The hvac system to water cooled chiller construction essay

Many studies, empirical analysis, and energy consultants repeatedly claim that there is a large unexploited economic potential for saving energy. Usually, this potential is estimated to be in the range of 10 – 20 %. This dissertation explores the determinants which influence the management of energy efficiency in commercial building, and discuss possibilities how to support the exploitation of energy saving measures.

The theoretical concept is based on the ideas of behavioral decision theory and recent research in the field of organization development. In this view, energy related behavior and decision making in commercial building are formed by ability and the readiness to act of the person involved, and by the internal organizational structure, corporate routine and values.

Conducting the initial energy audit is a critical hurdle for energy efficiency, regardless whether the audit is integrated in an energy management process or a stand alone activity. The initial energy audit requires readiness to act, considerable effort and an extensive amount of practical and methodical knowledge and know how, which commercial building do not possess.

We do the modeling by using the simulate a commercial building. As an example, we identify and thoroughly describe energy saving measures within building heating, ventilation and air conditioning (HVAC) system. Taking into account the conditions of initial energy audit, we modal the measurement in such a way that, apart from basic data no further measurement are required to come to conclusion. The information necessary is acquired using formula, data tables, rule of thumb, estimate and cover in a simplified calculating costs of labor, material, equipment of HVAC equipment and system and how to calculate the resultant energy saving.

Acknowledgements

Abbreviations, Units and Conversion Factor

List of symbols

Table of Contents

1. Introduction

1. 1 Background

The use of air conditioning in Hong Kong attributes a large proportion of our total electricity consumption, due primarily to its geographic location and economic activities. In 2004, air conditioning accounted for 30% of the total electricity consumption. Our electricity consumption by air conditioning had a growth of about 17% from 1994 to 2004. The use of air conditioning is expected to grow further in view of our increasing population and economic activities. We therefore need to take measures to improve our energy efficiency, in particular, on air conditioning.

Currently, a large amount of energy is being consumed by HVAC systems in buildings. According to the statistics from the Hong Kong SAR government, about 17% of the total energy, which is about 30% of the electric energy (Chow 2006) is being consumed by HVAC systems in buildings. Therefore, energy conservation of HVAC systems in buildings will clearly have a sizeable impact on total energy consumption.

Up to date, a lot of efforts have been made in various buildings to minimize the energy consumption in HVAC systems. For example,

Marriott (2006) proposed three approaches that can be easily applied in buildings to improve the energy efficiencies of HVAC systems. The approaches are optimizing the supply air temperature, recovering energy from condenser water and making use of the geothermal heat pump system.

According to a study conducted by the EMSD, the energy saving from various types of the water-cooled air conditioning system ranges from 14% to 35%. The capital cost of evaporative water-cooled air conditioning system is about 15% lower than air-cooled air conditioning system on new system basis. Hence, if the conversion of existing air-cooled air conditioning system to evaporative water-cooled air conditioning system can be planned at the end of economic life of existing air-cooled air conditioning system, it is likely to have a reduction in replacement cost for choosing evaporative water-cooled air conditioning system in lieu of air-cooled air conditioning system. The operating life of air-cooled packaged chiller condensers is around 15 years while for fresh water cooling towers is around 20 years.

Chan (2006) proposed optimum control logic for the HVAC system of a building in Hong Kong, which minimized the mismatch of cooling load demand and chilled water flow demand. Around 435, 000 kWh was saved by the developed control logic from June 2003 to May 2004.

Mathews et al. (2002) developed a simulation tool, QUICK control. It estimates the effect of different control strategies on the energy saving performance in various buildings. Effects of control strategies such as fan scheduling, set point setback, economizer cycle, new set point, fan control, heat plant control, etc. can be investigated in detail this simulation tool. Mathews et al. used this simulation tool to study the energy saving potential in a conference center in South African. A new control strategy was developed with the aid of this simulation tool. It was predicted that about 58% of the HVAC system energy could be saved.

Chan (2006) and Mathews et al. (2002) showed that besides the energy efficiency of the machines (chillers, pumps, fans, etc.), control strategy also plays a very important role on HVAC energy consumption.

Kim et al. (2001) conducted a computational fluid dynamic simulation for analyzing the indoor cooling/heating load. It was coupled with a radioactive heat transfer simulation program and a simulated HVAC control system. The output of the simulated HVAC control system can be fed back to the boundary condition of the CFD simulation program and the indoor environment was simulated. New control signal can then be determined based on the indoor environment. Energy saving performance of the control strategy can be investigated accurately. With the same simulation program, thermal comfort can also be estimated by the calculated indoor status using PMV based approach.

In this paper, a practical study on energy saving in a commercial building was carried out. Chillers, pumps and the control system were retrofitted based on the analysis of the characteristics of commercial building cooling load. Energy conservation performance of the retrofit was investigated.

1. 2 Research questions

The aim of this dissertation has been to be answered and prices calculated regardless of what the retrofit involves.

What various options are available to rectify this waste, what is the retrofit cost of each and how much will each save in energy cost?

What is realistic purchase prices of any equipment needed?

How much labor is needed to remove the old one and install the new one

What piping, valve and ductwork change will be needed?

Hoe much labor will be involved in draining original system, flushing, pressuring, testing and refilling new system and start up?

How much will be needed for balancing and adjusting the system and monitoring energy costs?

And lastly, the big question, what will the energy saving be with this approach and what is the payback and return on investment?

It is absolutely necessary to obtain this information and compare the various avenues available and make a wise decision based on accurate and thorough cost projections and energy saving.

1. 3 Research objectives

1. 3. 1 Main objective

The main of the objective is to consideration of perform various retrofit change, calculate the energy saving and the renovation costs. It provides procedure and formulas for energy program, audits, engineering and estimating.

1. 3. 2 Specific objective

The focus of this dissertation is placed on the specific objective is thinking about energy conservation in HVAC system in the following manner.

Generalities: Start off energy conservation program thinking in terms of principles or generalities and then follow up with particulars. Think about reducing HVAC loads, O & M saving, improving efficiency of equipment and system, reducing flow, etc.

Specific: After a general concept is formed then think in terms of specific heating and cooling equipment, particular HVAC system, piping system, ductwork system, insulation, control, etc.

Load Variation: Think about hoe the building cooling load may vary due to occupancy, the shifting sun, operations, etc. and about which cooling loads are constant on a daily basis without variation.

Low Cost, No Cost Item: Think in terms of no cost, low cost energy saving measures which can be done easily and quickly and which may have phenomenal payback.

Capital Investment Item: Then think in term of capital investment energy improvement searching for those with the greatest energy savings and the highest rate return or fastest payback.

Electrical: Distinguish electrical consumption cost of fans, pumps, chillers, condenser, cooling tower, lighting etc.

1. 4 Research methodology

This dissertation using the regression analysis method for establishing the commercial baseline. Regression analysis involves finding the relationship that shows how energy use alters with changes to an independent variable or variables. This relationship can be used to quantify energy use for different values of the independent variables.

Data is collected over the same time period and interval for the proposed independent variables and the dependent variable, in this case energy consumption. The data is then analyzed to develop an equation, generally linear, that describes the relationship or ‘ regression line’. This line is an estimate of the dependant variable for values of the independent variable or variables.

Independent variables that affect energy consumption can include factors such as production rate, product mix, raw material, occupancy and ambient temperature.

1. 5 Structure of the dissertation

Chapter 2 provide review of existing literature for actual research process of energy saving technique, thereby providing the basis technical information for the energy saving. The chapter begins by estimate the energy auditing for the commercial building and then provides the energy consumption of the commercial building and a methodology for retrofit cost and analysis, financial evaluation.

Chapter 3 addresses research methodology used to generate the energy conversion model for the process used in this study. In additional to this, data collection for Secondary data and Primary data are defined.

Chapter 4 deals empirical simulation using case studies of actual commercial building. This lead to discuss on the procedure and applicability of the models for auditing, retrofit Cost and Analysis, financial Evaluation, as well as an explanation of the energy cost saving that can be obtained as a result.

Chapter 5 concludes the theoretical and the empirical findings and closes the research report by summing up the results and providing ideas for further research.

2. Literature Review

2. 1 Energy Audit

The purposed of an energy audit is to determine the energy consumption and cost of overall building and of its specific components, the structure, system and equipment. It is to generate energy improvement options, to project energy saving, to estimate the cost of energy improvement, calculate payback, and on this basis evaluate the various options.

The code of practice mentions the energy audit in Hong Kong. As state by EMSD, (2010) the technical guidance and details in respect of the energy audit requirements under the Ordinance. Energy audits conducted in accordance with this Energy Audit Code are deemed to have satisfied the relevant requirements of the Ordinance in the technical aspects. Energy Audit Code is developed by the EMSD in conjunction with various professional institutions, trade associations, academia and government departments.

(EMSD 2007) In fact, the guideline of energy audit indications that an effective energy management tool. By identifying and implementing the means to achieve energy efficiency and conservation, not only can energy savings be achieved, but also equipment/system services life can be extended. All these mean savings in money.

Based on the principle of " The less energy is consumed, the less fossil fuels will be burnt", the power supply companies will generate relatively less pollutants and by-products. Therefore, all parties concerned contribute to conserve the environment and to enhance sustainable development.

(International Congress ISPE/PDA Pharmintech 2010) Given that case study at

Sanofi Midy Research Center covers a renovation of a research centre included the data collection review of the documentation it is possible to identify the facility weak points. The example of site survey for verify the consistency of the documentation and the identify the major problems to identify areas more easily upgradeable

According to recent research by (Robert Greenwald 2004), are presentations the overview of the energy audit and conducting the energy audit process included data gathering, utility analysis, inventory and review of equipment performance, measurements and monitoring, identify potential energy conservation measures, analysis of saving potential, financial analysis and reporting.

The (Minnesota Legislature and the Governor commissioned the Minnesota Department 2007) of Commerce to work with the University of Minnesota, Minnesota State Colleges and Universities (MnSCU), and state agencies to identify barriers, describe the costs and benefits of actions that would lead to an annual 1. 5 percent energy savings energy used in buildings, and develop policy recommendations that could lead to those actions. The report provides background on energy savings in government buildings and addresses the questions asked by the state law. It also found that state government-owned buildings are a significant potential source of energy savings. The government is in a unique position to think about the long-term implications of present day decisions. Through leading by example, the government can serve as a platform for the development and implementation of energy savings programs, policies and technologies. That said, there are information, organization, and resource barriers to achieving energy savings in Minnesota government buildings.

2. 2 Energy Saving Technical

As a corollary (ASHRAE 2011) provide recommendations to design a low-energy-use building and is not a minimum code or standard. The Guide provides both multidisciplinary design strategies and prescriptive design packages to significantly reduce energy consumptions in small to medium office buildings. Even though several design packages are provided in the document, this Guide represents a way, but not the only way, to build energy-efficient small to medium office buildings with 50% energy savings. Energy Standard for Buildings Except Low-Rise Residential Buildings. Use of this Guide can help in the design of major renovations that consume substantially less energy compared to the minimum code-compliant design, resulting in lower operating costs. This Guide presents a broad range of subject matter, including broad concepts such as the integrated design process, multidisciplinary design strategies, and design tips and good practices on specific energy systems, while the focus of this Guide, especially the later chapters, is on building and system details that can help achieve the desired results.

(Dr. James Brodrick, 2002) disturb on surveys of the HVAC literature, identified 170 technology options that could potentially reduce the energy consumption of HVAC systems in commercial buildings. After developing first-cut energy savings potential estimates for each option, 55 options were selected for further study in consultation with a range of HVAC experts Each of the 55 options received further study, including more detailed investigation of their technical energy savings potential, current and future economics (cost), barriers to achieving their full market potential. Many of the 40 technologies have significant technical energy savings potentials. Many of the 15 technologies selected for refined study have significant technical energy savings potential, combined with attractive or reasonable simple payback periods. Three of the options, Novel Cool Storage, Variable Refrigerant Volume/Flow, and Adaptive/Fuzzy Control, had highly variable simple payback periods that did not readily translate into an average simple payback period, while the simple payback period for Microenvironments exceeded 100 years.

Except the above energy saving potential of Literature Review, some valuable Specific topics are shown as below.

2. 2. 1 Automatic Tube Cleaning System

As the condenser is an important component in the chilled water system, the operating condition of the condenser is the key factor that affects the efficiency of the unit. However, the condenser will be seriously deteriorated by the debris and foul ants accumulated in the tubes of the condensers. When fouling and scaling in the condenser increase, the heat transfer efficiency will be decrease, resulting in more power consumption of the chiller.

The Engineering Department of The Park Lane hotel identified the above problem and started to install an automatic tube cleaning system called " CQM" for chiller in October 2003. The system has been running for 12 months. Feedback from operators and engineers are good, In the COP comparison approach, the percentage of energy saving was 11. 9% and the average COP was improved from 3. 7 to 4. 2. (Richmond Consulting Engineers, 2005).

Further more, (Wallace Wu & Dave Chan, 2003) proves that estimate the improvement on COP is around 11. 8% and CQM Automatic Tube Cleaning System can greatly improve the heat transfer efficiency of the condenser tube and save significant amount of energy in water cooled chiller. Besides, from the economic analysis, it shows that the payback is less than 2 years.

2. 2. 2 Retrofit of the HVAC system to Water Cooled Chiller

The (EMSD 2000) of HKSAR completed a Preliminary Phase Consultancy Study (PPCS) regarding “ Wider Use of Water-cooled air conditioning system in Hong Kong” was completed in April 1999. The PPCS established the technical viability of the wider application of WACS and its economic/environmental benefits. The implementation study for WACS in Hong Kong was commissioned in 2000 to examine in greater details on technical viability, financial viability, infrastructure works, land use, traffic impact, environmental/health issues, and regulatory control; especially for nondomestic buildings.

A study guide done by HKUST Research, (2005), describe energy saving in a hotel HVAC system was carried out. It included replacement of the chillers and pumps.

In review the retrofit of the hotel HVAC system, the improved energy efficiency resulted from three aspects, i. e., improved energy efficiency of the chillers, improved energy efficiency of the pumps and the intelligent control system. Comparing the COPs of the original and the new chillers, it is seen that the new chillers has an energy efficiency about 18% to 36% higher than the original chillers which may contribute to about 14. 4% to 28. 8% of the total energy saving. The efficiency of the new pumps is estimated to be 30% higher than the original pumps. As the pumps generally consume about 20% of the total chiller/pump system energy, the replacement of the pumps contributes to about 6% of the total energy saving. Then, the remaining 27% to 45% of the energy saving should result from the intelligent control system. With the new system, 63% to 74% of the chiller/pump energy was saved. The result shows that a considerable amount of energy can be saved in hotels with a good control system and high efficiencies of the chillers and pumps.

(Kenny Chan 2009) research claims the investigate for sustainable design and life cycle costing considerations in adopting relevant air-conditioning system to cater for long range planning in facility/maintenance management. Form the research and analysis, conversion from ACAS to WCAS would save around 35% running costs.

2. 2. 3 Variable speed drives

A case study done by (G Jones 2009) to compares the energy consumption of the centrifugal fan when driven by a star/delta starter and using variable speed drives to control motor speed. During the initial monitoring of the energy consumption, the centrifugal fan was controlled by the original star/delta starter. This had been the method of controlling the fan since the machine was initially installed/ commissioned. After the fan had been running for over 390 hours the exact run-time and energy consumption was recorded. The Motor Control Warehouse then replaced the star/delta starter for a 22kW open loop Inverter. After optimizing the Inverter settings, the fan was used in normal production and after approximately 300 hours, as with the star/delta starter the exact run-time and energy consumption was recorded. Changing the 22kW centrifugal fan control from a star/delta starter to an Inverter introduced an energy saving of 41. 3%.

(Lappeenranta x. x. 2008) analyses the calculation of Fan and Pump energy saving tools calculation. With these programs energy consumption of variable speed drive control for fans and pumps can be compared to other control methods. With Fan centrifugal and axial fans can be examined and Pump deals with centrifugal pumps. By means of these programs also suitable frequency converter can be chosen from the ABB collection.

2. 3 Conclusion on the literature review

The chapters above have discussed the related information for the dissertation to assist estimate, measure, evaluate and track energy savings, quantifiable costs and benefits created as a result of implementing energy efficiency opportunities.

Specific improve the understanding of how to forecast and measure energy savings, realize energy savings by accurately quantifying the whole of business costs, benefits and payback of energy efficiency opportunities, determine the economic value of an energy efficiency opportunity so that investment quality information is provided to company decision makers and quantify the accuracy range for each stage of the energy savings analysis.

3. Methodology

3. 1 Research Methodology

This dissertation is descriptive in nature: it aims to describe the energy saving of the commercial building. Time wise, it focuses on the year 2009, when the research was carried out. Changes in commercial building's energy consumption between earlier studies and the present one are also observed. To construct a comprehensive picture of the studied phenomenon, the present research utilized both quantitative and qualitative data and means of analysis.

This study is divided into two parts. The theoretical part of the study is a literature review. This existing theory was used as a conceptual tool to gain a more structured understanding of the energy consumption and saving potential of commercial building. Based on the theoretical part, an initial understanding of the commercial building of energy use was built.

The empirical part of the study consisted of one case studies that provided energy consumption of commercial building and the building description of Category, Heating and cooling system, etc. should be present. The research focused on describing the situation of the problem with the existing HVAC system and building and proposed energy saving method of renovation.

The data collected in the theoretical part was also utilized in the empirical part in estimating the current energy consumption of commercial building.

3. 2 Data Collection

3. 2. 1 Secondary data collection

Secondary data sources were utilized both in the theoretical part and the empirical part of this study. Most of the sources used in the literature review were either article published in journals and in industry magazines or conference papers that were accessible through the databases of the Public library. In addition, publicly available resources such as reports from EMSD were used. The secondary data collected for the empirical part consisted of technical details from device manufacturers’ websites.

3. 2. 2 Primary data collection

The primary data for this research was collected used Hong Kong energy efficiency and conservation competition awards were organized by EMSD. These were used in the empirical part of the study. To estimate the energy consumption of the commercial building in Hong Kong. The dissertation consult the competition awards of the energy saving method to adopted for estimate the energy saving.

3. 2. 3 Problems related to data collection

The energy analysis was the most problematic part of the data collection phase. This was due to involve much formulation of the questions and lack of open source. It turned out that did not have such information.

In the device convergence case, the purpose was to compare devices in terms of

their life cycle energy consumption. However, life cycle energy data was available for

only a few products. Information on the weight of the products was readily available on the manufacturers' web sites. In turn, data from which energy consumption could be estimated had to be collected from various sources, including Manufacturer technical report, product descriptions at Internet retailers' websites and external party sites. Even so, the data sometimes had to be completed with educated guesses.

3. 3 Data analysis

The collected data help to develop a strategic plan for energy decisions, just as they would for other key business decisions. A major focus of an energy management plan is performing a self-assessment to identify energy savings opportunities.

4. Results, discussion and evaluation

The typical 34 storey Commercial Building situated at Causeway Bay of Hong Kong Island. used as an caste study in this dissertation was built in 1992. Overall the HVAC, electrical and plumbing system in the building consumed total $ 8 million for the year.

Generate and develop potential energy saving improvement, operation and maintenance correction, reducing flows and resistance of HVAC system, considering more energy efficient equipment and system, lighting, electrical, control, heat recovery possibilities, solar, etc. Then, calculate the potential energy saving of the various improvements and estimate the retrofit costs involved. Lastly, evaluate payback and return on investments.

4. 1 Energy Auditing

An energy audit involves the systematic review of the energy consuming equipment/systems in a building to identify energy management opportunities, which provides useful information for the building owner to decide and implement energy saving measures for environmental consideration and economic benefits.

The purpose of an energy audit is to determine the energy consumption and costs of the overall building and its specific components, the structure, system and equipment, it is to generate energy improvement options, to project energy saving, to estimate the cost of energy improvement, calculate payback, and on this basis evaluate the various options.

A good audit is diagnostic in nature, develops a valid prognosis of the cause of energy wastes, and leads to scientific establish remedies. There are two basic phases phase or type of audit, short walk through audits and in depth detail audits, either of the entire building or of only select parts of building.

4. 1. 1 Collecting Building Information

The audit team should then proceed to collect information on the building. The information should include:-

General building characteristics such as floor areas, numbers of end-users, construction details, building orientation, building facade, etc.;

Technical characteristics of energy consuming equipment/ systems, design conditions and parameters; Building services design report with system schematic diagrams and layout drawings showing system characteristics;

Equipment/system operation records, including data logs of metered parameters on temperature, pressure, current, operational hours, etc.;

Record of EMOs already implemented or to be implemented;

Record of maximum demand readings;

O&M manuals and testing and commissioning (T&C) reports

Energy consumption bills in previous three years.

In general, it should be assumed that the building manager would have information on general building characteristics and the O&M personnel would keep the equipment/system technical and operation records. The audit team should determine the appropriate parties to be approached for information collection, the need to discuss with these parties for familiarization of the building, the equipment/ systems to be investigated and data verification and the need to discuss with selected end-users.

The audit team should consider issuing questionnaires to end-users to collect information on thermal comfort, lighting comfort, operational hours of individual floors/offices, electrical equipment and appliances, etc.

4. 1. 2 Conducting Site Survey and Measurement

More activities should include the following actions:-

Proceed to plan the site survey for the areas and the equipment/systems to be investigated.

Develop energy audit forms to record the findings.

Plan ahead on the site measurement to supplement or verify the information collected. The measurements should focus on equipment/systems that inadequate information is available to determine their efficiency and equipment/systems that appear to be less efficient.

4. 1. 3 Analyzing Data Collected

At this stage of the audit, the audit team has collected a lot of information on:-

Equipment/system characteristics obtained from site surveys;

Equipment/system performance data obtained from O&M log sheets;

Equipment/system performance data obtained from site measurements; and

Equipment/system operating conditions of equipment/systems based on design and/or general engineering practices.

Based on the above, the audit team should screen and spot the parameters with values and trends that deviate from what would be anticipated or required respectively. These are the potential EMOs. However, they should take into account the analysis of the irregularities caused by changes in occupancy or other activities.

4. 1. 4 Costing

To identify the improvement works for the potential EMOs, calculations should be performed to substantiate the improvement works by quantifying energy savings. In evaluating the effectiveness of an EMO, the auditor has to calculate the payback period, net present worth or rate of return.

Most calculations can be done using simple payback approach by dividing the EMO's capital cost by the cost of anticipated annual energy saving to obtain the payback period in years.

However, if there are appreciable deviations between the trends of energy cost and the interest rate or if the capital costs of EMOs are to be injected at different stages with different energy savings achievable at different times, the audit team may have to perform a life cycle cost assessment that can better reflect the cost effectiveness of EMOs.

4. 1. 5 Annual Monthly Energy Consumption Profile

Based on the energy consumption bills over past years (preferably 3 or more), the auditor should estimate the annual energy use of the building. Graphs of energy consumption against different mon