Sustainable approach for building energy optimization based on occupant's behavior

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ABSTRACT: Modern age has witnessed an increasing dependency of Malaysia's population towards electricity which was reflected on its distributive high energy consumption. Consequently, a few vital points on energy issues are discussed predominantly in the engineering world on how energy could be utilized optimally. One of the ways of solving this matter is through an Energy Management System (EMS). However, certain issues arise which related to human comfort and real-time parameters as this criterion was set aside in Building Energy Management System (BEMS). Hence, this study was conducted with the aim to improve the system by proposing a more effective methods surrounding the energy efficiency and human comfort factors. Methodologies proposed in this study consists of three parts, which are: (i) correlation analysis of occupant's behavior with building energy performance, (ii) predictive analysis of energy consumption based on occupant's behavior, and (iii) sustainable approach through electricity harvesting from radio frequency for powering data-collecting Internet of Things (IoT) devices. Under Microsoft Azure Services, these three methodologies combination were conducted for an aggregate monitoring of building energy consumption and identification of future consumption trend. Other than that, notification services for alteration of occupant's behavior was constructed as part of energy saving measure.

Keywords: *Energy Management System; Energy Efficiency; Energy Harvesting*

1. INTRODUCTION

Moving into a progressive future, sustainability and energy efficiencies have a significant impact on the economic stability and the environment. Designing a Building Energy Management Systems (BEMS) that allows for a fully automated and efficient energy usage management, but this system usually neglect human comfort and real-time parameters. Energy performance which related to occupant's behavior in a building is a key parameter in the design of BEMS. This correlation was due to a direct influence of energy optimization automations, real life human intervention and usage trends towards the energy consumption of a building

In this research, a set of data involving temperature, occupancies, user perception and expectation along with a set of electrical parameters are used to determine the usage trends and their dependencies to each other. The usage pattern and its relevant factors surrounding the action will be studied and compared. The research will utilize Microsoft Azure Services as the system architecture from data collection until data visualization and alerting system.

2. METHODOLOGY

Ensuring the research was conducted efficiently and thoroughly, the methodology was divided into 3 phases, which are:

Phase 1: Correlation analysis of occupant's behavior with building energy performance
Phase 2: Predictive analysis of energy consumption based on occupant's behavior
Phase 3: Sustainable approach through electricity harvesting from radio frequency for powering data-collecting IoT devices

3. RESULTS AND DISCUSSION

3.1 Behavioral Pattern in Altering Building Control

Behavioral analysis indicates that occupants have the impulses to change and react differently to any situation. Such cases cause changes in habits and usage of equipment. A person interaction with climate, systems, and appliances shows significant effect on the energy usage. Psychologically a person will act differently to a situation than another person. Figure 1 illustrated how a person's judgments and interactions can changes and how a decision related to energy interaction are conducted. Figure 2 further illustrates the key direct and indirect behavioral patterns found from this study to justify the differences in energy consumption measure and simulation runs with comfort on and off. Talks about the 'Theory of Unconscious' that described three levels of consciousness in the human mind. First being, the conscious mind; perceived to be aware of the moments but only understand small amounts of it. The pre-

conscious mind: a state of awareness of an event actions or impact but are not conscious of it. The unconscious mind: a state of mind where we are unaware and out of reach from reality. This is said to be the sole decision makers in any humans' behaviours [1].

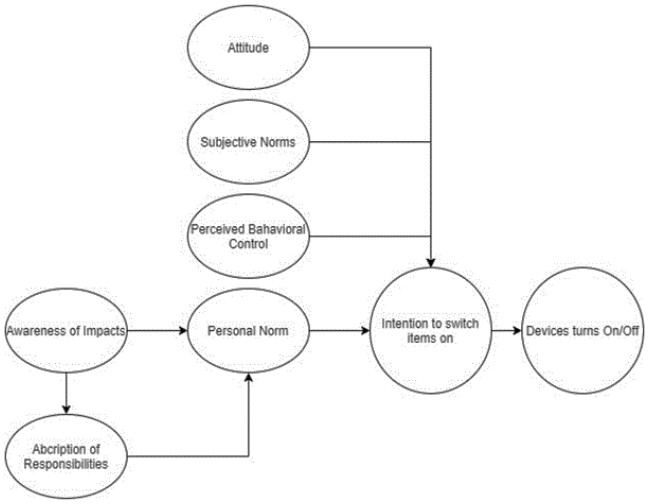

Figure 1 Decision-making related to energy interaction

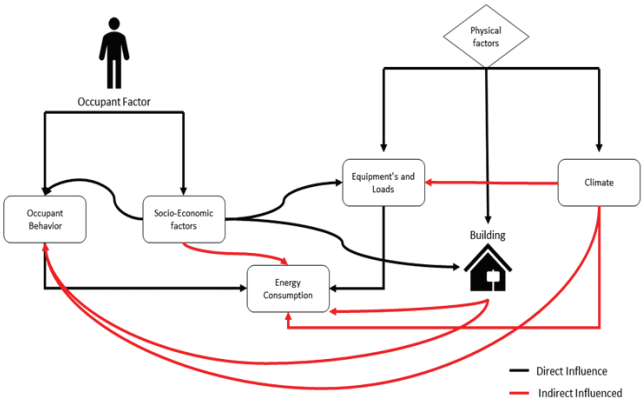

Figure 2 Key direct and indirect behavioral pattern

3.2 Data visualization and alerts through Power BI

As part of energy optimization measures, this research promotes rational thinking and trigger occupant conscious mind to save energy by providing significant information regarding the building occupancy, environment condition and energy consumption level. Figure 3 shows the dashboard of the data visualization in Power BI. The dashboard managed to show the current total energy consumption, temperature inside and outside, number of occupants and distribution between phase consumption. Other than that, an insight on the next day energy usage was also previewed. Moreover, the weather condition was also shown which was compute based on distribution of rain. This dashboard was also published into mobile app view and include alert function for the anomalies detection as shown in Figure 4.

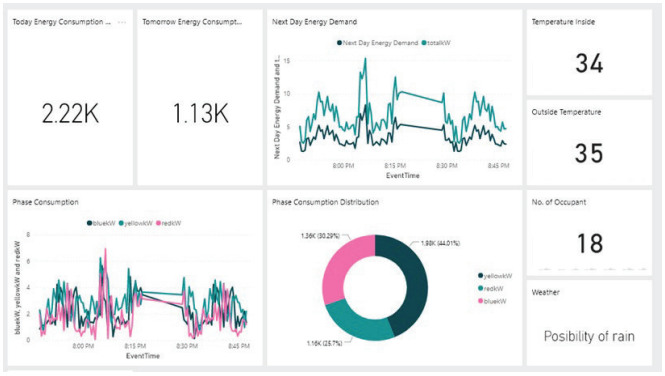

Figure 3 Power BI data visualization

Figure 4 Alert for sudden high energy usage inside Power BI mobile apps

4. CONCLUSION

It is concluded that human interaction in a building are correlated to their presumption of comforts. External parameters affected occupant judgment in deciding what to change inside of their comfort bubble. From this research, a sustainable energy optimization approach was proposed and simulated based on occupant comfort parameters. In which it utilized Microsoft Azure cloud services with web and mobile solution architecture to conduct data management, processing, analysing and publication. By simulation, the minimum benchmark voltage for energy harvesting of WIFI signal was achieved at stage 3 of the Cockcroft Walton rectifier configuration. However, there are many other factors need to be considered to support the WIFI energy harvesting application. The antenna for instance is one of the vital parts that need to be considered as it plays a huge role for the efficiency of WIFI signal gathered. The distance of source from the harvesting circuit also plays a significant effect on the strength of WIFI signal can be gathered.

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