MODELING AND OPTIMIZATION OF POWER CONSUMPTION TOWARDS ENERGY SAVING

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To my beloved parents , who have fulfilled my heart with love and brightness.

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ABSTRACT

In this project, the building's electrical equipment by using fuzzy logic rules are modeled and the appropriate fuzzy logic controller in order to reduce consumption of building's electrical energy is defined. Buildings are the largest consumers of energy worldwide including new residential and industrial buildings. The purpose of using fuzzy logic rules for building's electrical equipment (air conditioning system, lighting and blinds) is to save energy in the whole building while keeping occupants comfort based on the comfort zone. Most of the intelligence controller use the multiple controller consist of lighting controller, HVAC and blind controller in order to control the building power consumption or create the math model for just one part of building, but in this way, by applying fuzzy rules to the plant, there is no need to have any exact mathematical model of building and finally designed the fuzzy controller to save power consumption.

ABSTRAK

Dalam projek ini, perkhidmatan bangunan dengan menggunakan kaedah-kaedah logik kabur model dan pengawal logik yang sesuai kabur untuk mengurangkan penggunaan tenaga elektrik bangunan ditakrifkan. Bangunan itu ialah pengguna terbesar di seluruh dunia tenaga termasuk bangunan kediaman dan industri yang baru. Tujuan menggunakan kaedah-kaedah logik kabur untuk perkhidmatan bangunan (sistem penghawa dingin, lampu dan membutakan) adalah untuk menjimatkan tenaga di seluruh bangunan sementara memastikan keselesaan penghuni berdasarkan zon selesa. Kebanyakan pengawal perisikan menggunakan pengawal pelbagai terdiri daripada lampu pengawal, HVAC dan pengawal buta untuk mengawal penggunaan bangunan kuasa atau mencipta model matematik untuk hanya satu bahagian dari bangunan, tetapi dengan cara ini, dengan menggunakan peraturan kabur ke loji , tidak ada keperluan untuk mempunyai apa-apa model tepat matematik bangunan dan akhirnya direka pengawal kabur untuk menjimatkan penggunaan kuasa.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBRIVATIONS

IAQ	-	Indoor Air Quality
PMV	-	Predictive Mean Vote
ASHRAE	-	American Society of Heating Refrigerating and Air Conditioning Engineers
CO_2	-	Carbon Dioxide
TVOC	-	Total Volatile Organic Compounds
SBS	-	Sick Building Syndrome
DCV	-	Demand Controlled ventilation
AI	-	Artificial Intelligence
PID	-	Proportional–Integrate–Derivative
HVAC	-	Heating, Ventilating, and Air Conditioning
RLS	-	Recursive Least Square
AHU	-	Air Handling Unit
FL	-	Fuzzy-Logic
LED	-	Light Emitting Diodes
FLA	-	Full Load Amp
LRA	-	Locked Rotor Amps

LIST OF APPENDIX

CHAPTER 1

INTRODUCTION

1.1 Introduction

Climate change and growing shortages of resources are the big concerns of our time. In addition, many countries around the world are dependent on imported energy – in the EU, for example, 50 % of energy consumed today is imported – a figure expected to reach 70 % by 2030. Following the areas of transport and power generation, building technology is the largest consumer of energy. Heating, cooling and lighting in residential and office buildings comprise approximately 40 % of the energy consumed in the industrial nations – a share that leaves a lot of scope for efficient optimization. In other example, the energy consumed in Malaysia is 90% in the form of electricity. It has also been reported that Malaysia has one of the fastest growing building industry in the world. However, more than 40% of the energy consumed can be reduced if energy efficiency is adapted and sustainable technologies are applied to buildings. There are various techniques in order to manage consumption of powers for buildings but by using the appropriate way we can achieve to the desired result.

1.2 Problem Statement

As shown in Figure 1.1 consumption of the building is raising over the 40% in 2035 as compared to the industry and transportations, which is decreasing and remaining constant respectively. Therefore buildings are most important part of energy consumption in near future and by designing a controller that can control all part of buildings and by an efficient use and control of these systems, important energy and economical savings without affecting the users comfort could be gained.

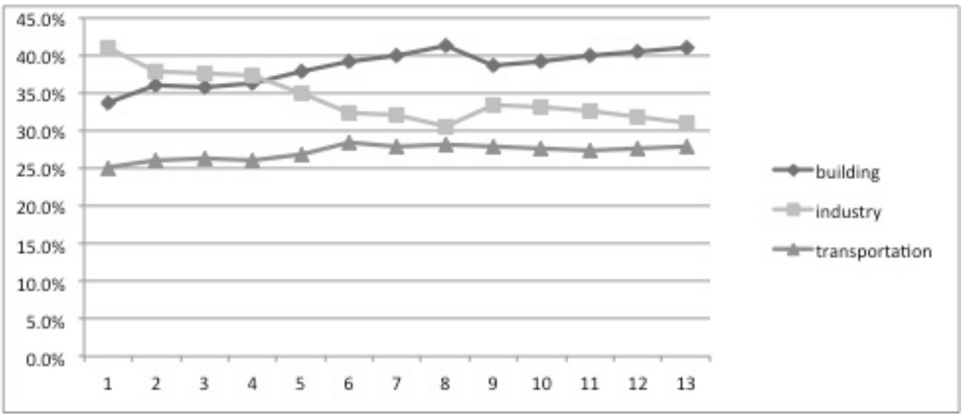

Figure 1.1: Energy consumption rating in building, industry and transportation between 1980 to 2035 according to energy data book

1.3 Comfort conditions

In the 1970s and 1980s, the need for energy savings resulted in the design and construction of buildings that had small openings, lacked natural ventilation, etc. Because people spend more than 80% of their lives in buildings, the environmental comfort in a work place is strongly related to the occupants' satisfaction and productivity. On the other hand, as well known, energy consumption is also strongly and directly related to the operation cost of a building. Hence, energy consumption and environmental comfort conditions most often are in conflict with one another.

In the past 20 years, special emphasis has been given to the bioclimatic architecture of buildings. Bioclimatic architecture is geared towards energy savings and comfort; utilizing glazing and shadowing systems, solar spaces, natural ventilation, thermal mass, Trombe walls, cooling systems with evaporation and radiation, etc. Bioclimatic architecture focuses on the design and construction of bioclimatic buildings that take advantage and make use of solar radiation and natural airflow for natural heating and passive cooling.

The quality of life in buildings (comfort conditions) is determined by three basic factors: Thermal comfort, visual comfort, and Indoor Air Quality (IAQ) [1],[2],[3] and [4]. Thermal comfort is determined by the index PMV (Predictive Mean Vote) [4], PMV is calculated by Fanger's equation [4] and [5]. PMV predicts the mean thermal sensation vote on a standard scale for a large group of persons. The American Society of Heating Refrigerating and Air Conditioning Engineers (ASHRAE) developed the thermal comfort index by using coding −3 for cold, −2 for cool, −1 for slightly cool, 0 for natural, +1 for slightly warm, +2 for warm, and +3 for hot. The ISO recommends maintaining PMV at level 0 with a tolerance of 0.5 as the best thermal comfort. Visual comfort is determined by the illumination level (measured in lux) and by the glare that comes from direct viewing of the solar disk.

Indoor air quality can be indicated by the carbon dioxide (CO_2) concentration in a building [1] and [3]. The CO_2 concentration comes from the presence of the inhabitants in the building and from various other sources of pollution (NOx, Total Volatile Organic Compounds (TVOC), reparable particles, etc.). Ventilation is an important means for controlling indoor-air quality (IAQ) in buildings. Supplying fresh outdoor-air and removing air pollutants from interior spaces is necessary for maintaining acceptable IAQ levels [6]. However, ventilation rates inside buildings must be seriously reduced in order to control the cooling or thermal load in an improved manner and reduce the energy load. In many cases though, this contributes to a degradation of the indoor-air quality and to what is generally known as' sick building syndrome' (SBS) [7]. For these reasons, IAQ is now a major concern in building design. Demand-controlled ventilation (DCV) systems offer an efficient solution for the optimization of energy consumption and indoor-air quality [8].

The main characteristic of DCV systems is that ventilation rates are modified according to the value of a certain parameter, for example the CO_2 concentration, which is representative of the pollutant load in a room. This technique has already been successfully applied in many cases by using mechanical ventilation. Dounis et al. [9] investigated the potential application of CO_2-based DCV to control ventilation rates for a building with natural ventilation. Simulations were performed in which window openings were adjusted based on measured CO_2 concentrations. Due to concerns over the constant variation of natural ventilation driving forces, fuzzy logic was used instead of conventional on-off or PID control. Carbon dioxide concentrations, window openings, and air temperatures are presented for a simulated day. The feasibility of such a system was demonstrated.

Wang et al. [10] developed a robust control strategy to overcome the control difficulties when DCV control is combined with economizer control. The main difficulty is the emergence instability phenomena (alternation and oscillation) in the transition phase between different control modes. Wang et al. [11] developed an optimal and robust control of outdoor ventilation airflow rate. This strategy employs a dynamic algorithm to estimate the number of occupants in the indoor building based on the CO_2 measurement. The optimal robust control strategy achieves indoor air quality and minimum energy consumption. Hence, the second main goal and characteristic of advanced control systems is the achievement of occupants' comfort conditions.

1.4 Background of the Study

1.4.1 Intelligence buildings

According to the above matter, intelligence building is becoming one of the main factors of the future building construction. Advantages of these buildings, such as high-level comfort, high power efficiency, environmental friendliness, result in using this kind of building in order to satisfying consumers. This technology is a hardware/software combination of microprocessors, and artificial intelligence (AI) software that yields artificial intelligence based tools to monitor the power consumption of a device.

Figure 1.2: Smart building using sensors and relevant actuator

Figure 1.2 is shown the overall features of smart buildings .The main propose of using smart buildings is to predict when building's equipment will not be used so that it may be either powered down, or placed in a low power consumption mode.

1.4.2 Using controller toward energy saving

Now, the important matter is that, which kind of controller must be used to achieve desired result in consumption of power? Previous studies showed that by using the math model of every services and creating the relevant model in each part of building such as lighting, HVAC and blinding, power is saved approximately about 11~31%. But obtaining this amount of saving requires applying exact math model of the every part of building and designing several controllers, which they should work together at the same time to achieve the desired result. In this project, we are going to discuss about the unique model of building which is consist of all services by using fuzzy logic algorithm and then designing the relevant controller according to the fuzzy rules.

1.4.3 Fuzzy logic system as controller

The use of fuzzy logic can help to circumvent the need for strict mathematical modeling. Fuzzy logic is a valid extension of conventional logic, and fuzzy logic controllers are a true extension of linear control models. Therefore, anything built for using conventional design techniques can be built with fuzzy logic, and vice-versa. However, in a number of cases, conventional design methods would have been excessively complex and, in many cases, might prove simpler, faster and more efficient.

Figure 1.3: Using fuzzy logic system as model for building power managing system including sensors and actuators

1.5 Objectives of the Study

Living space climate regulation is a multivariate problem having no unique solution, particularly in solar buildings. More specifically, the goals of an intelligent management system for energy and comfort are as follows:

(i) High comfort level: Learn the comfort zone from the user’s preference, and guarantee a high comfort level (thermal, air quality and luminance) and good dynamic performance.

(ii) Energy savings: Combine the comfort conditions control with an energy saving strategy.

(iii) Air quality control: Provide CO2-based demand-controlled ventilation (DCV) systems.

1.6 Scopes of the Study

(i) Using fuzzy logic rules as data for controller
(ii) Designing the unique model for buildings
(iii) Comparing the output amount while applying the desired amount from comfort zone chart

1.7 Thesis Organization

This thesis is organized as follows. Chapter 2 provides detailed explanations of smart building, which is used controller in order to reduce consumption of power in buildings. After that, Chapter 3 discusses the steps of designing of fuzzy logic membership functions and relevant fuzzy rules and defining the model for buildings at end of Chapter 3. Chapter 4 discusses the results and comparison with comfort zone chart. Chapter 5 ends this thesis with conclusions and recommendations for future works. Finally, the references are placed at the back of this thesis.

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