University of Southern Queensland

Faculty of Engineering and Surveying

Intelligent Building Automation System

A dissertation submitted by

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in fulfillment of the requirements of

Course ENG4111 and 4112 Research Project

towards the degree of

Bachelor of Mechanical Engineering

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ABSTRACT

1. INTRODUDCTION

It is our divine duty and obligations to protect our environment in whatever ways we can for our own benefits and also for our future generations. This project deals with this intention and narrowed down to energy conservation in buildings which is most suitable in densely built up city like Singapore.

2. BACKGROUND

The definitions of an intelligent building can be systemically classified by the information and control services that serve the needs and expectations of the occupants. The specially designed controlling software and actual electronic hardware and devices installed within the structure that manipulate the telecommunications and building automation functions are necessary to create such a facility. Thus, the study of Intelligent Building is now a common topic worldwide. In our current quest for modernization in this particular scope, there are two areas which deserve added attention, both from the research and professional communities. Designers need to break discipline-oriented patterns and embrace a team approach to ensure that the building owner receives the best product possible. Hence, everyday, building designers face exciting new challenges in incorporating new and innovative technologies in designing an efficient integrated intelligent building in areas of the building structure and its mechanical and electrical systems. The innovative technologies would need to ensure that the end users achieve the utilization of its abilities in conserving energy. For this project, a public building named 'Housing Development Board, Hub' as elected.

3. OBJECTIVES

The aim of this project is to evaluate the energy efficiency implications of using Intelligent Building Automation system (IBAS) in HDB Hub. The purpose being:

i. To determine how IBAS system manage the energy usage in HDB Hub

ii. To determine whether the IBAS really helps to save energy.

iii To suggest some recommendations to attain a better energy conservation.

4. METHODOLOGY

Case study approach was used for this dissertation, as this approach is the best approach to clearly depict the importance of IBAS in a public building. A detailed research was carried out with all the available information. To complement this, interviews with public users and people working inside the building. Relevant dissertations, journal, handbooks on energy efficiency are read to develop the background of this study.

5. CONCLUSION

This project will conclude with the analysis of all available information in detail to determine whether the building currently understudy is indeed energy conservative. Recommendations and suggest would be provided if determine to be helpful in further improvement on the energy conservation effort.

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Limitations of Use

Prof G Baker

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Certification

I certify that the ideas, designs and experimental work, results, analyses and conclusions set out in this dissertation are entirely my own effort, except where otherwise indicated and acknowledged.

I further certify that the work is original and has not been previously submitted for assessment in any other course or institution, except where specifically stated.

Ler, Eng Loo

Student Number: 0031138291

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Signature

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Date

Acknowledgments

For the development and production of this project itself I feel a deep sense of gratitude and would particularly like to thank Dr. Harry Ku, whose advice made it possible for me to complete it satisfactorily and on time.

I would also like to thank my colleagues and friends for their unceasing support and encouragement during this period.

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Artist Impression of HDB HUB

CONTENTS

CHAPTER 1

INTRODUCTION

1.0 Objectives

The aim of this study is to evaluate the energy efficiency implications of using Intelligent Building Automation System (IBAS) in HDB Hub.

The objectives are: -

1 To determine how the IBAS system manage the energy usage in HDB Hub.
2 To determine whether the IBAS system really helps to save energy.
3 To suggest some recommendations to attain a better energy conservation.

1.1 Background

The definitions of an intelligent building can be systemically classified by the information and control services that serve the needs and expectations of the occupants. The specially designed controlling software and actual electronic hardware and devices installed within the structure that manipulate the telecommunications and building automation functions are necessary to create such a facility. Thus, the study of Intelligent Building Integration is now a common topic worldwide.

In our current quest for modernization in this particular scope, there are two areas, which deserve added attention, both from the research and professional communities. Designers need to break discipline-oriented patterns and embrace a team approach to insure that the building owner receives the best product possible. Hence, everyday, building designers face exciting new challenges in incorporating new and innovative technologies in designing an efficient integrated intelligent building in areas of the building structure and its mechanical and electrical systems.

The innovative technologies would need to ensure that the end users achieve the utilization of its abilities in conserving energy complemented with the economic viability associated with their implementation. It will be an uphill challenge to these researchers and professionals as the end users are vastly diversified. However, once such systems have been identified, designed and implemented, building owners and managers must operate them optimally in order to achieve the ultimate result in term of energy efficiency.

Nowadays, building design and operation techniques have been evolved and emphasis has been placed on the performance of the building as a sum of its integrated systems and components and the need of an equally technically competent operation team in manipulating and controlling the systems. The reason being that many countries provide support like utility deregulation which in turn led building researchers, designers, and managers to explore integrated intelligent structures with built-in diagnostic and control capabilities which in turn need competent technical people to manage the systems for added value. Nevertheless, since its inception, the intelligent building concept has grown into a marriage of technology, efficiency and economy with greater emphasis placed on information exchange, occupant interaction and computerized control systems. Further training in computers and information systems will allow all of the team members to communicate and have access to exchange of information. This also provides a good opportunity to become familiar with some of the technological advances that are currently being used by the industry to address the energy efficiency issues of new and/or existing buildings.

From simply replacing an old system with a new highly efficient system to installing newly developed fully integrated computerized control systems, there are numerous retrofits and improvement programs that can significantly reduce the energy consumption and improve the overall efficiency of a system or building.

In Singapore, many of the new office buildings that were built recently should have a central control system to ensure that the building is energy efficient. Nevertheless, we still need to able to judge the level of efficiency of the building for further improvement.

In order to determine the efficiency, the said building will need to undergo some stringent audit tests. The level of the studied building energy efficiency can only be determined after the analysis of these test results.

For the purpose of this dissertation, the author will recommend a study of a building which was recently built. Housing Development Board (HDB) has built a New HDB center at Toa Payoh Town. This is named 'HDB Hub'. This building has brought a brand new look to Toa Payoh Town Center. Toa Payoh Town Center had become a vibrant town since HDB's Head Office moved to its vicinity.

1.2 Methodology

Case study approach was used for this dissertation, as this approach is the best approach to clearly depict the importance of IBAS in a public building.

A detailed research was carried out with all the available information. To complement this, interviews with public users and people working inside the building were made.

Relevant dissertations, journals, handbooks on energy efficiency are read to develop the background of this study.

1.3 Organisation of Study

This study is divided into eight chapters.
Chapter One, highlights the background, objectives and methodology.

Chapter Two, reviews past researches related to this study.

Chapter Three, examines the Energy Efficiency standard and the importance of Building Automation System.

Chapter Four, describes the profile of the building used in the case study.

Chapter Five, will focus on how BAS in the case study helps to control and monitor the energy consumption.

Chapter Six, Using information from professional sources to establish realistic benchmarks.

Chapter Seven, analyses all available information in detail to determine whether the building is an efficient building and
Finally Chapter Eight, conclude by stating whether the objectives of this research have been met. Some recommendations and difficulties encountered during the research are also reflected and shared in this chapter.

CHAPTER 2

LITERATURE SURVEY AND CITATION

2.0 Introduction

It is necessary to review some researches done in the past that are related to this study. These related past dissertations, journals, reference books and websites would be introduced. It will be divided into three (3) parts. First part will review various researches on what constitutes an 'Intelligent Building'. The next part will look into Building Automation System and the last part will focus on energy conservation measures.

2.1 What is an 'Intelligent Building'?

Review of Past Dissertations and Journals

Prakash (1991) uses OUB Centre as a case study to highlight the pros and cons of having an automated building system. An intelligence building attracts more tenants because it enables tenants to work in a more sophisticated environment that indirectly increases their productivity. As for the owner, with automated system, manpower level and energy consumption may decrease, thus it would directly reduce the monthly electricity costs. However, such saving could only be achieved if the system is properly utilized and managed.

Lim (1995) looked into factors an 'Intelligent Building' should have in order to be considered an intelligent building. Being Intelligent, the building should be at least able to control various systems like air-conditioning, lighting system and others and able to manage them in the most energy efficient manner. Thus it is important to have BAS in an 'Intelligent Building'.

Koh (1998) investigates the role of a Building Automation System in a commercial building. A survey on nine commercial buildings was conducted and score tactics was used. In this thesis, the result showed that the technologies that are integrated into the BAS enable a building to be intelligent.

Arkin and Paciuk (1997) evaluate the intelligence of the building according to the level of systems integration. In this paper, a building is considered an intelligent one only when it is able to provide an environment and the means to optimal utilization of the building according to its designation. In order to achieve an intelligent building, various building systems, example lighting system, air-conditioning system, communication system and others, are required to equip in the building. These systems must able to integrate among the systems and between the systems and building structures in order to function well in the building. Therefore all these systems' integration has to be properly planned from the initial design stage of the building.

2.2 Building Automation System

Review of Past Dissertation and Journals

Toh (1984) looked into the types of Building Automation System (BAS) used in various buildings. This thesis focused on the various functions available in BAS and the benefits in having such functions.

Chua (1999) looked into the importance of incorporating Energy Management and Control System (EMCS) into building automation system in order to manage the energy consumption effectively. This thesis uses the DOE-2 simulation program to run the two sets of data in which one set is with the presence of EMCS and the other without. DOE-2 is a software program that uses a description of the building layout, constructions, usage, air-conditioning and lighting systems and utility rates provided by the user, along with weather data, to perform an hourly simulation of the building and to estimate utility bills.

Clark and Mehta (1997) proposed a methodology for integrating the data within a BAS using multi-media networking technology and providing the BAS with artificial intelligence (AI) through the use of knowledge-based system (KBS) technology. The early design of integrated building management system is a system that merely collects the output from the various controllers for monitoring purposes. Thus with the help of AI in BAS, the system is capable of assessing, diagnosing and suggesting the best solution. Energy saving can be achieved by inserting rules, like time schedule, into the system to control the environment within the building for maximum occupant comfort at minimum cost.

2.3 Energy Conservation

Review of Past Dissertations and Journals

Lee (1993) made use of computer simulation to analyze the energy performance of the various energy conservation measures with respect to the design of commercial buildings. The design refers to the building shape, size, texture, lighting level etc. The results showed that there was a possibility of 40% energy reduction from a combination of design improvements. Thus it is important to include energy efficiency as criteria during the design stage.

Suey (1995) studied on the various energy saving measures applicable to the commercials buildings. There are some energy saving methods, like reducing lighting power of buildings, make use of day lighting to supplement artificial lighting and others, which are effective and yet will not affect the occupants' thermal comfort.

Hoo (2001) focused on the energy usage in air-conditioning system. The thesis had covered the various type of air-conditioning system in the markets and ways to conserve energy. It also touched on the benefits of using BAS in conserving energy use in air-conditioning system.

Nyan (2000) focused on the lighting control techniques which could help in energy saving. Lighting not only consumes energy but also generates heats in the building, thus it adds to the cooling loads on the air conditioning system. In this thesis, two methods were introduced. First method was to shorten the operation time through the application of lighting control. Through this method, it was able to achieve 84% energy saving. Another method was to use 'infra-red' occupancy sensor whereby the energy saving of 50% can be realized.

Boey (2001) studied on the relationship among Indoor Air Quality, Energy Consumption and Ventilation. In order to achieve a good indoor air quality with efficient energy usage, the movement of the air has to be controlled within a space through ventilation. The result showed a direct relationship between the ventilation and energy consumption. What it means is, when there is an increase in ventilation rate in a room, there would be an increase in energy consumption because more energy is required to cool down the warm ventilated air.

Wong (2001) looked into the various factors that would affect the energy performance of the buildings. This thesis used three case studies and comparison is made on the Energy Efficiency Index (EEI) in areas like tenancy characteristics, building design, service design and management of energy usage. The higher the EEI, the more energy is consumed per unit area. One of the factors is the presence of the Building Automation System in a building.

2.4 Review of Energy Conservation in ASEAN (Associations of Southeast Asia Nations)

Energy Conservation is a global issue. In ASEAN, every country tries to invoke several competitions or energy conservation programmes to its buildings in the hope of playing a significant part in saving the earth.

For example in Malaysia, the government has placed efforts to promote energy efficiency. They have introduced Energy Efficiency and Conservation (EE&C) program that aims to encourage industries and building owners to audit their energy usage for the purpose of reducing energy cost and increasing productivity. In order to attract companies to participate, the government-introduced incentives for EE&C programmes like tax exemption on equipment etc.

In Singapore, Building and Construction Authority (BCA) also introduced Energy Efficient Building Awards. The purpose of this Award is to promote energy efficiency in the building.

The Association of Southeast Asia Nations proposed an ASEAN Energy Awards to promote the building energy efficiency and also to serve as a platform for private sectors to be involved in the energy development. In 2001, the winner of this competition was the Securities Commission of Malaysia. It is Malaysia's first truly flexible office working environment, which allows easy configuration of systems. This building is equipped with BAS to control the lighting system as well as other systems. The BAS is able to optimize energy consumption. The runner up is the Urban Redevelopment Authority of Singapore. Here, the Mechanical and Electrical systems are also controlled by BAS. The energy used can be easily monitored by BAS. From these winners, one can conclude quite easily that BAS is an essential system that is important consideration if a building wants to achieve an energy efficient building status

2.5 Reviews on Past Seminar/Research on Energy Efficiency in Bldg

Wong (2001) studied into the need for energy audit in a building. The audit can be just a simple walk-through survey or studying in details by monitoring the energy use in the building services plus doing some evaluation and studies.

CHAPTER 3

INTELLIGENT BUILDING FRAMEWORK

3.1 Introduction

In Singapore this year, soaring electricity bills due to escalating of oil prices have sent companies scrambling to conduct energy audits. Energy audits are an essential first step towards cutting energy costs in firms. Conducted by energy service companies, known in the industry as Escos, they test the efficiency of a company's heating, cooling, ventilation and other systems that consumed electricity and hence it can reduce their utility bills. A good energy management of a building will determine the effectiveness of energy consumed, thus will directly affect the monthly operational budget.

3.2 Intelligent Building

In Singapore, an intelligent building must fulfill 3 conditions. They are:

i) The building should have advanced automatic control system to monitor various facilities, including air-conditioning, temperature, lighting, security, fire etc. to provide a comfortable working environment for the tenants.

ii) The building should have good networking infrastructure to enable data flow between floors

iii) The building should provide adequate telecommunication facilities.

An intelligent building must be smart enough to vary the environment to suit the users and also to provide various means of communication or network regardless of whether it is internal or external.

Building intelligence starts with monitoring and controlling information services known as Building Automation System (BAS). BAS is able to optimize environmental and safety aspects in an economical way. This can be achieved by using computers, together with function distribution control techniques, to optimize the usage of various pieces of equipment within the building such as the electrical facilities, the air-conditioning systems, fire-prevention equipments and security devices.

Intelligent building, with the use of automated control system such as BAS, enables both building owners and tenants enjoy the benefits of financial gain and enhanced accommodation/management quality.

3.3 Energy Efficiency

The energy performance of a building has become an important factor in the design of the building. Building and Construction Authority (BCA) has introduced an "Energy Efficient Building Awards 2004" to emphasis the importance of integrating various energy management systems into the building in order to have an energy efficient building.

A study on 'Energy Efficiency' by Prof Lee Siew Eang (National University of Singapore) on Office Buildings in Singapore was done. Lee (2000) found that ***75% of the buildings studied have energy efficiency indices of between 100 and 200 kWh/(sqm.yr).***

The energy efficiency indices will set as a benchmark for the case study findings in the later part of this research.

3.40 Building Automation System (BAS)

Building Automation System (BAS) comprises of electronic equipment that automatically performs specific facility functions. The commonly accepted definition of a BAS includes the comprehensive automatic control of one or more major building system functions required in a facility, such as heating, ventilating, and air conditioning (HVAC) system, lighting, power, lifts, security and more. In short, BAS is to integrate the traditionally separate functions of Temperature Control, Energy Management, Fire and Security under one common operation. Figure 3.1 shows this schematically.

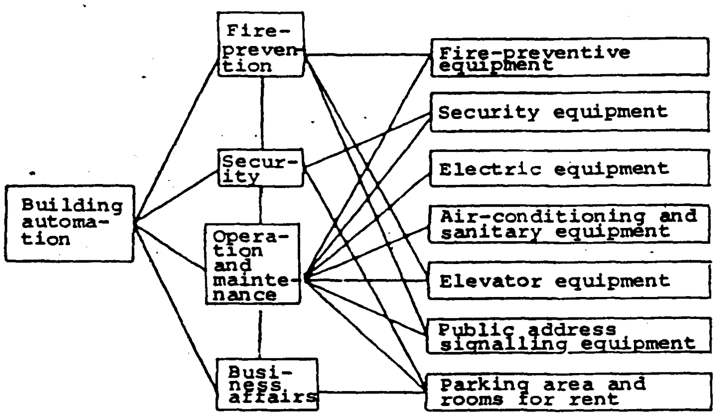

figure 3.1 BAS and its function

BAS includes a collection of sensors that determine the condition or status of parameters to be controlled, such as temperature, relative humidity, and pressure. Similarly, output devices impart electronic signals or physical action to control the devices. Examples include electric relays or damper and valve actuators.

Below are some examples in which the BAS can lighten the loads as well as helps to conserve energy.

3.5 Lightings and Air-conditioning Systems

These two systems contribute most of the electrical bills at the end of the months. Switches for these individual systems are placed strategically around the building. In the past, security guards will have to physically go to every floor to switch off the lights and air-conditioning every night. This is a tedious and time-consuming work. Energy is also wasted in the interim period when staff goes back after work and the security guards reach the location to switch off the lights and air-conditioning. Moreover, during this period, the office strength might be reduced to half, but the energy consumption remains the same. At present, with BAS, all lightings and air-conditioning are schedule at pre-defined time. At the end of the office hour, all lights will be automatically switched off. Staff who are still working can extend the lightings hours by switching on the by pass switch.

3.6 Maintenance

Traditionally, mechanical maintenance scheduling has been based on empirical data regarding average run time per month, rate of failure, etc. To get this data, maintenance staff will have to walk to all counters to read the run time. This is not only time consuming, but is also a very tiring way to get information in order to derive a scheduling chart. With the use of BAS, all relevant data about the building operations can be easily obtained. This data is integrated into automated tools for management, scheduling, thus precious time is saved, and a better and more accurate scheduling is obtained.

A commercial building consists of various systems like Ventilation & Air-conditioning, lighting, power, lifts, security and protection. All these systems require energy in order to operate. Based on Singapore Power's (1999) research, in the tropical climate of Singapore, much of the electricity is used in the Air-conditioning and Refrigeration of a commercial building, thus the study of the BAS in HDB Hub is critical in determining the energy efficiency of the building.

CHAPTER 4

BUILDING PROFILE

4.1 Introduction

This research is carried out to investigate the energy efficiency of HDB Hub. The result will be benchmarked against the study carried out by National University of Singapore's School of Design and Environment.

4.2 Building Profile

The HDB Hub comprises of two Office Tower Blocks namely the 'West' and 'East' wing. The HDB staff established their offices totally in the 'West' wing which comprises of 33 storeys. The 'East' wing was allocated to private commercial use and thus was leased out to many different companies. This wing comprises of 28 storeys and can be easily accessible to the public whilst the HDB wing is closely guarded with security and only accessible with the proper pass. Visitor can access to this wing only through the exchange of a 'visitor' pass with our national identity card. Of course, during the exchange of the pass, the reason for visiting must be highlighted. In Brief, these two blocks is linked to a 6 storey podium with 3 levels of basement car-park and a 9 storey Rental Office slab block. Apart from office space, the development also includes Training Center, Staff Recreation Centre, an Air-condition Bus Interchange and four blocks of Commercial /Retail Blocks. This whole development project cost was $450 million and the total gross floor area is about 174,000m^2.

Since HDB Hub was a high profile project, it is important to convince the users and public that it is an intelligent and user-friendly building. The latest "intelligent" building features for Intelligent Building Management System (IBMS) are incorporated into the building design in order to provide a convenient, friendly, responsive, effective, support environment for its users.

Value engineering is adopted in HDB Hub to ensure the most cost efficient building services are installed. Apart from selecting energy efficient design, a good energy audit and metering system and building automation system is employed to monitor the energy consumption. Figure 4.1 is a photograph to show the HDB 'East' and 'West' wings linking together by two enclosed bridges.

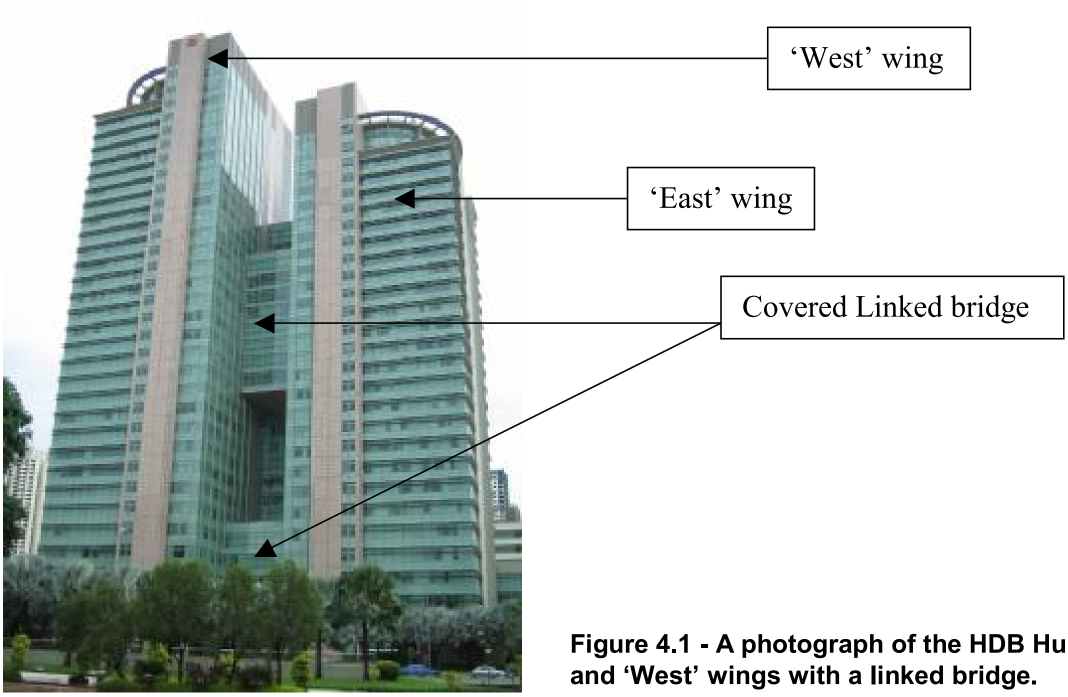

Figure 4.1 - A photograph of the HDB Hub's 'East' and 'West' wings with a linked bridge.

4.3 Intelligent Building Management System (IBMS)

The Intelligent Building Management System (IBMS) for New Housing Development Board Headquarter at Toa Payoh Centre is a multiple network management system. It provides an Intelligent Integrated Solution for all Building Services

The IBMS system for HDB Hub Centre make up of 3 networks. They are IBMS Network (IBMS LAN), Building Automation Network (BAS LAN) & NHDB Office Network (NHDB LAN).

The IBMS Network (IBMS LAN) interconnects the various Central Severs, Client stations and BAS Workstation. It is also interfaced with NHDB LAN for other uses through standard communication components such as Routers, Bridges and Switches.

Building Automation Network (BAS LAN) provides the lowest level network structure interconnecting various LAN Controllers for ACMV and electrical system. All LAN controllers are connected directly on to the BAS LAN. Once configured, controllers operate autonomously with no interaction required from other system. All the control application modules (power failure, auto restart time schedules, optimal start stop, etc) are resident in LAN controller memory for standalone operation.

NHDB office Network (HDB LAN) is connected to IBMS LAN through suitable Routers/Bridges to exchange the information for different services like Help Desk System, Intelligent Display Controllers, etc.

The focus will be on the Building Automation Network (BAS LAN) as it can reflect the efficiency of HDB Hub. In fig.4.2, it shows a typical control room of an intelligent building; whereby trained technical persons monitor the daily operation.

Figure 4.1 Intelligent Building Management System (IBMS) Control Room

4.4 Building Automation System

The Building Automation System (BAS) installed in HDB HUB is an important part of the overall Intelligent Building Management System (IBMS). It not only shows the energy consumed in the building, it also provides monitoring and controlling functions of all the building services within the building. In HDB HUB, BAS only controls the lighting, Air-conditioning, and Mechanical Ventilation. As for fire, security, carpark, lift system, other contractors due to security reasons manage them.

The BAS Workstation is loaded with Intellution iFix Supervisory Control And Data Acquisition (SCADA) software along with the necessary drivers to interface to the LON controller for monitoring and control.

4.5 Software

Intellution iFix SCADA is a popular automation software. This software turns the computer screen into an operator display station. The status of various systems is shown in graphical and text form. Different colours will indicate the different operating status of the equipment. In addition, this software allows the operator to control the (On/Off) switches of the equipments on the screen.

Figure 4.3 shows the lightings in Block B 11 storey. Those areas in "GREY" indicate the lights are switched off. Areas in "BLUE" means the light circuits in these areas are offline and areas in "YELLOW" mean the lights are on. The lights in Zone G are also on but they are manually controlled in the control room to be on. In the figure, "Override", "Command" and "Control" are in "GREEN".There is indication of KWH reading in the figure. It shows the amount of energy used on that level. From the reading, the owner knows the amount of energy used in different levels in office Block A and B.

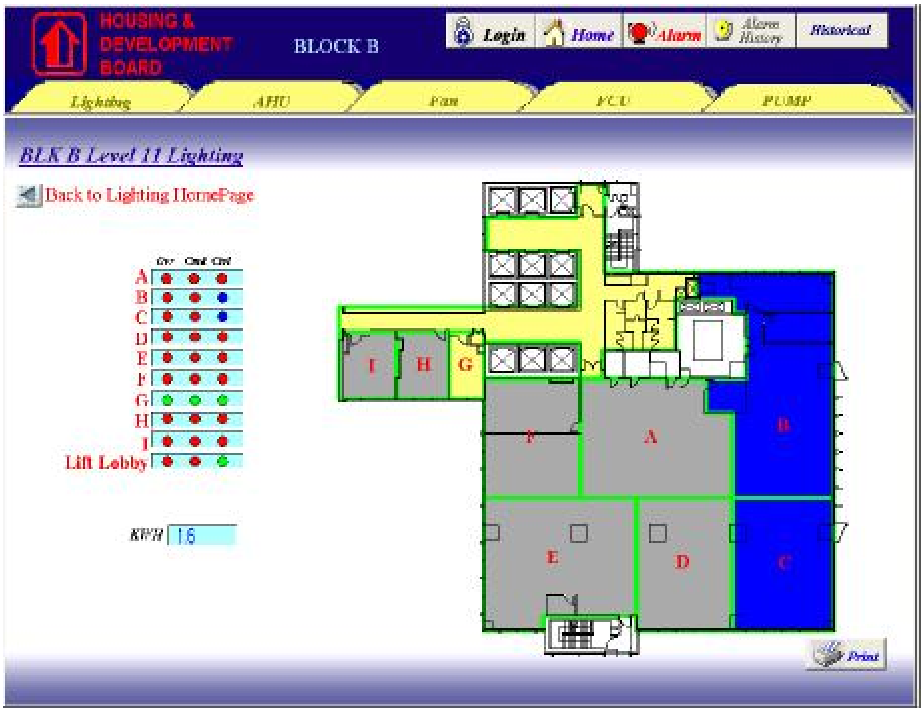

Figure 4.3 iFix Intellution SCADA View for Lighting

Intellution iFix has two basic functions. They are the Data Acquisition and Data Management. Data acquisition is the ability to retrieve the process data from the respective equipment floor and to process that data into usable form. Control signal can also be sent to the equipment to control various devices, thus establishing a two-way link between the equipment and the software. Data management is to manipulate and channel upon the request of the software applications once the data is acquired.

4.6 LON controller

LON controller has the function of design, installation, documentation, operation and maintenance. It also supports the network recovery thus reducing the maintenance costs for legacy systems and fast network merging for large system.

CHAPTER 5

BUILDING AUTOMATION SYSTEM

5.0 Air Conditioning and Mechanical Ventilation (ACMV)

5.1 Introduction

The Air-conditioning system consists of Air Handling Units (AHU), Fan Coil Units (FCU), ducting and related works. Variable Air Volume (VAV) Air Handling Unit (AHU) is used in office blocks (Main Building) and individual FCU with multiple fan speed and individual temperature control used in meeting rooms, conference rooms, library, server room and others.

The Air temperature for indoor condition is set at about 24 ^{o}C and the relative humidity is around 55%.

5.2 Air Handling Units (AHU)

The Main Building is served by 86 numbers of Variable Air Volume (VAV) Air Handling Unit (AHU). The VAV units are controlled by room thermostat in order to maintain the desired environmental condition of the respective areas and rooms.

AHU (Figure 5.1) are equipped with variable speed drives (VSD) and carbon dioxide sensors (Figure 5.2). VSDs are used to adjust the supply airflow rate of the AHU in accordance to the changes in load pattern and the carbon dioxide sensors are used modulate fresh air input into the system upon detection of excessive carbon dioxide level.

A flushing air system is installed for each AHU. The BAS will activate the flushing air system daily to purge out foul air trapped in the air-conditioned room and refresh the air. During this operation outside and exhaust air dampers are opened but return air damper is closed and fan will be command to "on" position. This operation is normally scheduled after office hour.

Every AHU is provided with selector switch for selecting either Manual or BAS operating mode. Under BAS mode, the AHU will operate according to the time schedule. Under Manual mode, BAS controls are disabled but monitoring functions will be retained.

Figure 5.1 Air Handling Unit (AHU)

5.2 Carbon dioxide Sensor

5.3 Variable Air Volume (VAV) System

5.3.1 Introduction

This system (Figure 5.3) responds to the load variation by varying the amount of air supplied into each conditioned space based on the actual instantaneous load. The higher variable of the building load, the greater is the saving. The required fan motor horsepower for a variable volume system under full load is less then that for an equivalent constant volume system. As the cooling loads for various conditioned space decrease, supply air volume reduces proportionately with the reduction in cooling load. Under a partial load condition, the fan motor horsepower reduces significantly as the volume of air is reduces.

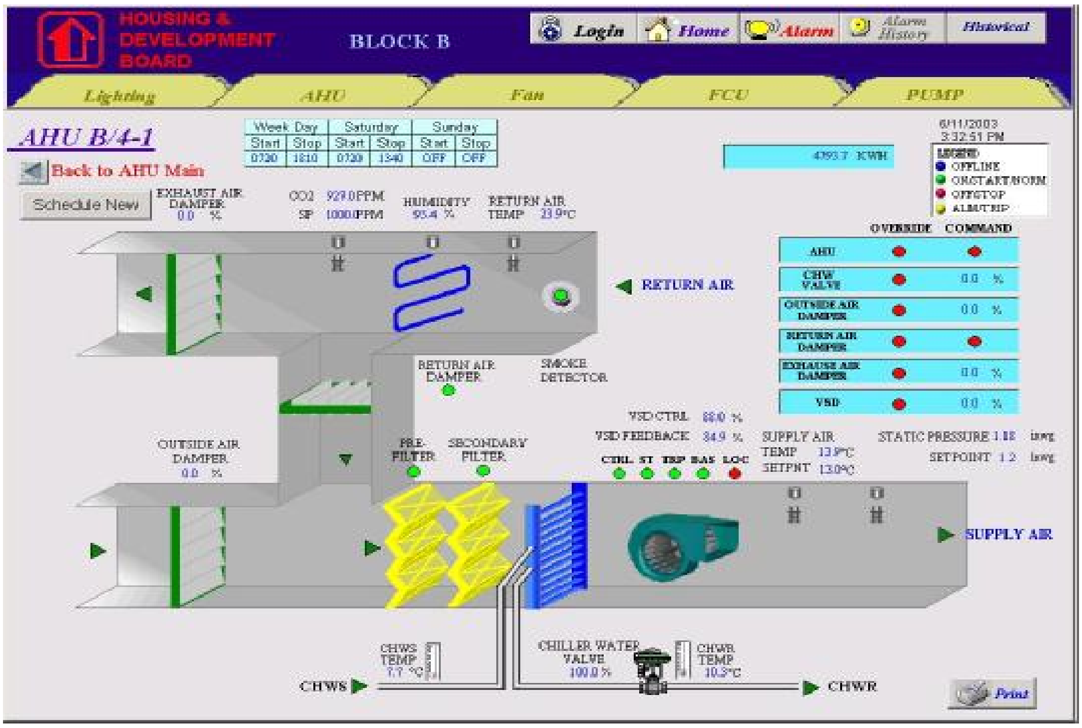

Figure 5.3 Variable Air Volume Air Handling Unit

5.3.2 Intelligent Feature

When occupants in the room increase, the VAV thermostat (Figure 5.4) will sense the increase in the room temperature. VAV box will then open its damper to allow more air to the room, thus this will cause a drop in the duct static pressure sensed by the duct static pressure sensor (Figure 5.5). In order to maintain the static pressure in the duct, the BAS activates the VSD to increase the fan speed in order to build up the duct pressure to the desire point.

Chilled water valve will also moderate accordingly in this system. In this case, the valve will vary depending on the supply air temperature and its set point.

Figure 5.4 VAV Thermostat

Figure 5.5 Duct Static Pressure Sensor

In the case of fire, the smoke detector (Figure 5.6) mounted at the return duct will stop the system operation immediately to prevent the smoke from circulating in the room. When the carbon dioxide level is higher than the set point, the outside and exhaust air dampers will open. During this refresh operation, outside air damper will allows fresh air from outside the building to get into the room and exhaust air damper will allows extraction of foul air out from the duct.

Figure 5.6 Smoke Detector

5.3.3 Control and Operation

As mentioned earlier, the AHU has two switch modes. When manual mode is selected, “LOC” will show “RED”. When BAS mode is selected, “BAS” will show “GREEN”. In order to control the AHU from the control room, the switch mode of the equipment must be at BAS. Figure 5.7 shows the switch mode indication.

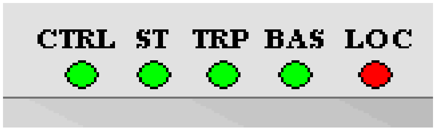

Figure 5.7 Switch Mode for BAS and Manual

The user can also manually control, any point in the AHU by selecting “Override” and “Command” to “GREEN” (Figure 5.8). This will allow user manual control by activating the script to do the task that the user wants. Chill water valve, outside air damper, return air damper, exhaust air damper and Variable Speed Drive (VSD) can be controlled. The user can control from 0% to 100% depending on the user requirement. Normally manual control is not used often unless troubleshooting in the system is needed when an error or fault occurs.

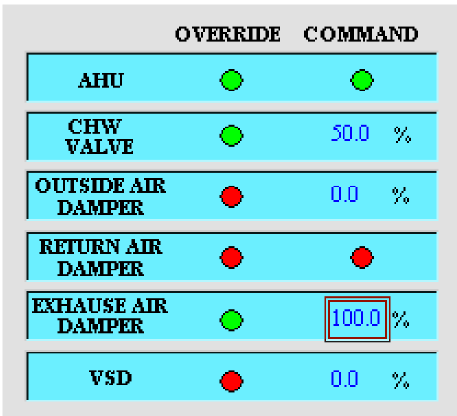

Figure 5.8 Override and Command

5.4 Fan Coil Unit (FCU)

5.4.1 Introduction

There are 2 types of FCU used in this project. Notice in type 1 FCU (Figure 5.9) does not have return air temperature, and chilled water valve is controlled by thermostat. This type of FCU is used in rooms, e.g. meeting rooms, where individual users can manual control the room temperature (i.e. occupant control the temperature by selecting the fan speed and adjusting the set point on a local thermostat). For the other type of FCU (Figure 5.10), it is controlled by the BAS using the return air temperature. When the return air is higher than the set point, chilled water valve will open to allow more chilled water to cooling coil in order to bring down the temperature and vice versa. This type is used in server room.

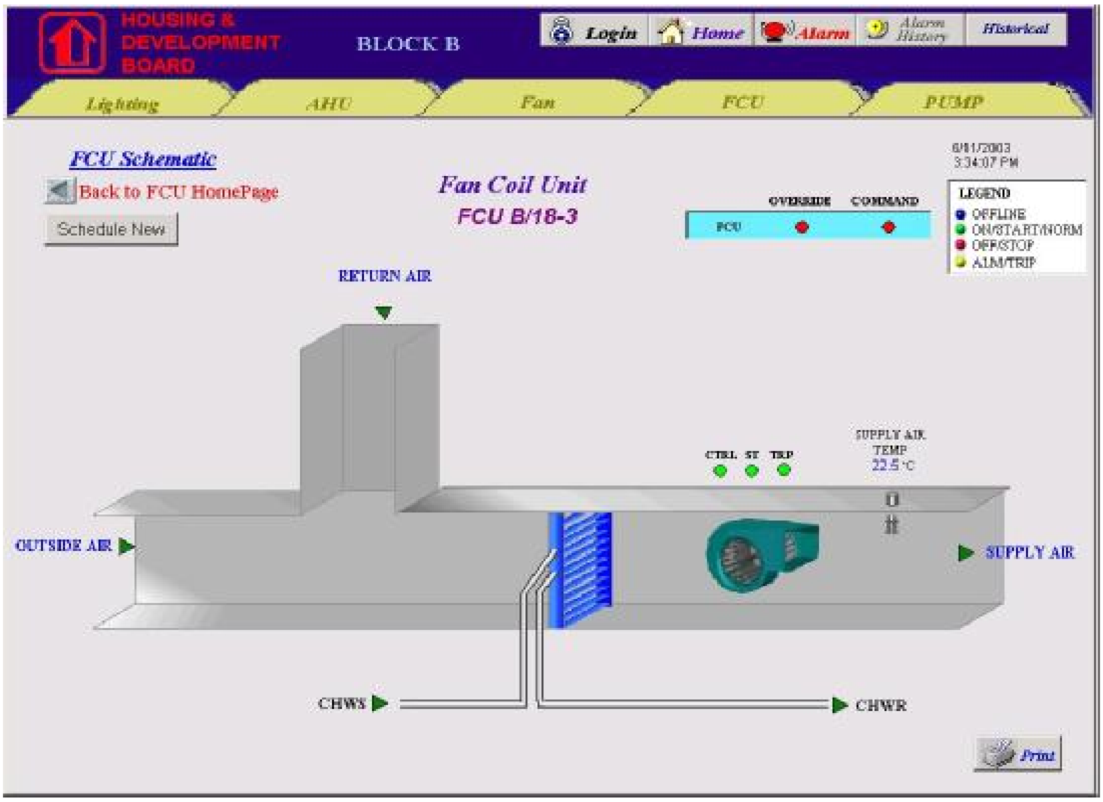

Figure 5.9 Type 1 Fan Coil Unit

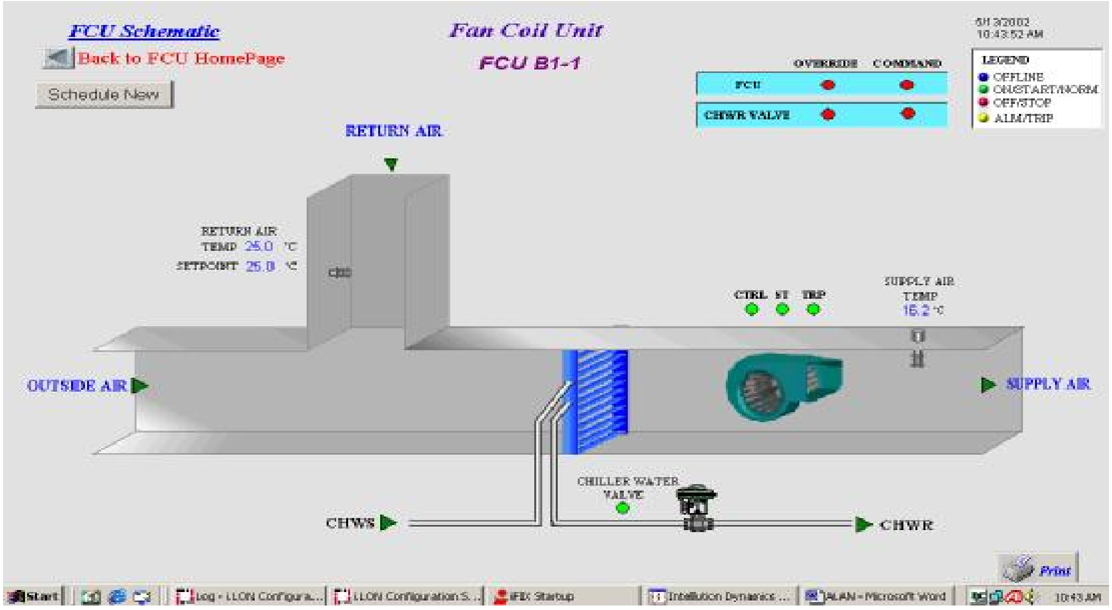

Figure 5.10 Type 2 Fan Coil Unit

5.4.2 Intelligent Feature

For Type 1 FCU, the thermostat with a local temperature set point setting is provided to maintain the space temperature by controlling the 2-way ON/OFF valve. The thermostat will disable the power supply to the control valve, thus closing it when the FCU is not working.

For Type 2 FCU, when the FCU is not functioning, the BAS will then detect the ‘OFF’ status of the FCU and will send a close signal to the On/Off valve, thus closing it. For example, if the room temperature set point is fixed at 23 degree Celsius, but the actual room temperature is at 24 degree Celsius, BAS will give a command to open the CHW valve. Once the temperature falls below 22 degree Celsius, the BAS will shut the valve.

5.5 Main Chiller Plant

5.5.1 Introduction

The BAS provides an automatic monitoring and control of all the Main Plant Room equipment and its associated field devices. The chiller system for the Main plant Room comprises of the following equipment:

- 4 units of water cooled chiller of 1050RT each (CH)
- 2 units of water cooled chiller of 500RT each (CH)
- 7 units of Primary Chilled Water Pumps (PCHWP)
- 10 units of Secondary Chilled Water Pump (SCHWO) – All are equipped with Variable Speed Drive
- 7 units of Cooling Towers (CT)
- 7 units of Condenser Water Pumps (CWP)

Two numbers of central chilled water systems are designed to serve HDB HUB. One of the systems serves the 2 Office Tower Blocks, 6 storey podium with 3 basement carpark, Rental Office slab, Staff recreation Centre and Training Centre, whereas the other serves only the New Toa Payoh Bus interchange. As for the other four blocks of Commercial Retail Blocks, air-conditioning is not provided but only the power supply to the air conditioning is provided.

5.11 Chiller Room

5.5.2 Time Schedule

The chiller system operation is separated into Day Operation and Night Operation.

Weekdays Operation

6am to 7am – Force start during the day

At 6am, the first chiller (1050RT) is switched on with the help of time schedule program function in the BAS system. The Second and third chillers will then turn on with a delay time of 20 minutes after the front chiller is switched on.

Weekdays 7am to 9pm

From 7am to 9 pm, the chillers (1050RT) will either operate or stop depending on the cooling load in the rooms.

Weekdays 830pm to 9pm

The time schedule, from 8pm to 9pm, in BAS will activate to turn on the 500RT chiller. 1050RT chillers will continue to run till 9pm.

Weekdays 9pm to 6am

The 500RT chiller will continue to be on till 6pm where 3 1050RT are forced to start up. This cycle will go again. The 500RT will depend on the cooling load of the rooms.

Weekends & Public Holiday Operation

The time schedule function will not be activated for Day Operation, but the Night
Operation (9pm to 6am) will still follow the weekdays schedule.

5.6 Lighting System

5.6.1 Introduction

The Lighting System in HDB HUB is controlled by the BAS by switching On/Off based on the pre-defined time schedule. However, the operation can override the Lighting command (On/Off) from the operator's workstation in IBMS control room. With the help of BAS, most of the lights will be automatically switched off especially after office hours

5.6.2 Intelligent Features

5.6.3 Zoning

Figure 5.12 shows the layout of NHDBC in SCADA (Supervisory Control and Data Acquisition) view. The layout is divided into various areas, namely Block A, Block B, Block C, Block D, Block E, Block 180 and Block 180A. The zoning is done by grouping various blocks activity together. For example, Block A, Block B, Block C and Block D are office areas, thus the lighting time schedule will be from 8am to 6pm. What it means is that the office block's lightings will automatically come on at 8am and off at 6pm sharp.

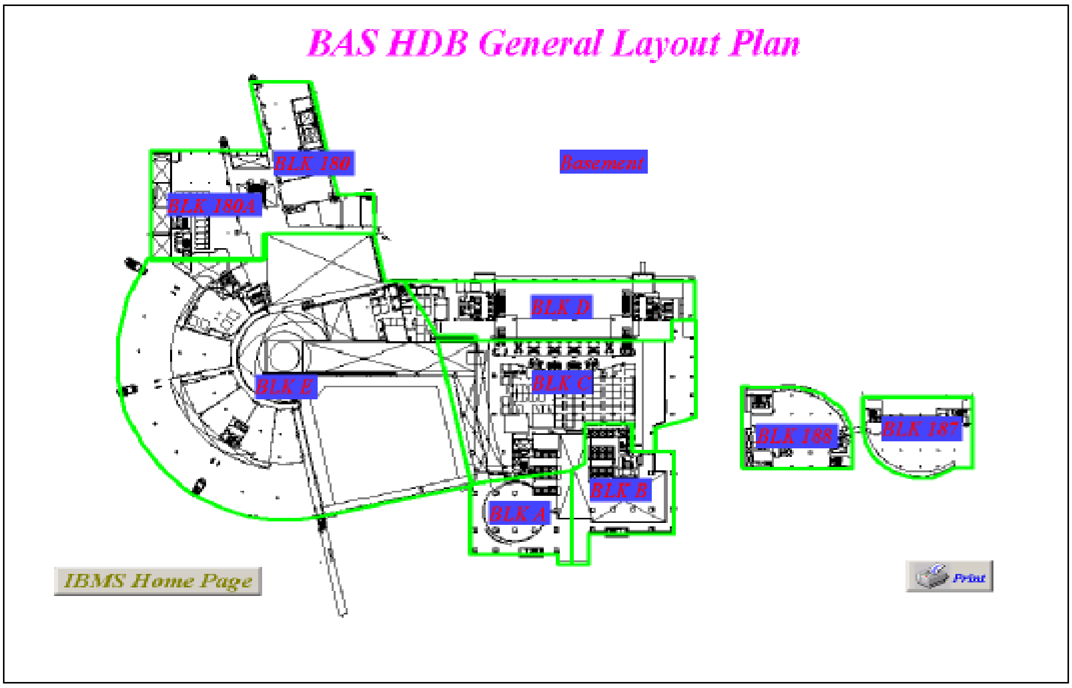

Figure 5.12 HDB Centre Layout Zoning

After zoning into main blocks, each block will then be divided into various sub-zone per storey. Referring to Figure 5.13, the numbers of sub-zones will depend on the number of time extension switches (TE) available. If the office workers need the lights to be on after office hours, they have to press the time extension switch for the zone. Every time the time extension switch is pressed, the lights for that zone will be extended by an hour. The extension switches are only for the office areas and not the Lift Lobby zone. The Lift Lobby is controlled by time schedule that is from 0800hrs to 0000hrs

Figure 5.13 SCADA Display For Light Zonings

5.6.4 Efficient Lightings Schedule

Block E is a recreation facility that consists of game room, jackpot room, and playground. There are row of lights that consists of three light circuits. Therefore for energy saving after 2359 hours, one circuit can be switched on for two hours at a time while the other two circuits will be off. For example, the first circuit may be ON from 2359 hours to 0200 hours, the second circuit ON from 0145 hours to 0400 hours, and the third circuit ON from 0345 hours to 0600 hours.

The zoning for the car park area (basement one to basement three) is different from the office areas, as it has to be lighted twenty-four hours a day for security reasons. Taking into consideration that a row of lights consists of two circuits, the zoning is done such that all lights are on from 0600 hours to 2300 hours, one circuit turn off from 2300 hours to 0300 hours, while the other circuit turns off from 0300 hours to 0600 hours. In this way, from 2300 hours to 0600 hours, only fifty percent of the lights are on.

In the case of an emergency, the followings will take place:

AHU will stop operation when over-current occurs; it activates “Trip” from “GREEN” to “YELLOW”. For detection of smoke, the “Smoke Detector” will turn from “GREEN” to “YELLOW”. Then “Status” will turn from “GREEN” to “RED”, this is to indicate AHU stop operation.

In conclusion, chapter 5 had captured the major control and monitoring systems and scheduling for both the ACMV and Lighting of the HDB HUB. This information will be further analyzed in the next chapter of study.

CHAPTER 6

ESTABLISHMENT OF BENCHMARKS

6.1 Introduction

In this chapter, the important and critical events would be to collect sufficient data and information relating to the project for an intensive analytical study to establish realistic bench markings. The study would be to focus on determining the benchmarks of an energy saving intelligent building in order to compare with those of the HDB HUB. The National University of Singapore had conducted many surveys in this area and has thus set up benchmarks and data base for this study. The author truly believes that these survey results could be used as they were all collected by a reputable university in a most professional way. In order to achieve a realistic target, the bench markings should adopt the performance within established norms and also frequent reference to well tried existing technology.

6.2 Energy efficiency classifications of office Building in Singapore

Setting Building Energy Performance Target

(Office and Commercial Buildings)

Designation	Performance Limit	Classification	Percentile
Excellent	150 kWh/m^2/yr	Class 1	Top 10%
Very Good	180 kWh/m^2/yr	Class 1	Top 25%
Good	200 kWh/m^2/yr	Class 2	Top 40%
Average	240 kWh/m^2/yr	Class 2	Top 60%
Poor	270 kWh/m^2/yr	Class 2	Top 75%
Very Poor	>360 kWh/m^2/yr	Class 3	Last 25%

Notes: Performance based on 56 hours weeks systems' operation and at least 80% occupancy rate. Building with less than 10% data centre area and not exceeding 15% of GFA (Gross Floor Area) designated as car park.
(This survey was conducted by the National University of Singapore)

National University of Singapore had conducted a survey on the energy efficiency performance on 104 offices building in Singapore. The purpose of this survey is to set a useful benchmark in determine the energy performance of office buildings in Singapore. The result is then translated into a cumulative percentile distribution curve as shown in Figure 6. This would become a useful design benchmark for consultants or building manager to determine the energy performance of their building in terms of percentile position measured versus the energy performance of 104 office buildings.

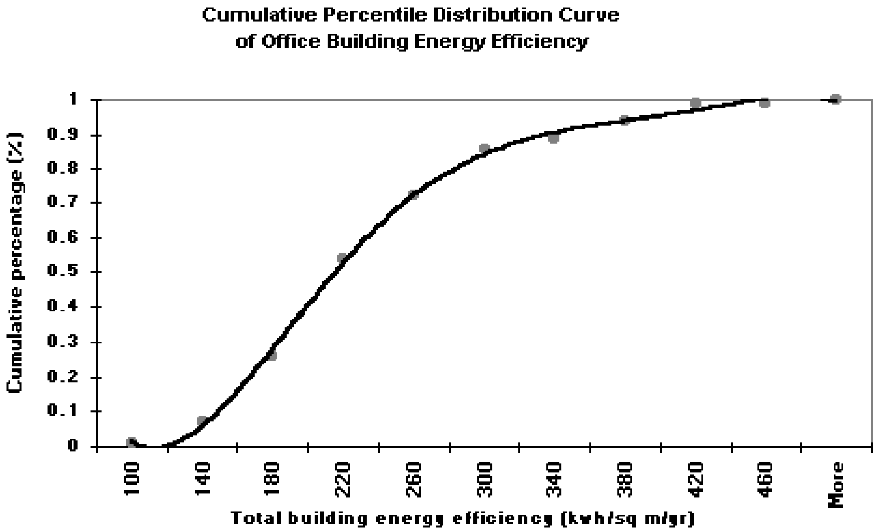

Figure 6: Cumulative percentage distribution curve of energy efficiency of office building.

The above data are useful for building managers to compare and conduct energy audits to determine where and how the buildings had performed. From a researcher's point of view, further benchmark information is needed at lower levels such as landlords and tenants' level.

It is also useful to determine the energy performance indicators and identifying the key indicators. This is useful information for building designers and managers. The landlords' consumption includes all the main and central air-conditioning, lighting in common areas and all other equipment such as pumps and ventilating fans and so on. The tenants' consumptions are mainly in the areas of lighting and appliances including fans, printers, computers and so on.

The cumulative energy consumption curve of landlords is given in Figure 6.1 below. The total building consumption cumulative curve is also plotted for comparison. One can observe that the total building energy consumption is significantly spread as compared to that of the landlords' consumption.

All the 104 buildings studied are clustered in the range of 68 to 270 kWh/(sqm.yr). Energy performance ranking for landlord is therefore relatively more sensitive to minor increment. 75% of the buildings studied have energy efficiency indices of between 100 and 200 kWh/(sqm.yr). This is relatively competitive. In comparison, for total energy consumption, the bottom 20% of buildings had energy efficiency ranging between 300 and 460 kWh/(sqm.yr).

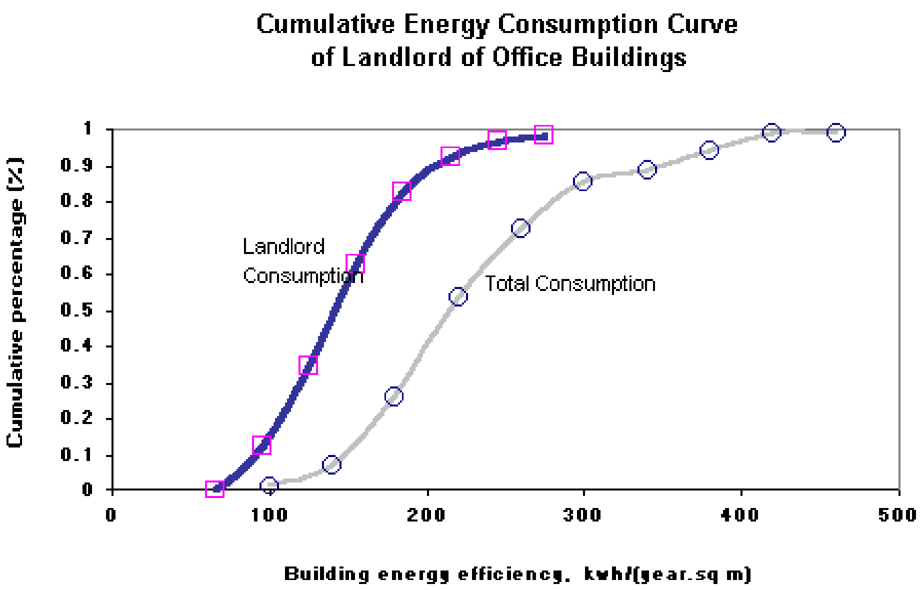

Figure 6.1

(Source Energy Efficiency Of Office Buildings In Singapore, Lee Siew Eang)

From the survey, it was concluded that most of the 104 office buildings have energy efficiency indices of between 100 and 200 kWh/(sqm.yr).

Factors affecting the Benchmarking

There are seven (7) important factors that directly contribute to the energy performance of a building. They are as follows:

1. Gross Floor Area (GFA)
2. Age (air conditioning, lighting, facades)
3. Height of Building
4. Use and Function
5. Occupancy rate
6. Operating Hour
7. Overall Thermal Transfer Value (OTTV)

CHAPTER 7

INFORMATION COLLECTED AND ANALYSIS

7.1 Introduction

In this chapter, information from available sources would be collected and collated for further analysis. The results would then be compared with the established benchmarks so as to determine whether HDB HUB is indeed a modern energy efficient intelligent building. This information would be collected through the internet, websites, HDB HUB's annual reports, related seminar (Intelligent Building Seminar) and site visit.

7.2 Air conditioning and Mechanical Ventilation system ACMV)

The HDB HUB adopted centralized cooling system and the plant is designed using a decoupled primary-secondary pumping system with variable speed drives. The chiller plant is optimized through an advance chiller optimization programme using a predictive algorithm. The VAV system is used in both the office blocks of the HDB Hub. This system is selected because the amount of cool air pump into the room will depend on the cooling load in the room. In the early morning, for example, when the building does not require much cooling, the main fans will run more slowly, reducing the total air flow through the system. However, even at this time, a VAV terminal box supplying a room with many occupants can fully open its damper, providing needed cooling. As offices begin to fill up during the day and the sun rises, generally heating the building, the total air flow will increase as necessary. If some rooms remain unoccupied throughout a particular day however, the VAV terminal boxes for those rooms will remain closed. The wall-mounted thermostat determines how much the supply air valve should open in order to maintain the room temperature. Unlike the Constant Air Volume (CAV) System whereby a constant amount of air is pumped into the room even if there is only one occupant. Much energy is saved using this VAV system, as the BAS will keep track on the room temperature. Should there be any drop or rise in the room temperature; BAS will control the speed of the fan and the chiller valve effectively.

FCU system is used in those small rooms in office blocks like meeting rooms, conference room, etc. Most of the time, these rooms are not occupied, thus lightings and air-condition will be switched off. Upon booking of these rooms through IBMS system, the operator will key in the time and date schedule into the BAS. The BAS will switch on and off the lighting and air-condition punctually. This control allows much energy to be saved when users often forget to switch off the lightings and air-condition.

By using BAS, one can take comfort that the negligence is keep minimum since human factor is not present, thus more energy is conserved. Once the pre-define data like room temperature, carbon dioxide level, others is set in system, the BAS will take the control of the room. If the room conditions fall below the pre-define data. In addition, any failure to the equipment will be alarmed to the operator.

7.3 Carbon Dioxide and Carbon Monoxide Sensors

The HDB HUB installed numerous number of above sensors to different areas and locations in order to gauge and monitor these gases which would directly influence the ventilation needed for the building. These sensors would be set to activate the ventilators via the BAS. Basically, the carbon monoxide sensors would be installed at the underground car parks to dissipate this toxic gas and carbon dioxide sensors would be installed in rooms and confined areas where people gathers. These sensors would help to assist in conserving energy by signaling the system to activate the ventilators only when required and not continuously running throughout the day.

7.4 Lighting Zones & Predefined Schedule

The BAS is an important system used in controlling the lights based on time schedule. This enable the lights to switch on and off at a preset time. There is also a local override switch so that users can restore the light whenever needed.
In HDB HUB, all the towers and podiums were divided into various individual blocks as shown in Figure 4.3. Each level of the individual block is then further sub-divided into various small areas. For example, Figure 5.13 Block 'A' at the 8^{th} storey has been further sub-divided into seven areas namely zone A, B, C, D, E, F and corridor area. The office area zones; A to F are separated from the corridor area whereby the corridor area's lighting will be switched on even after office hour. Based on the pre-defined time schedule in BAS, all office lightings will be off at 6pm automatically. If any user needs to extend the lighting hour, the user will just have to switch on to by-pass and activate the time extension (TE) switch of his zone. Every extension is preset to extend for an hour. Only the lightings at the user's zone will be switched on while the other zones remained off. This reduces energy wastage and thus resulting in energy saving.

The zoning need not be in term of areas as it can also be in term of rows of lightings as used in car park. On preset time scheduled in BAS, various rows of lightings will be switch on and off. Effective zoning, with the help of BAS, will definitely result in energy saving.

7.5 Luminaries

In HDB HUB offices, the main type of luminaries used is the Philips TBS 630/228 HF consists of 600x1200mm ceiling recessed luminaries with TL5 2x28W onmi-directional luminaries mirror optics and HF electronic ballast. Ballast is a device for stabilizing the current in the discharge. It is an essential part of the fluorescent lamps, transforming standard voltages into the voltage needed for the lamp. The TL5 fluorescent tubes are currently recognized as the most energy efficient and environmental friendly lamps in the world. If compared with the normal fluorescent tubes, TL5 combined with electronic HF ballasts, can reduce the energy usage by up to 40%. In additional, TL5 can gives 12% higher luminous efficacy and luminaries' efficiency improved by 15%.
The TL5 fluorescent light temperature is about 25°C and the relative humidity level is about 55%. This is within the American Society of Heating, Refrigeration and Air Conditioning Engineers, Inc a (ASHRAE) guideline, which the building had adopted.

7.6 Natural Daylight and Ventilation

Full height glass panels were introduced to reduce the need for artificial lightings. These glass panels were double-glazed at 6mm thick outer lite with double low-e coating with 12mm airspace in between and 6mm thick inner lite. The double glazed with air space will help reduce the thermal heat transfer and also act as a sound barrier. (Please see figure 7.1). The office towers are both provided with shading devices and curtain wall vision glass of visible light transmittance of 60% and U-value of 1.7 W/m^2 deg K. Skylight is provided in selected location which is made of low-emissivity glass.

Figure 7.1 Photo shows entrance to tower blocks

7.7

Motion sensors detect the activity of people which then triggers the activation of the connected equipment. These sensors are usually installed at escalators and toilets. At the HDB HUB, all the toilets were equipped with the motion sensors but unfortunately, there was none at any of the escalators. The toilet motion sensors will activate the lightings and ventilators within seconds upon detecting human activity. This device is certainly very effective in energy saving as running the lights and ventilators when no one is using the toilet is a sure waste of energy. Motion sensors that are to be installed at escalators will likewise activate the escalator whenever someone approaches it. There are different types of activation of these escalators whereby some will start moving upon detecting people approaching it whereas, some escalators will only start moving when someone step on it. There is another type of escalator that will not totally stop running but will slowed to a economical speed and will only quicken when someone step onto it.

7.8 Management and Maintenance Scheme

It is only natural that after years of services, equipment will tends to lose it mechanical efficiency which is similar to our human beings of getting old and sickly. However, this inevitable process can be slowed down with effective preventive actions. Similarly to human beings where effective exercises and proper diet can slow down this process, effective programme and proper maintenance schedule will delay the losing of the equipment mechanical efficiency. For HDB HUB, they had adopted a rigorous and consistent operations and preventive maintenance programmes, which include scheduled maintenance, training of facility maintenance staff, regular meetings with maintenance specialists and users, regular improvement programmes, energy feasibility studies and on-going energy audits.

CHAPTER 8

CONCLUSION AND RECOMMENDATION

8.1 Conclusion

This project topic was specially selected because in recent years, our dependent on energy has escalated. There are many ill effects such as the often mentioned 'global warming' and 'green house effect' that can cause harm to our environment. We know that the earth current source of energy is still produced mainly from the use of the fossil fuel. All the products and by-products that are produced from this fossil fuel are extremely harmful to our natural environment; therefore it is to our benefit to use less fossil fuel through energy saving in our daily lives. Of course, energy saving is only a part of the total contributing factors in saving our environment but this should be a considerable major step in moving towards this objective.

With this objective in mind and in order to fulfill the project requirements, a site (building) would be needed for further study. This building would need to be a high profile public building where human traffic flow is high. The reason being that with high human traffic flow and located in a tropical country like Singapore, the lighting and air-conditioning would be complex in the sense of being able to provide cooling comfort and bright enough environment to both the public and staff working there. It should also be convenient and accessible to the public. With these conditions in mind, the HDB HUB was finally selected as it fit into the criteria and also this building was awarded 'Energy Efficient Building Awards 2005' by the Building and Construction Authority.

From the project, interesting facts were being revealed through studies and findings during the information collection phase. From the results of their analysis, we have learnt the importance of having an intelligent building which would basically be to incorporate the IBMS and BAS in order to achieve the main objective of energy saving. In all buildings, the study has also revealed that the two (2) main contributing factors in energy consumption would be in the lighting, air-conditioning and mechanical ventilation (ACMV).

With the knowledge that the main contributing factors are in lighting and ACMV, experts has developed programmes to handle these factors. The IBMS and BAS are programmes that use artificial intelligent to control and manage energy saving through reducing wastage. As explain in the earlier chapters, to simply describe the basic objectives of IBMS and BAS are to activate equipment only when needed and to shut off automatically when not needed through preset conditions. Of course in reality, the systems are more complex which were fully explained in the earlier chapters.

8.2 Limitations

8.2.1 Limitations of IBMS and BAS are as follows:

1. From the studies, it was realized that when the structural designers were not initially given the full requirements and understanding of IBMS and BAS, the structural forms may not be suitable for the implementation of these systems. An example would be the failure to provide an adequate and proper control room as shown in the earlier chapter of a typical control room. Another example would be the required space for conceal piping for wiring and cabling.
2. It is common knowledge that many intelligent building did not have adequate follow-up actions as in energy consumption monthly and annual auditing and maintenance programmes. A good intelligent building will lose its efficiency through aging and lack of maintenance.

Sometimes, this lack of auditing and follow-up actions was due to staff turnover and also lack of leadership and ownership of the manager in training the new staff.

3. The cost of implementing the IBMS and BAS sometimes put off owners when they face shortage of fund even though they realized the benefit of these systems.
4. The IBMS and BAS are not well publicized at this moment and many local developers are not knowledgeable enough in this area to widely implement them to their buildings. They failed to see the long term effects and benefits of having these systems implemented in their buildings.

8.2.2 Limitation to information collection

During the information collection phase, many approaches were made to friends and acquaintance working inside the HDB HUB to assist in getting some confidential information but most of them were flatly rejected for fear of being 'punish' by their departments. Some of the information was retrieved from websites, annual reports and seminar conducted in which HDB HUB was used as one of the topic in intelligent building implementations. Some of the information needed but not able t o access to it is as follows:

1. Monthly bill for energy consumption and expenditure by HDB HUB.
2. Auditing reports and maintenance bill.
3. Actual savings in term of dollars and units were not given to the public. (The HDB did publicized in one of the websites that their energy saving effort through auditing and rescheduling of their lightings and air-conditioning, they have saved S$1.56 million a year)

8.3 Recommendations

8.3.1 Publicize Building Intelligent Concepts

The following recommendations will certainly help motivate developers in accepting the concept of building more intelligent buildings for a better and greener future environment whereby many tangible and intangibles benefits could be reaped by society as a whole:

1. Singapore government should encourage by giving tax incentives to developer for adopting the intelligent building concept.
2. The Building Construction Authority (BCA) should conduct intelligent building courses at cost to attract developers and people in the construction industry to attend. Once the concept is widely accepted, implementations will take flight.
3. Engage in aggressive promotional campaigns to publicize the intelligent building concept. This will make those uninformed aware of such programmes.
4. Strongly encourage the use of after implementation tool like periodical auditing and maintenance programmes. These tools will allow the developers or users to fine tune their systems to achieve optimal results.

8.3.2 Suggested installations to HDB HUB

HDB HUB has implemented the intelligent concept well but after visiting the building on several occasions, the following recommendations would be suggested:

1. Installed motion sensors to all escalators as currently there was none.

2. All manual full glass panel doors leading to the car parks should be installed with door closer as it was observed that they were opened most of the time allowed warm air into the building and also leaking cool air unnecessary.

8.3.3 Further Study

It is quite ironical that Singapore being near the equator fails to take advantage of the long hours of daylight available. There is a seeming lack of interest in retrieving a clean source of energy. I certainly would think that this area needs in depth study to find out how we can retrieve this clean source of energy cheaply and efficiently.

In Singapore, the electricity usage is very high in the day and almost negligible in the night. This is understandable as not many industries work three (3) shifts and the power plant supply electricity cannot be shut down during the night due to economical reason. As such, there should be a potential possibility to tap this cheap energy rate and reuse the by-products during the day to cut the rate of usage. In short, we may use the same amount of energy but due to the different time, the rate would be extremely cheap. One potential topic would be is it possible to freeze enough ice to provide chilled water throughout the next day's usage. This will certainly cut down the electricity bill due to the low rate and less work load for the chillers.

The author suggested the further studies of the above two topics because they are closely related to energy source and conservation. A cleaner and environmental friendly source of energy would be able to complement the effort of energy conservation. However, the author would hope that other earth loving engineers would do more researches and studies on these topics and adapt these sources of energy to use them to complement the effort of energy conservation of an intelligent building.

APPENDIXES

University of Southern Queensland

FACULTY OF ENGINEERING AND SURVEYING

ENG 4111/4112 Research Project
PROJECT SPECIFICATION

FOR:	ENG LOO, LER
TOPIC:	INTELLIGENT BUILDING AUTOMATION SYSTEM
SUPERVIORS:	Dr. Harry Ku
ENROLMENT:	ENG 4111- S1, X, 2006; ENG 4112- S2, X, 2006
PROJECT AIM:	The aim of the project is to verify that Intelligent Building Automation System Is indeed energy saver through the monitoring and controlling of energy Consumption.

PROGRAMME:

1. Highlights the background, objectives and methodology of study.
2. Reviews past research related to this study.
3. Examines the energy efficiency standard and the important of Intelligent Building Automation System.
4. Describes the profile of the building used in the case study.
5. Focus on how Intelligent Building Automation System in the case study helps to control and monitor the energy consumption.
6. Analyses all the data in detail to determine whether the building is an efficient building.
7. Some recommendations and difficulties encountered during the research.

AGREED: ENG LOO, LER (Student). Dr. Harry Ku (Supervisor). 12/4/06

Project Timelines

S/N0	Task	Duration	Commence	Complete
1	Highlights the background, objectives and methodology	15 hrs	27 March 2006	9 April 2006
2	Reviews past research related to this study	30 hrs	10 April 2006	30 April 2006
3	Examines the energy efficiency standard and the important of IBAS	30 hrs	01 May 2006	17 May 2006
4	Describes the profile of the building used in the case study	65 hrs	18 May 2006	23 June 2006
5	Focus on how IBAS in the case study helps to control and monitor the energy consumption	80 hrs	24 June 2006	31 July 2006
6	Analyses all the data in detail to determine whether the building is an efficient building	60 hrs	01 August 2006	24 September
7	Some recommendations and difficulties encountered during	20 hrs	07 October 2006	15 October 2006

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11 August 2006

Mr Ler Eng Loo
Technical Officer

Fax : 6479 4358

Dear Mr Ler,

INTELLIGENT BUILDING SEMINAR ON 2 AUGUST 2006 – LETTER OF ATTENDANCE

This is to confirm that Mr Ler Eng Loo has attended the Intelligent Building Seminar 200
on 2 August from 9am to 5pm. The Seminar was at Meritus Mandarin, Belvedere Room, Level 4
Grand Tower.

2 Should you need any further clarifications, please do not hesitate to contact me.

Yours sincerely

Roshida Jamari
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