The home's interior lighting is managed by a light sensor located on the exterior. Users can monitor their electrical appliances from afar using their internet connection. Inputting the IP address of the web server allows you to remotely turn off lights and other electrical equipment.

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Priya et al. (2016) discuss a password-protected remote system for controlling household appliances. It connects to the Bluetooth module, initialises the LCD and UART protocol, and displays the status of the power loads. The system primarily makes use of two user interfaces. The user is able to view the operational status of their devices via this interface. If the state of the appliance changes, the user interface will be updated immediately. The window GUI will act as a bridge between the desktop and the mobile device, allowing data to flow freely between the two. In the event of a connection drop, you can try reconnecting over the USB cable. With the help of IoT, a user may check in on their devices and make changes to their configurations from any location in the world.

Home Automation Device Protocol is a proposed protocol standard by ***Thomas et al., 2015.*** (HADP). The goal of this infrastructure is to enhance the performance of interoperable home automation devices. Using the If-This-Then-That (IFTTT) service, we can create a system of inter-device communication protocols and actions that can produce and control interactions from a single location. When activating a home automation device, the system will only send the minimum number of data packets required, thereby reducing its energy consumption and thus its negative effect on the environment.

IMPLEMENTATION METHODOLOGY

We have created an energy management system for the house (CIEMS) that relies heavily on ARM 7 as a central component. Multiple electrical components, such as relays, relay drivers, current transformers, and voltage transformers, are connected to the ARM 7. Right now, the metre is being used to measure the voltage and current being used by the electrical equipment, with the results being presented on the LCD screen. First, we need to know how much electricity is used by each of the home's electrical appliances, and then we can add those totals to get a sense of the home's total power usage. When we know how much energy is being used in total, we can allocate the power from the wall sockets to the various appliances in the house so that they receive the amount of energy they need. In addition, if it is found that a device is not needed during a particular time of the day, the supply for that device can be shifted to another device with a larger requirement for supply. There is also a cell phone and a bluetooth gadget that serve as the controller. As a result, the CIEMS system and the control section talk to one another mostly over bluetooth. The CIEMS system communicates with the homeowner, who also has a mobile device, via bluetooth to report on the health of all of the interconnected devices. As seen in Fig. 1, is a block diagram of the proposed system.

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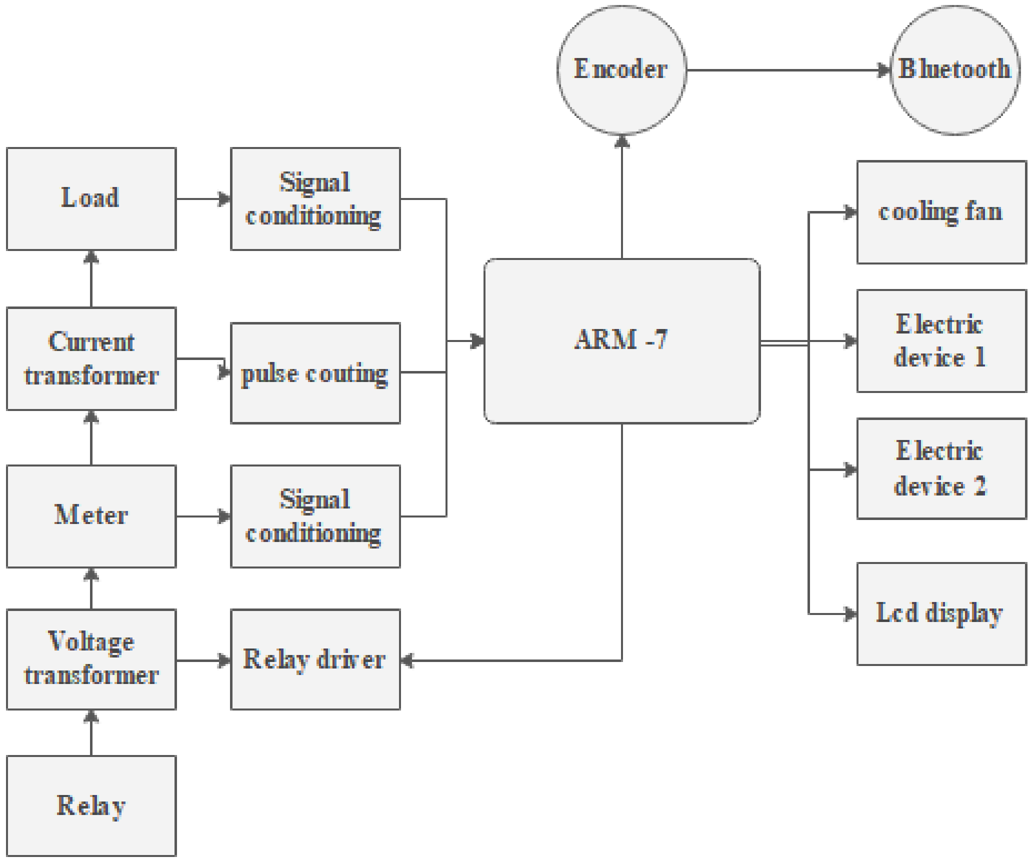

Fig 1: Block diagram of proposed model

Let's assume that the DR event signal sent by a utility to a home always includes both the demand limit amount (in kW) and the period of a DR event (hours). The demand limit determines the maximum amount of energy a single home can consume throughout the duration of the DR event. Water heaters (WH), air conditioners (AC), dryers (DW), and electric vehicles (EVs) are all considered by the embedded CIEMS algorithm (EV) The load management algorithm used by CIEMS begins with a phase of data gathering in which:
a) The maximum permitted demand in kilowatts and the duration of its effect are determined.
b) The total kilowatt hours (kWh) that the appliances consume.

Temperatures in the room, the air, and the water heater are all expressed as a c) F.
d) Prioritizing workloads and user preferences.
Second, the CIEMS algorithm looks for violations of the demand limit and the comfort level. The CIEMS algorithm determines whether or not the aggregate consumption of a household is higher than the set demand limit. The CIEMS algorithm, for instance, examines these factors for violations of the user's comfort level:

a) if the WH's hot water temperature drops below the set point.

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b) If the air conditioner is set to kick on when the temperature drops below a certain point.
c) If the dryer is able to complete the cycle in less time than the allotted drying time.
d) In the case of electric vehicles, if the EV can be fully charged in the allotted period.

Third, the CIEMS unit determines the status of each appliance according to the intended demand limit level if a comfort level violation has occurred. When the CIEMS unit detects a demand limit has been exceeded, it will transmit a signal to turn OFF the appropriate appliances in order of priority. In the event of a deviation from the desired temperature or humidity, the appropriate appliances will activate automatically. The CIEMS system will make the necessary decisions to keep the home's total power consumption (with all appliances turned on) below the set maximum.

RESULTS AND DISCUSSION

Each of the four loads' power ratings and electrical measurement data from the experiment. The actual power usage of the hair dryer was far lower than its rating would indicate because of the low heat setting used in the tests.

Parameters of the house are presented in Table 1, including the overall square footage of the dwelling, the square footage of its walls, ceilings, and windows, the square footage of the dwelling's heat resistance, and the number of people who call the dwelling home.

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Table 1: Different parameters present in the home

This house has the electrical capacity to run an electric water heater, air conditioner, clothes dryer, and electric vehicle. We simulate a clothes drier with a hair dryer, an air conditioner with a real unit, a water heater (WH) with an electric baseboard heater, and a battery-powered car with yet another electric baseboard heater in our lab. The load controllers monitor the real-time current and voltage of a hair dryer, air conditioner, and two electric baseboard heaters to demonstrate the potential of the planned CIEMS system for DR in the house. As can be seen in Table 2, scalar factors are applied to the readings to make tCIEMS equivalent to the power consumption by the four programmable appliances in the made-up home. The reload database's expected critical load information is combined with the CIEMS's amplified readings to derive the home's total consumption in kilowatt hours. The additional hypotheses are (a) the cooling capacity of the air conditioner is 34,000 BTU, (b) the size of the WH tank is 80 gallons, (c) drying an entire load of laundry takes 60 minutes, and (d) charging the battery of the EV takes 90 minutes.

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Household controllable loads	Values (Kilowatts)	True loads utilized in the demo	True loads (KW)	Scale Factors
Clothes dryer	3.0	Hair dryer	0.90	5.1
Motor	0.3	Motor	0.5	1.8
Heating coils	3.7	Heating coils	4.0	0.01
Air conditioner	2.3KW	Portable Ac	2.5	4.1
Water heater	4.5KW	Heater 1	0.61	**8.2**
Electirc vechile	3.3KW	Heater 2	0.61	5.8

Table 2: comparing various household manageable load and their values in kilowatts

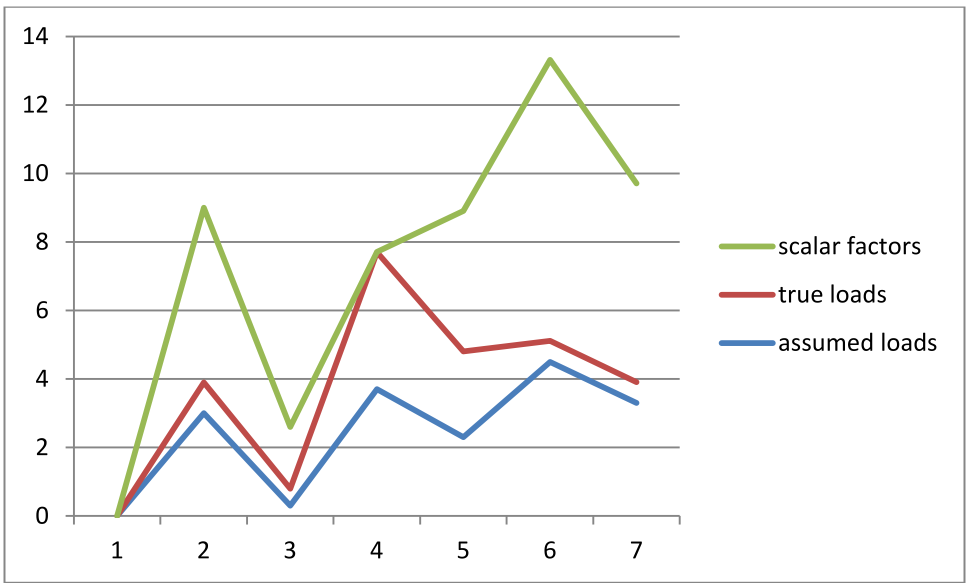

Fig 2: Guessed load values vs True load values

These theories suggest that the water heater should be prioritised above the air conditioner, the air conditioner over the clothes dryer, and the clothes dryer over the electric car. The assumptions we use while setting your preferred temperature are as follows: Both the hot water and the surrounding temperature should be between 110 and 120 degrees Fahrenheit, with the latter ideally matched with a temperature of 74 to 78 degrees. You have till midnight to dry your clothes, and that time cannot exceed 30 minutes, of which no more than 30 minutes can be spent with the heating coils turned on (to prevent heat loss). The electric vehicle needs to be fully charged before 8:00 a.m., and the charge must be maintained for at least 30 minutes before the status can be paused. It is possible to temporarily disable a preference option if doing so is required to keep a higher-priority appliance operational.

CONCLUSION

Therefore, we have built a functional CIEMS system and are keeping tabs on how each load performs when controlled by the CIEMS. The CIEMS unit has recorded electrical measurements of various loads, and power distribution has been accomplished in compliance with device

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requirements.

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