ENERGY MANAGEMENT SYSTEM FOR INTELLIGENT BUILDINGS USING GRID CONNECTED SYSTEMS

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*Abstract—****Buildings are the major factor of power demand because, they consumes 40% of total power in a systems. So, Demand Side Management (DSM) is a promising technology for power balancing in future energy systems. To avoid or delay large investments in grid infrastructures and storage facilities we have an idea i.e., Energy management using grid connected sources Smart buildings provide customers with information on various services and allow them to track the impact of their resource consumption on the overall sustainability of their buildings. Energy management is one of the most demanding issues within such urban centers owing to the complexity of the energy systems and their vital role. This project introduces a planning and operation models within the smart buildings by classifying roles demand side management (DSMs) into main intervention areas: parameters and temperature constraints, tracking human, energy prices, regulatory constraints and energy demand. More-complex building energy models integrating more than one intervention area are also reviewed, outlining their advantages and energy demand, existing trends and challenges, and some relevant applications. Finally, a methodology for developing an improved energy model in the smart buildings context is proposed, along with some additional final recommendations***

Keywords: Intelligent building, load shedding, grid, PIR,Human detection, LDR,temperature sensor.

1.INTRODUCTION

The concept of intelligent building was born in the United States of America in the early 1980sThe first ever intelligent building in the world, according to China Intelligent Building Technology Information Network (C1BTIN) (2002) was built in Hartford in the United States in 1984.That notwithstanding, there has not been a clearly defined concept of what is to be considered an intelligent building even till date. Those outside the construction industry often wonder how an assembly of inanimate building materials can be intelligent, even members of the industry, especially developers and owners. Some see buildings furnished with the latest technology as being intelligent. The Intelligent Building Institute in the United States has proposed thus; *"an intelligent building is one that provides a productive and cost-effective environment* through optimization of its four basic elements - structure, systems, services and management, and the interrelationships between them. Intelligent buildings help business owners, property managers and occupants to realize their goals in the areas of cost, comfort, convenience, safety, long-term flexibility and marketability .*Such definition certainly leads to a broader meaning* - **overall performance, not only of the building itself, but also of the entire construction process.** The new trend in intelligent buildings is concentrated on both economic and environmental sensitive developments. Flexibility and low energy consumption have become the issues, which must be addressed, to cope with the fast growing technology and ever changing of the modern world.[1].This project will changes many complications surrounding the definition of intelligent building and attempts to summarize them into more simplified, clearer and un-ambiguous terms. It also seeks to enlighten both the private and corporate building developers on this emergent high-tech, environmental friendly, safe and automated buildings, with effective telecom systems, and bring to fore, some challenges it poses to building practitioners, in Nigeria in the 21st century The increasing availability and affordability of wireless building and home automation networks has increased interest in residential and commercial building energy management [2]. This interest has been coupled with an increased awareness of the environmental impact of energy generation and usage. Residential appliances and equipment account for 30% of all energy consumption in OECD countries and indirectly contribute to 12% of energy generation related carbon dioxide (CO2) emissions (International Energy Agency, 2003) [3].These figures highlight the importance of managing energy use in order to improve stewardship of the environment. They also hint at the potential gains that are available through smart consumption strategies targeted at residential and commercial buildings. The challenge is how to achieve this objective without negatively impacting people's standard of living or their productivity. The three primary purposes of building energy management are the reduction/management of building energy use; the reduction of electricity bills while increasing occupant comfort and productivity; and the improvement of environmental stewardship without adversely affecting standards of living. Building energy management systems provide a centralized platform for managing building energy usage. They detect and eliminate waste, and enable the efficient use electricity resources.[3] The use of widely dispersed sensors enables the monitoring of ambient temperature, lighting, room occupancy and other inputs required for efficient management of climate control (heating, ventilation and air conditioning), security and lighting systems. Lighting and HVAC account for 50% of commercial and 40% of residential building electricity expenditure respectively, indicating that efficiency improvements in these two areas can significantly reduce energy expenditure. These savings can be made through two avenues: the first is through the use of energy-efficient lighting and HVAC systems; and the second is through the deployment of energy management systems which utilize real time price information to schedule loads to minimize energy bills. The latter scheme requires an intelligent power grid or smart grid which can provide bidirectional data flows between customers and utility companies. DSM is used to control the customers' load demand. Thus, it modifies the customer's energy consumption and also improves customer satisfaction. In order to implement DSM, a Home Energy Management System (HEMS) is required to flatten peak hour demand and reduce power consumption[4] .The smart grid is characterized by the incorporation of intelligence and bidirectional flows of information and electricity throughout the power grid. The smart grid will also facilitate greater incorporation of renewable energy sources such as wind and solar energy, resulting in a cleaner power grid.[5] The smart grid must however, be allied with smart consumption in order to realize its full potential. The extension of the smart grid into the home via smart meters, home automation networks (HAN's) and advanced metering infrastructure (AMI) enables the provision of real-time pricing information and other services to consumers.[6] This facilitates services such as residential DR. DR is the modification of user electricity consumption patterns due to price variations or incentives from the utility, and its objective is to reward behavior which reduces energy utilization during peak pricing periods.[7] Smart grid DR provides a means of stretching current power infrastructure and delaying the need to build new power plants. The combination of appliance energy monitoring and control, with intelligent lighting can result in energy savings greater than 15% in residences alone.[8] We begin by defining intelligent buildings and discuss building and home automation networks, as they provide the framework for intelligent environments.[9] We then discuss appliance energy management and follow this with intelligent lighting control.[10] We conclude with a discussion of the privacy and security threats that must be addressed in smart environments in order to guarantee widespread adoption of these technologies.[11]

1.1 Intelligent buildings

The Intelligent Building provides a productive and cost-effective environment through optimization of its four basic elements – structure, systems, services and management – and the interrelationships between them. Intelligent buildings help building owners, property managers and occupants realise their goals in the area of cost, energy management, comfort, convenience, safety, long term flexibility and marketability.These buildings are characterized by three features.

- Automated control
- The incorporation of occupant preferences and feedback
- Learning ability

Such environments are distinguished by a tight coupling of HVAC, security, lighting, and fire protection systems. They are sensor rich and produce large amounts of data which can be analyzed to predict occupant behavior and detect equipment faults. They can automatically sense, infer and act in order to balance user comfort and energy efficiency www.intechopen.com Energy Management for Intelligent Buildings,a concept also known as ambient intelligence or pervasive computing. Pervasive computing is the networking of everyday devices, objects and materials using embedded computers equipped with networking, sensing and actuation capabilities. As networked embedded computers reduce in size and cost, they will proliferate at even greater rates. This development, combined with smaller and cheaper sensors and actuators, will result in the availability of networked processing power in smaller and smaller packages. The result is the permeation of pervasive computing into homes, offices, factories, automobiles, airplanes and every area that humans occupy

1.2 Building automation and home automation networks

The field layer comprises of temperature, humidity, light level, and room occupancy sensors. The actuators are made up of automated blinds, light switches, flow valves etc. The automation layer consists of direct digital controllers (DDC's) which provide precise automated control of building processes using digital devices (Newman & Morris, 1994), while the management layer provides centralized management of the entire system. It provides a view of the whole building, facilitating centralized control, data collection and analysis. A primary function of building automation systems is energy management. This goal is achieved by means of schemes such as the duty-cycling of loads to conserve energy; peak load management to regulate total power consumption during peak hours; scheduled start/stop of building HVAC systems at the beginning and end of each day; and real time control of building systems in response to occupancy detection Fig. 1. Building automation system hierarchy Sensors and actuators are an integral part of home and building automation networks. These devices serve as the eyes, ears, hands and feet of the system. Unfortunately, wiring costs frequently exceed the cost of sensors .so the availability of low-cost wireless communication schemes such as enables cost effective and rapid deployment of wireless sensors and actuators throughout a building. Wireless nodes also provide flexibility, easy re-deployment and reconfiguration, all of which are very important features for commercial buildings as they are often re-partitioned and modified to meet differing occupant requirements. Wireless sensor and actuator networks (WSAN) are defined as a group of sensors and actuators connected by wireless medium to perform distributed sensing and actuation tasks .These sensors tend to have the following features: battery powered; low-cost; low-energy consumption; short range communication facilities; limited sensing and computation capabilities.

2. PROPOSED SYSTEM

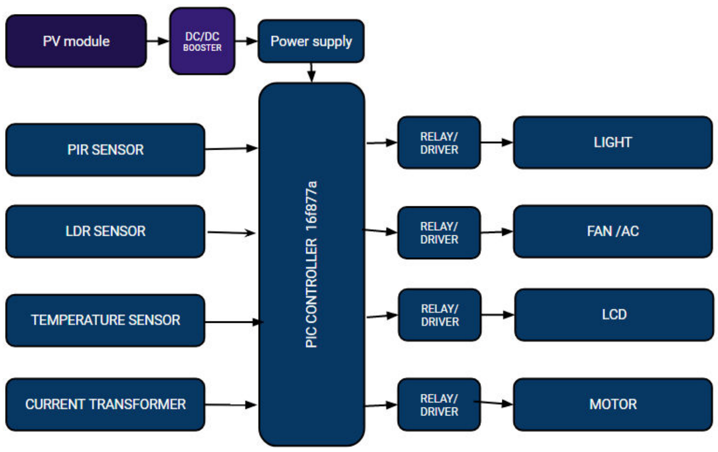


Fig 2.1 *Block Diagram Of Intelligent Building*

Load-shedding is a process by which the electrical authority handles the lack of the electrical power being consumed by the society. Shedding is done to minimize the load being consumed by the society through several substations which are connected to the main power station. When the frequency of the power generator falls down, it fails to generate the required power. As a result, the authority lacks the scheduled amount of power & this leads the authority to perform a shedding. And the main station orders the sub-stations to cut some of the feeders for a certain period of time & thus the shedding procedure continues. To ensure that the system is stable and available during disturbances, manufacturing facilities equipped with on-site generation, generally utilize some type of load shedding scheme. In recent years, conventional under frequency and PLC based load shedding schemes have been integrated with computerized power management systems to provide an "Automated" load shedding system. It can provide faster and optimal load relief by utilizing actual operating conditions and knowledge of past system disturbances.

To reduce the peak hour demand a controller based scheduling technique for handling the demand over the power scheduling concludes the time allocation based on shifting.

Table 2.1 Load Shedding Table

Appliances	Load priority	Needs	Rating	Usage Time
Light	1	4-8 Hrs per day	40 W	5 A.M -8 A.M 6 P.M – 11 P.M
Fan	2	4-12 Hrs per day	75 W	5 A.M - 7 P.M
AC (1 ton)	3	4-10 Hrs per day	1400 W	9 P.M – 7 A.M
Motor	4	1-2 Hrs per day	3000 W	7 A.M – 8 A.M

The block diagram consists of various sensors and operating drives which makes a building into intelligent building. Some of them are PIR sensor which is used to human detection and lighting solution for the entire buildings, LDR sensor used to control light intensity when lighting is available and then, temperature sensor (LM-75) used for the purpose of controlling room temperature via fan speed adjustments. The whole system is monitored through the LCD.

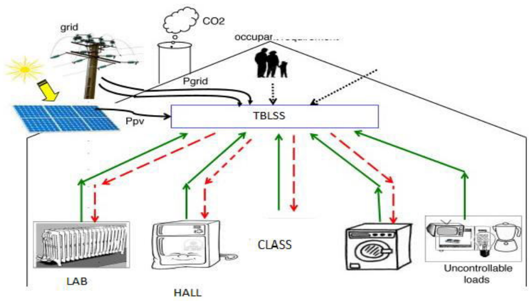


Fig 2.2 General TBLS System.

2.2 *CIRCUIT DIAGRAM*

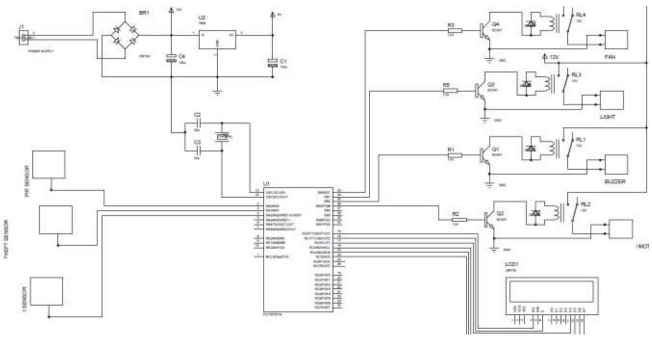


Fig 2.3 Intelligent controller Circuit diagram.

Algorithm:

1) Start.
2) Initiate the microcontroller.
3) Check the interrupt from sensors.

a. If first IR sensor produces interrupt then check for the interrupt from second sensor within 5 seconds and if interrupt is produced increment the count, else exit the loop.

b. If second sensor produces interrupt then check for the interrupt from first sensor within 5 seconds and if interrupt generated decrement the count, else exit the loop.

4) If the count! = 0 then set the output of microcontroller high, turning on the main switch.
5) When count = 0 then set the output of the microcontroller low.
6) Display the count.
7) Repeat steps 3 to 6.

The human detection circuit does not control any individual electrical appliances rather it controls the main switch of the room. So if the room is empty than automatically all the appliances will be turned OFF. A parallel switch is placed connected to the main switch to give the flexibility of manually controlling the power

3. ADJUSTING INTENSITY OF LAMP ACCORDING SUNLIGHT

If we use less wattage light its intensity is low. And another problem is with less sunlight we feel the requirement of lamp, as its intensity and wattage cannot be adjusted so we have to use the same high wattage bulb or tubes. So we need a lamp whose intensity can be adjusted according to the intensity of sunlight. The intensity of the lamp can easily be adjusted by controlling the voltage to the lamp. The charging time of capacitor can be adjusted using a series resistance. According to the charging of capacitor the voltage supplied to lamp can be controlled, controlling intensity.

3.1 LDR

The most used sunlight intensity sensor is LDR. LDR is a light dependent resister. The sensor's resistance varies with change in intensity falling on the sensor. The theoretical concept of the light sensor lies behind, which is used in this circuit as a darkness detector. The LDR is a resistor as shown in Fig. above, and its resistance varies according to the amount of light falling on its surface. When the LDR detect light its resistance will get decreased, thus if it detects darkness its resistance will increase.

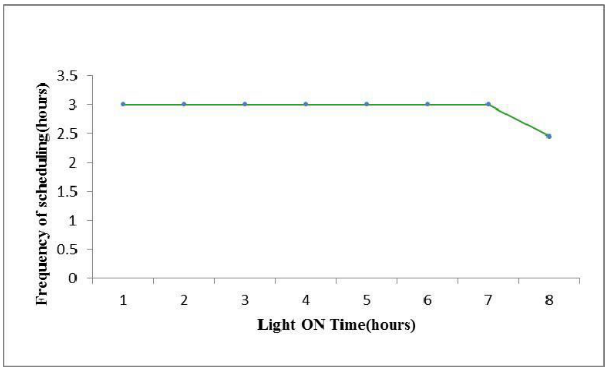
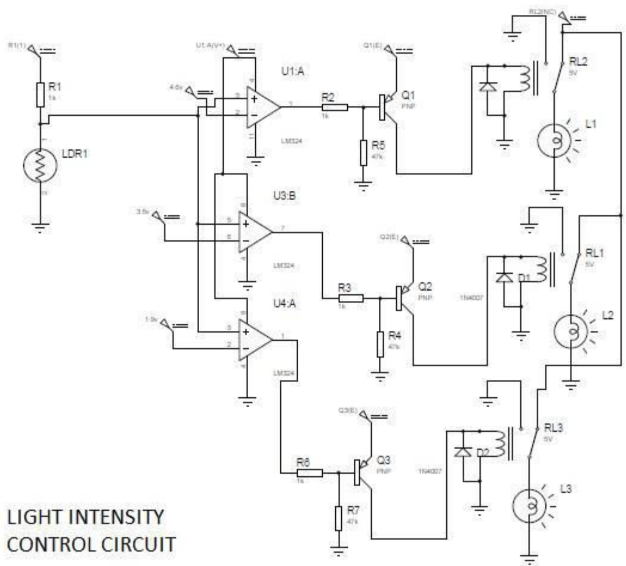


Fig.3.1 light ON Time on scheduling



In this section the circuit diagram of the auto adjustable intensity led lamp. Here L1, L2, L3 are the block of led. The AC voltage is first drop down and then rectified to dc 12v. Resistance of the LDR is varied according to the intensity of sunlight falling on the sensor. The LDR sensor should be placed near the window to get the appropriate change in intensity. The voltage at the comparator input changes according to the change in the intensity of sunlight. This voltage is compared with three different reference voltages switching the three led blocks. The output of comparator is given to the PNP transistor to drive the relay. The rectified 12v is given to the NC of the relay as PNP transistor is used. Whenever the sensor output voltage is greater than reference voltage the output of comparator goes high whereas the output voltage to the coil is zero so the bulb glows. With the increase in sunlight the resistance decreases, decreasing the sensor voltage. When the reference voltage is greater than the sensor voltage, the relay is activated and the led lamp is turned on. So the circuit is used to change the intensity of the led lamp according to sunlight entering the room without using any software. Saving large amount of power by using led lamp.

4. AUTOMATIC FAN CONTROLLER

The section is based on automatic turning ON & OFF of Fan for domestic & commercial purposes. Whenever there is increase in temperature we need to turn ON the fan for cooling the room. And whenever temperature decreases there is no need of fan. So, we need to turn OFF the fan. So, in this case we need to turn ON & OFF the fan manually. It will be better & advantageous if we will provide automatic mechanism for turning ON & OFF the fan. In this paper, we are going to provide a reference temperature level. In the method used for controlling the switching of fan is based on PI controller, but in this paper the method used is based on simple hardware and does not require any programming. Whenever the room temperature increases above reference temperature the fan will be turned ON automatically & when it decreases below reference temperature, fan will be turned OFF automatically.

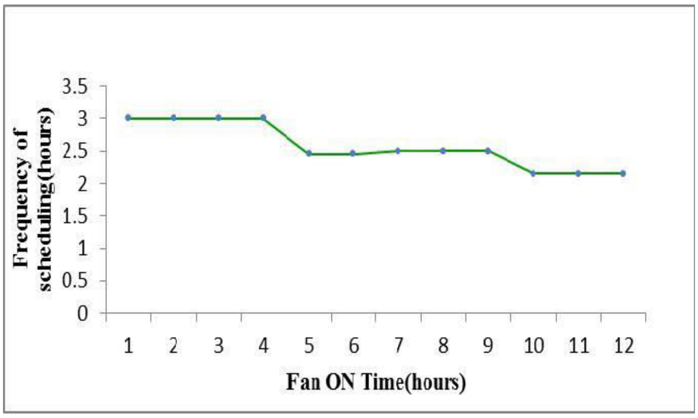


Fig.4.1 Fan ON Time on scheduling

In this LM 35 will sense the temperature & produce the output voltage proportional to it with the sensitivity of 10mV/degree C. This voltage will be compared with the reference voltage set by potentiometer. These two voltages will be compared by LM 324. If the voltage at the output of LM 35 is greater than reference voltage, the comparator output will be high & if it is less than reference voltage comparator output voltage will be low. So if the output is high, transistor will be turned ON & if it is low transistor will be turned ON. Whenever transistor is turned ON relay will be ON so that it will turn ON the Fan mechanism & When ever transistor is turned OFF relay will be OFF, so that it will turn OFF the Fan mechanism.

4.2 CIRCUIT DIAGRAM OF AUTOMATED FAN CONTROL

In the circuit diagram the output to the LM 35 is given to the positive input of the comparator. In this paper we have choose the reference temperature to 35 degrees. So the reference voltage is set to 35mV. When the temperature of the room increases to 35 degree the output of the comparator goes high turning on the fan. The circuit also *gives* the flexibility of adjusting the reference temperature by adjusting the potentiometer. So according to the output voltage of LM35 the switching of fan is controlled with a hysteresis of 5% of the output voltage.

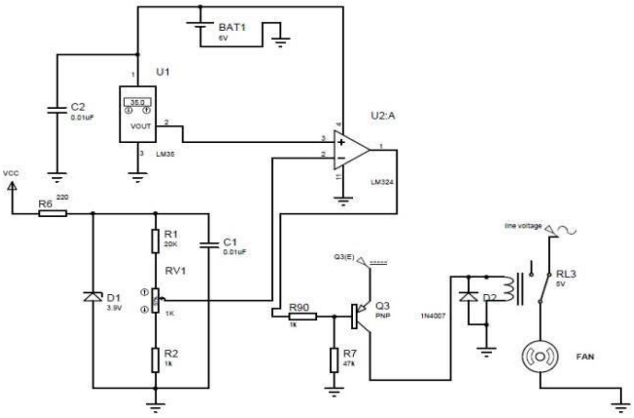


Fig. 4.2 circuit diagram of automatic fan controller

5. PERFORMANCE ANALYSIS

The algorithm is coded and simulated in Matlab to prove the efficiency of the approach. Initially, only four loads namely a light, a fan, an AC and a water heater are considered and the load curves obtained based on the customer preferences are shown in figure 5.1. Any number of loads can be added and the algorithm can be expanded**.**

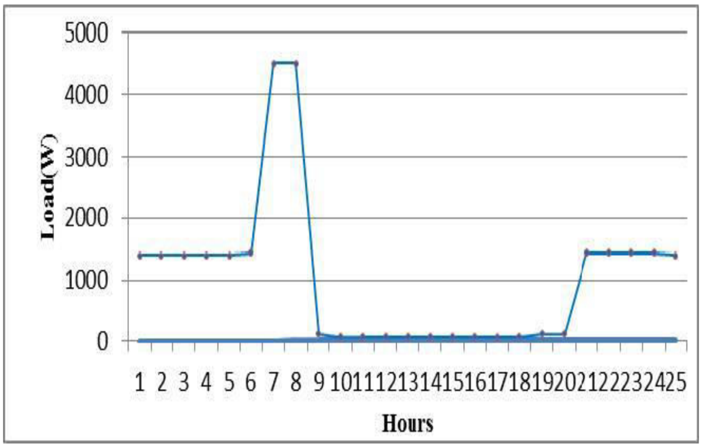


Figure 5.1 Load curve without scheduling

From figure 5.1 it can be seen that the maximum load is during the peak hours which when operated without considering supply power may result in power failure. To overcome this situation, the loads are scheduled based on the supply power available. For example, consider a scenario where the supply power varies from 1000 W to 3000 W. With the help of our algorithm, the loads are scheduled based on the supply power and consumer preferences. The load curve obtained after scheduling the appliances is shown in figure 5.2

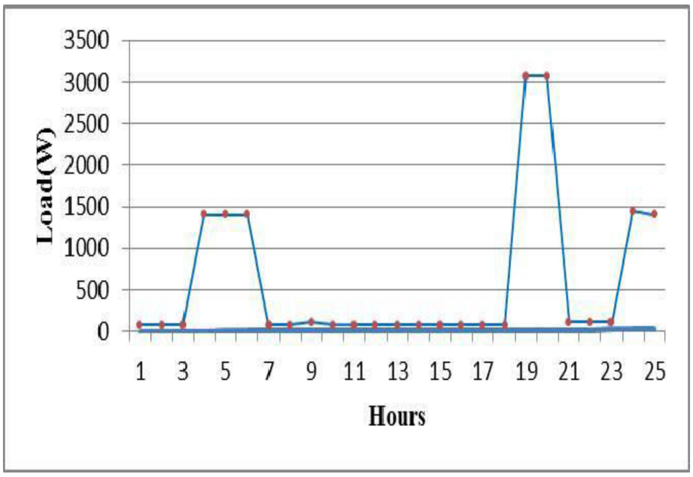


Figure 5.2 .Load curve with scheduling

From figure 5, it is inferred that for hours from 1 to 3, the supply power is 1000W and the AC is switched OFF and fans are switched ON. For hours from 4 to 7, the supply power is enough to operate the AC and thus AC is turned ON but not enough to turn ON the water heater. Hence water heater is shifted to hours 18 to 19. Similarly, for hours from 7 to 17, the supply power is enough to turn the lights and fan and both are turned ON.

Thus scheduling the appliances depending on the supply power available at that instant effectively varies the load. However, how frequent the scheduling can be done is a big question. For, overcoming this issue, control circuit is employed to determine the scheduling based on the ON time of the four appliances namely light, fan, AC and water heater. The scheduling is affected by the operating time of the appliances. To illustrate the impact of operating time on the scheduling, the appliances are switched ON one by one and the scheduling is obtained.

6.CONCLUSION

So, as we see large amount of power is wasted in day to day life just because of human tendency of being lazy. As we know 1 unit of power saved is equal to the 1 unit of power produced. So, this wasted energy can be conserved and can be contribute to large amount of saving of energy. The total cost of all the circuit is much low as compared to the amount of energy saved. If this system is adopted at every home and offices, it can contribute to large amount of energy savings.

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