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Life-Cycle Costing of Energy - Efficient Measures for Architectural Building

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Abstract: More than 40% of electricity power is consumed in commercial buildings in India. Life cycle cost analysis of energy-efficient measures for existing fully air-conditioned buildings have been carried out. These measures include electric ballasts for fluorescent lamps; air-to-air energy recovers and sequence control of multiple identical chillers and variable spaced drives. It has been found that sequence control of multiple identical chillers is the most attractive measure with a payback period of two years. With rapid economic growth and improvement in living standards, there has been tremendous growth in energy consumption in India particularly in commercial buildings. Test over two-thirds of the imported coat and oil products are used for electricity generation. There are four major electricity end users-industrial, commercial, residential and public areas.

I. INTRODUCTION

A small percentage (about 0.5%) is for street lighting. The consumption of the four major sectors can be seen that, as the local economy shifted from manufacturing based to services-oriented (e.g. tourism, finance, etc.) the commercial sector overtook industry to become the largest electricity end-user.

As an initial step to create a more energy-efficient design environment, the Government has considered legislative control of building envelope design of commercial buildings. However, it has been found that commercial building stock only grew at a net rate (i.e. new buildings minus demolition) of about 15% to 20% per annum during the 10-year period from 2000 to 2011. Effective control of energy use is therefore essential in both new and existing buildings if any impact is to be made on the overall level of consumption. Broadly speaking, there are three main types of commercial buildings - offices, shopping complexes and hotels.

It has been observed that heating, (some cold area), ventilating and air-conditioning (HAVC) and lighting account for 70-80% of total electricity use in commercial buildings. It has also been reported that life-cycle cost analysis can give a good indication of the economic viability of any energy-efficient measures.

Objectives of the paper are to estimate payback period of some energy saving measures in air-conditioned buildings and through life-cycle cost analysis to get some idea about the likely financial benefits.

Energy-Efficient Measures It is not intended to investigate the possibility of energy conservation measures in all the existing commercial buildings in India since there are different design features and operational characteristics in each individual building. Instead a study on some items selected from lighting systems and HVAC systems has been conducted.

In lighting systems, common energy-saving products for existing buildings are energy-saving lamps and electronic ballasts for fluorescent lamps. The fluorescent lamps with conventional magnetic core-and-coil are installed in most commercial buildings. There are only small numbers of tungsten down lights used in places such as lobby lounges and reception counters. Therefore, replacement of conventional ballasts with electronic ballasts is selected for a cost-effectiveness study in energy-saving measures of lighting systems. Now, concept LED took over to consumption of electricity. The saving of electricity is 40% the normal condition.

HAVC systems, the largest electricity consuming area in a building are divided into air component and water component. In the air component, air-to-air heat recovery system like thermal wheels could save energy by exchanging heat between intake fresh air and exhaust air from the air-conditioned spaces of a building, thus reducing cooling load on HAVC plant. However, information coming from discussion with professional engineers and building operators shows that there are few buildings in which thermal wheels are installed. In the water component, the chiller is the largest electricity consuming component. Similarly, through discussion with building operators, a study on modification of sequence control for multiple chillers is proposed instead of study on replacing old and less efficient chillers. This is because changing the control system on chillers is much simpler and will cause less interruption to the operation of a building. Variable speed drives have been used for energy savings in commercial and industrial installations for chillers, chilled and condenser water pumps, fans and heat rejection systems. The economic viability of variable speed drives for these equipment is also selected.

A survey of existing commercial buildings has been conducted to establish common design characteristics. A generic reference building is then developed for energy simulation and life cycle analysis for example. The building is 40-storey, 35 m X 35m plan with curtain-wall construction (single 6 mm reflective glass, 0.4 shading coefficient and a U-value of 5.6 W/m2K). U-values for external wall (spandrel) and the roof are 2 and 0.64 W/m2K, respectively. Details on space design conditions and HVAC plant are summarized in respectively.

An energy simulation program was used to estimate energy consumption of the reference building. There are 4 major parts, namely LOADS, SYSTEMS, PLANT, and ECONOMICS. The LOADS section calculates the heating and cooling loads within each space inside the building on an hourly basis. It then passes such loads data to the SYSTEMS section for system loads computation. After the loads in each HAVC system inside the building are computed, they are passed to the PLANT section to calculate the energy required for the cooling and heating. With the total amount of energy ascertained the ECONOMICS section then calculates the energy costs incurred together with the life-cycle cost of the energy conservation measures in the building.

A. Electronic Ballast

A fluorescent lamp with magnetic core and coil ballast is considered energy-efficient when compared with an incandescent filament lamp. However, the conventional magnetic ballast can incur power loss up to 25% approximate of the power rating of the lamp. Electronic ballast is more energy efficient. It generates high-frequency signal which 'ballasts' the fluorescent lamp circuit.

In assessing the economic viability of an energy-saving measure, financial benefit should able be studied. The life-cycle cost of a building in the life time of the energy-saving product is calculated. The difference between the life-cycle costs in NPV (Net Present Value) of both cases i.e. a building with conventional ballasts and a building with electronic ballasts would be the financial benefit that resulted quite benefitted to the national level.

B. Thermal Wheel

The thermal wheel is a rotator air-to-air heat exchanger in which exhaust air from an air conditioned space pre-cools outdoor intake fresh air to reduce the cooling load of an HAVC system in summer and pre-heats outdoor air to reduce heating load in winter.

In Hong Kong, during most of summer, the temperature and relative humidity of exhaust air from air-conditioned space are very close to the indoor condition and are very much lower than the outdoor hot humid air. Direct discharge of the exhaust air to outdoors would be a form of energy wastage. There is potential to pre-cool the intake fresh air which the exhaust air before discharging to outdoor.

In India the cooling season for commercial buildings with central air-conditioning plants runs from March to November. The remaining months are taken as winter. Calculations are based on a 10 hour day and 5.5 day week.

C. Sequence Control of Multiple Chillers

With reference to professional design engineers, it is found that multiple identical chillers are designed and installed in most commercial buildings in India. This arrangement gives simplicity in design and operation and also lowers the maintenance cost. However, very little work has been carried out to investigate energy-efficient mode of control for multiple identical chillers.

To simply the study, two identical chillers are modeled for the reference building. Basically, there are 3 types of mode for controlling the operational sequence of multiple chillers. Information from building operators shows that sequence control of multiple identical chillers mode one is most commonly applied in commercial buildings in India. Thus mode one is taken as the base case. Annual electricity consumptions and the corresponding NPV of the accumulated annual electricity costs have been determined.

It is found that a building with mode two sequence control, which is 2.6% more than that in the base case. It is obvious that under control of mode two, simultaneous part-load operation of two identical chillers occurs between 0% and 50% of total design cooling load which yields low energy efficiency.

However, this situation only happens during mid-season, in early March and late November, so that the annual electricity consumption between these two cases is very close.

Mode 3 sequence control has been found to be the most energy-efficient with annual electricity consumption of which is 9.5% less than the base case. This is mainly because this mode of control eliminates simultaneous part load operation of two identical chillers during part load condition between 0% and 50%.

D. Variable Speed Drives

The electric motor is the largest electricity consuming component in building services especially in HVAC systems. It has been used to investigate the energy performance and cost-effectiveness of variable speed drives (VSD) for chillers, water pumps and fans in HVAC systems. Performance data about VSD for chillers and fans have been obtained from manufacturers/suppliers.

II. SUGGESTION AND CONCLUSION

Four energy saving measures have been selected for the cost effectiveness study. These include electronic ballasts for fluorescent lamps, thermal wheels, sequence control of multiple identical chillers and variable speed drives for chillers, water pumps and fans measures in existing commercial buildings, these 3 options should be considered.

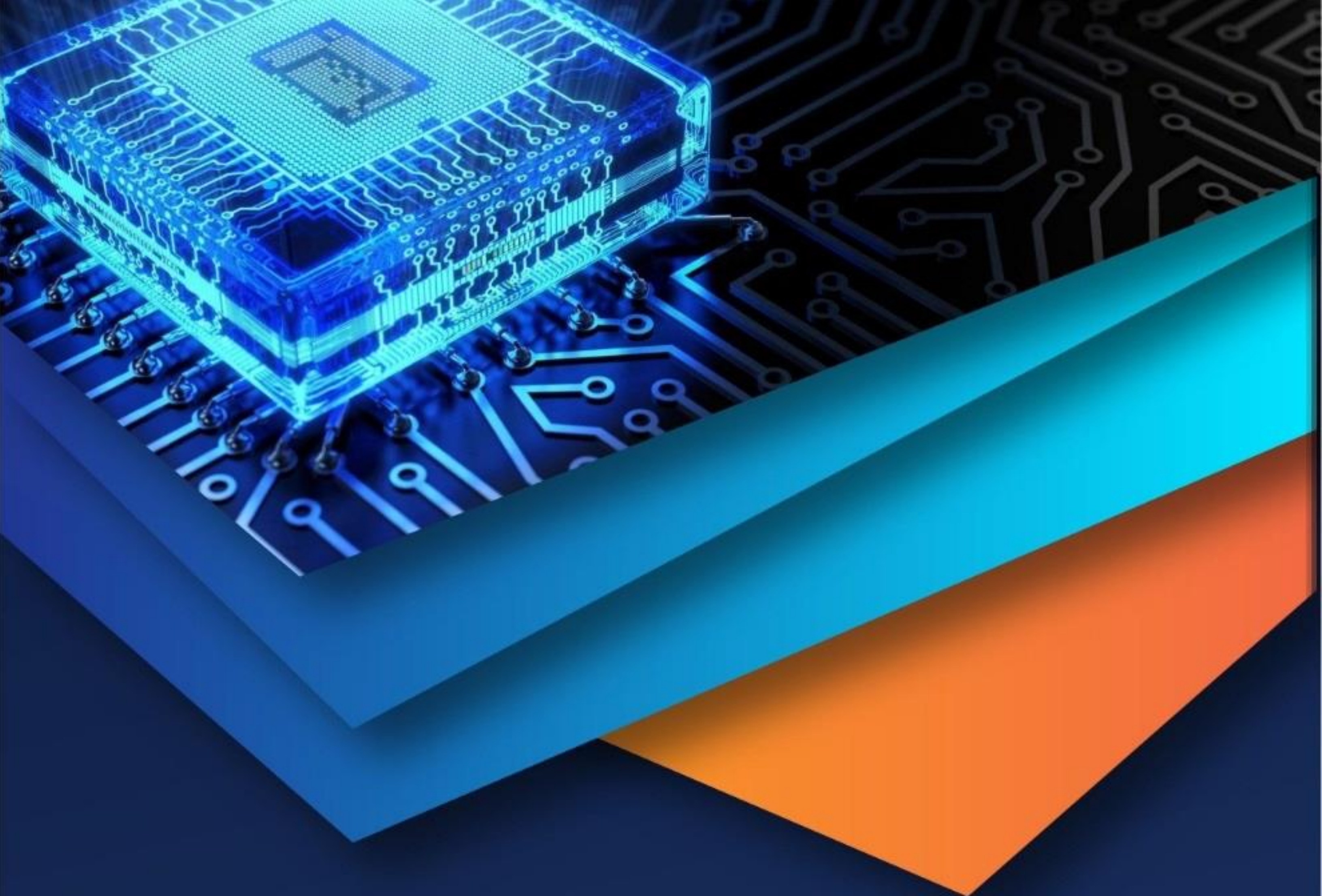
Based on the pay-back period and life cycle cost analysis, the economic viability of these energy-saving measures has been considered with reference to professional maintenance engineers & building operators, a payback period of 2 to 3 years would be acceptable. Payback periods for sequence control of chillers, VSD for chillers and VSD for water pumps are 2.7, 1.8 and 1 year, respectively. For assessing the viability and priority of energy saving measures in existing commercial building, these three options should be considered.

Pay back periods for electronic ballasts and VSD for fans are 3.8 and 4.3 years, respectively. As technology improves and cost lowers, it is envisaged that these measures will become attractive in the near future. The thermal wheel has the longest payback period of 8 years. Moreover, space could be a problem in existing buildings even when major retrofit is carried out. This is considered not viable.

Life-cycle cost analyses indicate that financial benefits within the excepted life time of these measures range 06 years for electronic ballasts & 25 years for sequence control of chillers.

REFERENCES

[1] Hong Kong Energy Statistics 1979-1992. Census and Statistics Department, Hong Kong, 1993.
[2] F.C.WINKELMANN and M.LOKMANHEKIM: Sun-control options in a high-rise office building. Energy and Buildings, Vol.8 (1985), pp. 1-13.
[3] J.C.LAM. Energy-efficient measures and life cycle costing of a residential building in Hong Kong, Architectural Science Review, Vol.36 (1993), pp. 157-162
[4] J.E.ETO and A.DE ALMEDIA: Saving electricity in commercial buildings with adjustable speed drives. IEEE Transactions on Industry Applications, Vol 24(1988),pp.439-443.
[5] B.P.ZELL: Design and evaluation of variable speed pumping systems. ASHRA Technical Data Bulletin, 1985, pp.40-49.
[6] G. MCMAHON: Energy savings by the speed regulation of fans. Australian Refrigeration, Air Conditioning and Heating, March 1993, pp.42-44.
[7] DOE-2 Reference Manual Parts 1 and 2, U.C. Department of Commerce, National Technical Information Service, Springfield (1980).



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