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Consumption-Based Priority Algorithm for Energy Consumption

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ABSTRACT

Energy management is a critical component of intelligent, low-energy buildings. Demand-side management may benefit more from energy management. It could allow the system to use less energy while still meeting its demand for the available resources. According to recent research, buildings may reduce their energy use by up to 30% via improved operations, which are often based on effective energy management using the load priority algorithm. As a result, there is still room for energy savings in buildings via improved and effective operation. Smart grids provide electricity systems with suitable infrastructure for enhancing building energy efficiency. The secret to creating energy-efficient processes is creating rules based on energy consumption priority algorithms. When an energy bank is limited and an energy supply to a system is needed for a specific time, the priority algorithm is frequently used. In this study, a priority algorithm is put forward and put to the test in a real-world setting of a low-energy building.

1. Introduction

The last decade. Intelligent building is closely related to the sense of human comfort, economic advantages, power security, and low energy consumption, which is required for zero-energy sustainable buildings today [1,2]. Some authors prefer the term intelligent over smart; an intelligent building (IB) is concerned not only with automation and control but also with architectural design, information and communication technologies (ICT), and the notion of a sophisticated living environment at home, as well as the maximization of occupants' work efficiency with minimum operational cost [3]. In 1991 [4] intelligent buildings were introduced as infrastructures to maximize

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the work efficiency of their occupants at the lowest possible operational cost by effectively managing and integrating all building components and correlating their data to save the most energy possible. Positive actions toward the environment and energy conservation have become obligatory in the 21st century. Reliable communication meshes, innovative interactive building features, and new priority algorithms, combined with intelligent control processes, will drive the transition to sustainable and intelligent buildings, resulting in decreased energy consumption and CO^2 emissions.

Due to a growth in energy consumption, electrical power networks have experienced normal stress conditions in recent years. Power outages are becoming an increasingly regular source of system stress, often during peak hours. Such occurrences result in a supply-limit scenario and intermittent load shedding. Implementing low-energy building techniques such as occupancy detection, load monitoring, and priority algorithms may significantly lower the 40% of the total energy used by the building sector [5]. It is envisioned that a prioritization system based on demand response would mitigate supply restriction issues by selectively reducing building envelope loads. In many regions of the globe, these strategies are frequently used by low-energy-converted typical structures. In the context of very energy-efficient office buildings, there are three kinds of priority algorithms [6]:

i. Priority demand response algorithm
ii. Demand response method with semi-priority
iii. Priority load restriction algorithm

The demand response priority algorithm is a completely automated set of decision-making rules that any residential energy management system may apply, but only if energy supplies are always available [7]. In the event of load shifting and shedding, a semi-demand response priority algorithm is often implemented to meet the unique set of needs [8]. In addition, the load limitation priority algorithm is a novel approach that utilizes an algorithm that routinely monitors the generating source and examines sensor values for decision-making. In this research, the load restriction priority algorithm is evaluated on a low-energy building, resulting in a 30% reduction in energy use. Different prioritization methods are suggested in the [9]. The priority algorithm has become a crucial energy efficiency tool for low-energy buildings. In [10] author developed a technique with a priority algorithm to switch on/off a specific appliance based on the available renewable energy source. If the source is not producing enough energy, but the load's priority is high, the appliance switches to electricity from the grid. It stays on as long as its priority is high.

Malaysia might face energy crises [11], to address the issue, an intelligent green energy building is good solution [12]. Low energy buildings or zero energy buildings are possible, if roof insulations [13], energy resistant walls [14], and intelligent load monitoring are introduced .

2. Automation in Building

Buildings have evolved from very simple construction mechanisms to quite sophisticated structures throughout the course of human history. These structures not only provide humans with a place to live but also make it possible for the industrial revolution to take place. Smart grids in lieu of extremely low-energy buildings developed as a prominent study subject in the recent decade, according to academics and researchers. The concept of a smart building is inextricably linked to the sense of human comfort, economic advantages, power security, and, in today's world, low energy consumption, which is essential to the construction of sustainable zero-energy buildings [15]. An intelligent building (IB) not only deals with automation and control, but it goes beyond that concept which incorporates architectural design, information, and communication technologies (ICT), and the notion of a sophisticated living environment at home along with maximization of occupant's work efficiency with minimum operational cost. Some authors prefer the word intelligent rather than the word smart [16]. Intelligent buildings were first introduced as infrastructures in 1991, with the goal of maximizing the occupants' work efficiency while keeping operational costs as low as possible. This was accomplished by effectively managing and integrating all building components, as well as correlating their data to save the most amount of energy possible.

3. Low Energy-Intelligent Building

According to operation, low energy buildings (LEB) and intelligent buildings (IB) are separate entities. Some academics see both as a single entity. There is no universal agreement on how to define either; instead, it depends on the region and the protocols established by several energy commissions worldwide. In smart buildings, energy usage is improved via energy efficiency and intelligent load switching. In comparison to conventional buildings, smart and intelligent buildings offer lower operating costs. An energy benchmark of 35KWH/m^2/year has been established for the definition of LEB. Ultra LEB is characterized as being below 30 KWh/m^2/year. More than 30 definitions of intelligent buildings are given in [17] all of which emphasize technical features while ignoring human involvement. LEBs in the current situation have definitions that include learning capabilities and performance regulations for building occupancy and its relationship with the environment [18]. IB is described as "a productive and cost-effective environment via optimization of its four components, namely building model, systems, services, and management, and interplay among them" by the Intelligent Building Institute of the United States. The European Intelligent Building defines (IB) as "an environment which maximizes the efficacy of inhabitants instead of efficient resource management with the lowest lifetime cost of hardware deployed." There are two distinct ideas; in Europe, the emphasis is more on user needs, while in the US, the concentration is on technological factors [19].

4. Proposed Priority Algorithm for Low-Energy Building

The building envelope is divided into three zones based on the highest, average, and lowest priorities as shown in Figure 1. Although load was also categorized into these priorities.

i. If power harnessing capacity is limited to 1.8KW, then the high-priority load will be provided energy.
ii. If a generation is limited to 3.5 KW, two zones will be supplied with energy.
iii. In the third case, if generation surpasses 4.5KW then the total load will be connected to the sourcing unit.

However, Occupancy is necessary for priority. If occupancy is not present in the respective zone, then the priority algorithm will follow the second step that is, checking occupancy in an adjacent zone. The algorithm will be fully applicable with its sole concept if occupancy is found in all zones.

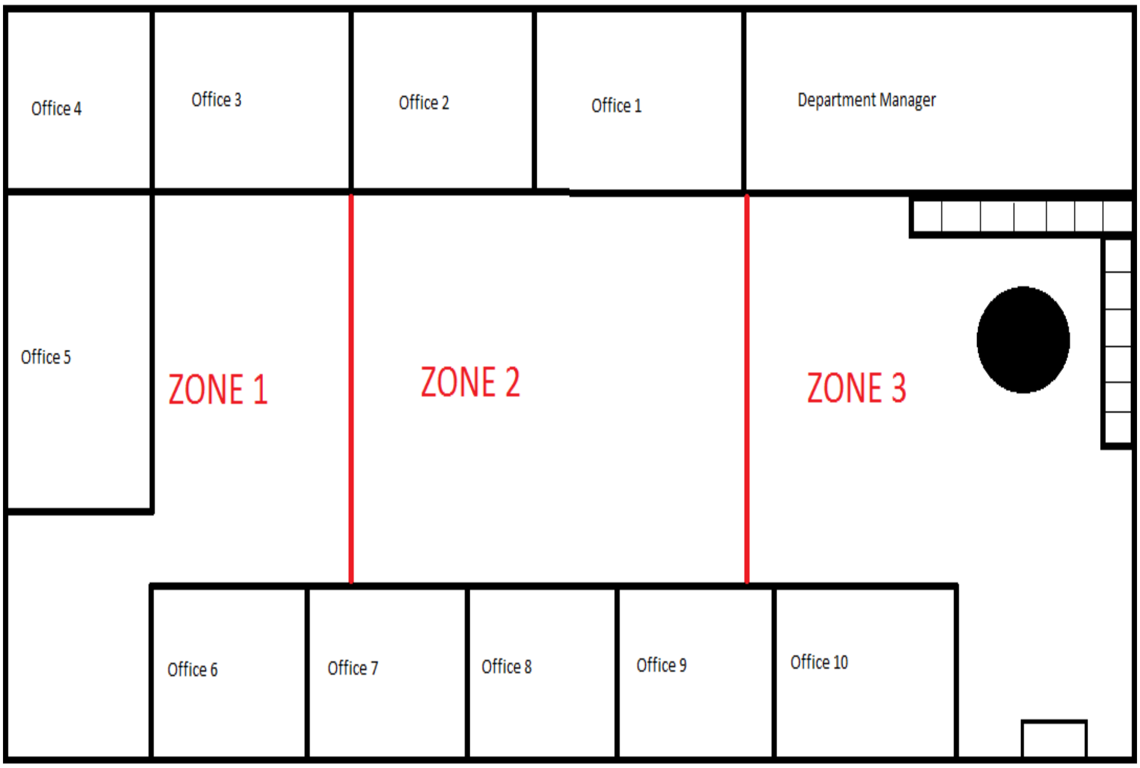

Fig. 1. Low energy building envelope zones distribution

The load profile of low energy building site is given in Table 1. The complete envelope contains different loads of 6KW having different priorities assigned in case of occupancy is detected.

Table 1
Low-energy building site load profile

Sr. No.	Load	Quantity	Power rating (watts)
1	Ceiling fans	4	240
2	Air conditions	3	3300
3	LED tubes	15	60
4	Laptop	7	140
5	Desktop PCs	7	700
6	Water Dispenser	1	150
7	Printer	1	25
8	Deferrable load	5	100

The decision-making process is shown in detail in Table 2. As solar radiation changes with light intensity, it follows that the energy produced by a solar panel will be proportional to the solar radiation that falls on its surface.

Table 2
Decision-making strategy

Energy Obtained	Occupancy			Decision (Duration is 15 mins)
	Zone 1	Zone 2	Zone 3	
2 KW	Yes	-	-	Start HVAC in Zone 1 for Indefinite duration
	-	Yes	-	Start on HVAC in Zone 2 for Indefinite duration
	-	-	Yes	Start on HVAC in Zone 3 for Indefinite duration
	Yes	Yes	-	Switch on the HVAC system for Zone 1 first, followed by Zone 2 about 15 minutes later.
	-	Yes	Yes	Switch on the HVAC system for Zone 2 first, followed by Zone 3 for about 15 minutes each.
	Yes	-	Yes	Switch on the HVAC system for Zone 1 first, followed by Zone 3 about 15 minutes later.
	Yes	Yes	Yes	The HVAC system will stay on for zone one initially, then zone two, and finally zone three. All for 15 minutes.
	-	-	-	Start the heating, ventilation, and air conditioning system in each zone one at a time for the allotted amount of time, and then switch it off.
4 KW	-	-	-	Zones 1 and 2 should be turned on initially and for the appropriate duration. In order to switch on HVAC for Zone 3, first turn off HVAC for Zone 1. Next, switch off any HVAC systems.
	Yes	Yes	-	Switch on the HVAC in both Zones. Duration 15 minutes.
	-	Yes	Yes	Switch on the HVAC in both Zones. Duration 15 minutes.
	Yes	-	Yes	Switch on the HVAC in both Zones. Duration 15 minutes.
	Yes	Yes	Yes	Switch on the HVAC for Zones 1 and 2 first at the appropriate times, and then turn off Zone 1's HVAC before turning on Zone 3's HVAC. When turning on HVAC for Zone 1, turn off the HVAC for Zone 3 if occupancy does not change.
6 KW	-	-	-	Switch on the HVAC throughout all zones for 15 minutes, then turn it off.
	Yes	Yes	Yes	For all Zones, turn on. No time limit.

As solar radiation varies with light intensity, a solar panel's output is proportional to the solar radiation that hits it. Only one zone may be powered with 2 KW. The controller activates the HVAC based on zone occupancy. Table 2 analyses case results. If just one zone is occupied at 2 kW, it will be powered forever. If numerous zones are occupied, the controller will turn on each for its allocated period. The controller turns on each zone for a set period when none are occupied. Only two zones may be powered with 4 kW. The controller will power two zones simultaneously based on their occupancy. If just one zone is occupied, the other two will be turned on simultaneously. The controller activates Zone1 and Zone2 when all three zones are occupied. Zone3 is activated by deactivating Zone1. When no zone is occupied, the controller turns on two zones at a time for their respective periods, then turns them off. Even with a single passenger, 6 kW will power all zones for an endless duration. Countless zones will be switched off 15 minutes later. The flowchart illustrates energy management algorithm implementation. Figure 3 shows an algorithm flowchart.

5. Decrease in Energy Consumption Due to the Implementation of the Priority Algorithm

The key factor influencing a building's energy usage is resident behaviours. Occupancy detection-based virtual generation in the building envelope saves energy use by 30%. The faculty hall of the Electrical department of the university is picked as the test site. IR sensors were put at each zone's gate. Priority was established according to need. 40% reduction in energy use has been noticed. On average, around 9KWh of energy use was measured. Figure 2 depicts a graphical examination of the energy savings resulting from the adoption of an intelligent algorithm.

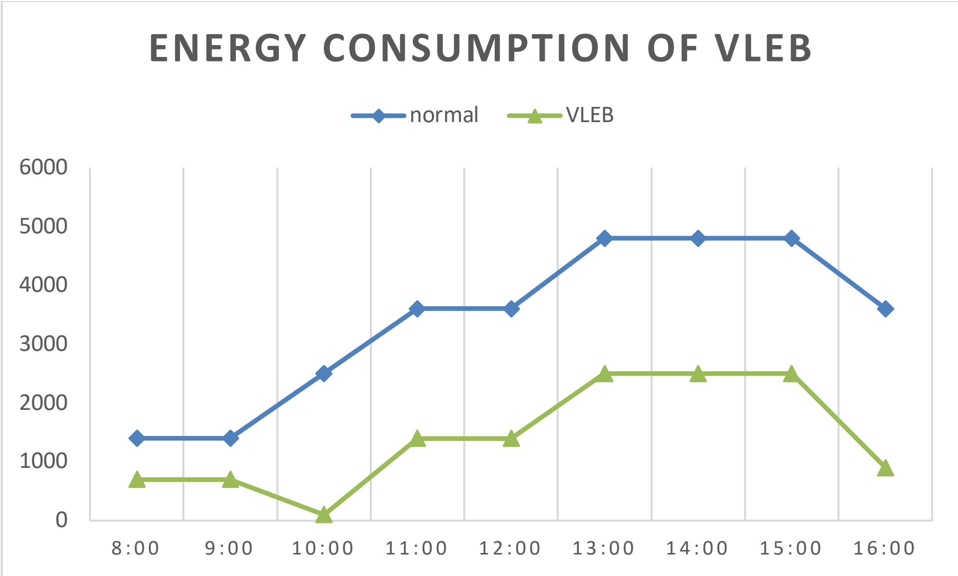

Fig. 2. Comparison of energy consumption in both scenarios

6. Conclusions

This research assesses several energy savings strategies by adopting and using intelligent prioritization algorithms. The subject of study is intelligent building envelope load control. Three power supply scenarios were studied, including 2KW, 4KW, and 6KW. According to our scenarios, if the power production was 2 kW, just one zone could be powered. Similarly, the controller was developed to make judgments when the power production was 4KW and 6KW, the specifics and decisions of which were previously mentioned. Conclusion: energy efficiency, low energy consumption, onsite energy harvesting, and trends of minimal grid dependence are shared objectives and responsibilities of smart grid-connected low-energy buildings. Nevertheless, energy-efficient load devices and building design may increase the societal effect of smart grid low-energy buildings. The smart grid-connected low-energy building model incorporates technical difficulties and current requirements, as well as occupancy patterns. A building model is a combination of all sorts of data and energy harnessing, as well as human integration into the system and its influence on the system's reaction.

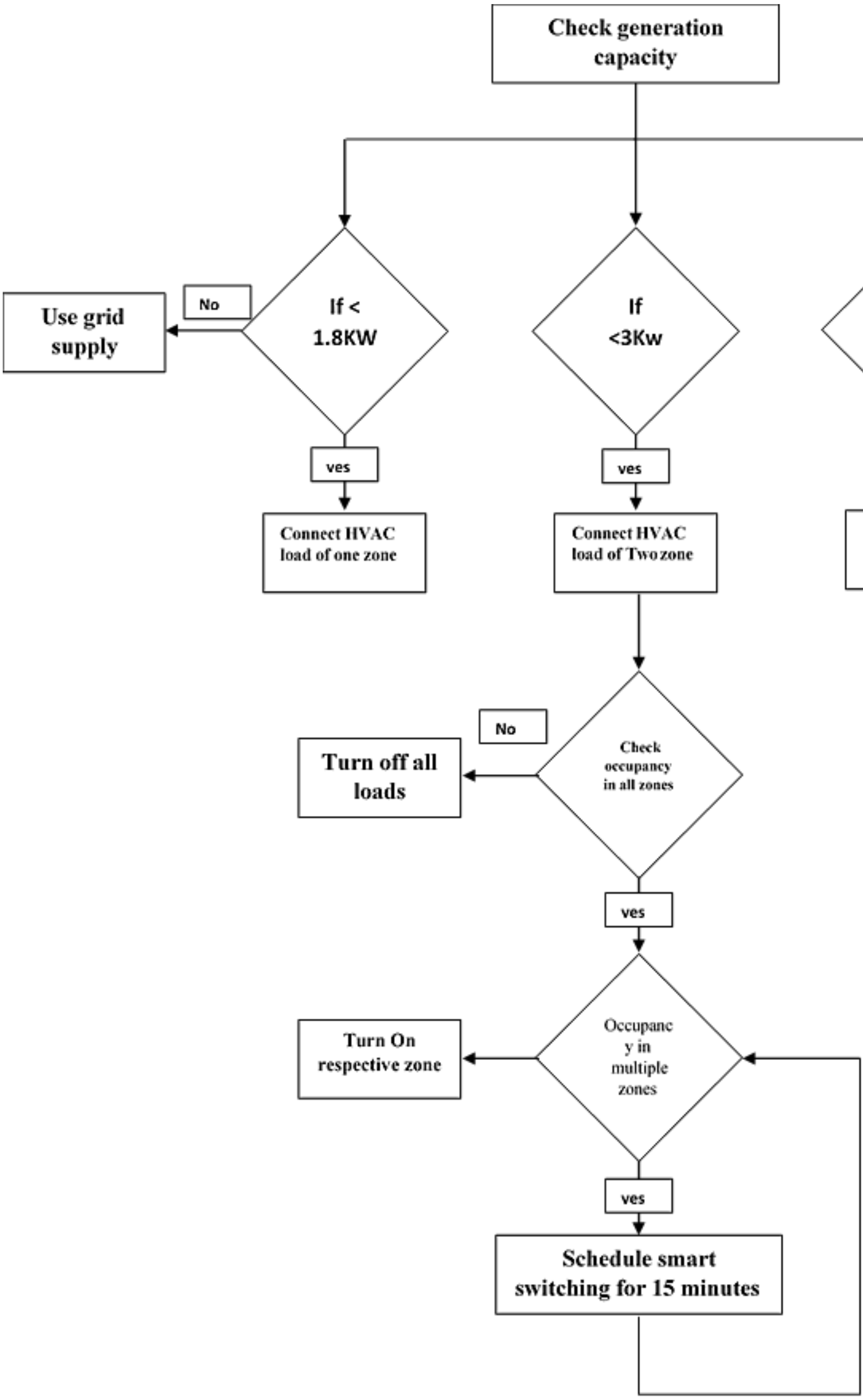

Fig. 3. Flow chart

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