Topic C6: Low energy building

# FEASIBILITY STUDY OF USING HEAT RECOVERY DEVICES IN HVAC SYSTEMS IN A BUILDING IN THE TROPICS

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## SUMMARY

For non-domestic buildings, the electricity consumption mostly comes from the usage of the air-conditioning system. Therefore, energy savings must be achieved to save cost, and hence there is a need to apply heat recovery technologies such as run-around coils, plate-to-plate heat exchangers, heat pipe heat exchangers and heat recovery wheels into the air conditioning and mechanical ventilation (ACMV) systems for these buildings. The examples of non-domestics buildings such as factories, hospitals and office buildings use more energy to supply fresh air into the space in comparison to residential buildings. According to Yau (2010), the changing of air must be at least 15 times hourly, and in certain cases such as the hospital, the prohibition of recirculation of the return air in operating theatres to ensure the air is clean from any virus or bacteria from the outdoor air is needed. The feasibility study on using heat recovery devices in a new medium-size building in University of Malaya was conducted. The potential of energy savings in the building was examined by studying the performance of the air-conditioning system. The heat recovery systems were analyzed, and the focus was on the energy savings of the HVAC system. The calculation of energy savings and payback periods were analyzed for the chosen heat recovery devices installed in the building. Based on the results obtained in this practical study, it is strongly recommended that heat recovery systems to be installed to reduce energy usages of air-conditioning systems operating in large buildings in the tropics.

## INTRODUCTION

Humidity degrades the indoor air quality but controlling humidity is costly. Air-conditioning system in the tropics contended with high relative humidity throughout the year often has a design that overcools the air to extract the extra moisture before heating the air back to the desired temperature. In the case of a hospital where cleanliness is a major concern, the system has dehumidifiers and other filtering systems installed to prevent the growth of fungus and bacteria (Yau and Ng, 2011). The operation of these systems is costly and the reason that buildings with high commercial and utility values in the tropics have very high electricity consumption. A statistical report released from Energy Commission Malaysia (2011) concluded that the major energy consumer in Malaysia is from the non-domestic sector; that is the sector of factories, hospitals and office buildings.

In order to reduce the energy consumption, the most effective ways are to implement energy recovery systems and energy systems that utilize the energy efficiently. In the former category, the options include the implementation of heat recovery technologies such as the run-around coils, the plate-to-plate heat exchangers, the heat pipe heat exchangers and the heat recovery wheels.

There are however challenges in heat recovery technologies, in terms of the building size, the fresh air requirement, the existing system, the operation efficiency, contamination and cost. This paper is a case study on the feasibility of operating heat recovery devices for a non-domestic building in the tropics.

## THE BUILDING OF INTEREST

The chosen building for the case study is a new, medium-size, biomedical facility located at the University of Malaya. The whole building is fully air-conditioned except for the car park area which is natural ventilated. Most of the building spaces are laboratories. Based on the tender drawing obtained, the existing type of air-conditioning system is a variable refrigerant flow (VRF) system with multiple fan coil units. The condenser units are located on the roof.

## FEASIBILITY STUDY

To apply heat recovery technologies, the supply air and the exhaust air must be collected. An initial inspection of the building shows that the building has five levels, not counting the lower ground. The exhaust fans are located on the roof, suggesting that in installing any heat recovery devices, the roof is a natural choice. There is an additional benefit of using the roof. The air quality on the roof is better than that at the lower level of the building. At the lower level of the building, which has a car park, the ventilation system may draw unacceptable levels of vehicle air pollutants, such as carbon dioxide, carbon monoxide, and nitrogen oxide. In using the roof, the supply air and the exhaust air are collocated such that duct air is pumped to and fro to each floor.

The selection of heat recovery devices depend on the supply rate, the convenient of an exchange medium, and the efficiency of heat recovery. Based on an estimate of the total air-conditioning area, an estimate of 20cfm (0.0094 $m^3$/s) per person of air, and an assumption of nine air change per hour (ACH) for the laboratories (ASHRAE, 2001), the required air supply flow rate is 9000cfm (4.25 $m^3$/s) per floor. As the supply ducts and the exhaust fans are both located on the roof, air is the best exchange medium in this case. Since the efficiency of heat recovery wheel is the highest compared to other types of heat recovery device (Yau, 2004), and with consideration the above conditions, the heat recovery wheel is selected.

A positive pressure in the building must be maintained. The exhaust flow rate is calculated based on the fresh air flow rate less any other exhaust flow, such as toilet exhaust, bin room exhaust and kitchen exhaust. It is found that the building satisfied these conditions.

In locating the heat recovery wheel on the roof, the placement must be convenient for ducting and the wheel installation itself. Additional considerations include the sun and wind direction at different time of the day and any possible obstacle in the immediate area surrounding the roof.

The installation of the heat recovery wheel is economical and environmental friendly. The existing HVAC system maintains the room temperature at 25°C. A survey of the weather records shows that the relative humidity, pressure, and ambient temperature are 80%, 1 atm, and 30°C, respectively. Assuming an efficiency of 75% and an operating load of 70% for the heat recovery wheel (Yau, 2010), an energy balance analysis shows that the potential energy saving is 70MWh. With electricity tariff of RM0.43 (USD 0.13) per kWh, the saving amounts to RM 31,000 (USD 9,329). A local survey of the cost of installation, including the heat recovery device, the air supply fan and the duct system is RM 38,000 (USD 11,436). The payback period is therefore one year.

Department for Environment, Food and Rural Affairs, United Kingdom (2014) estimates 0.43 kg of carbon dioxide released to one kWh of natural-gas electricity. In a year, the system reduces 30 tons of carbon dioxide emission.

## CONCLUSIONS

Heat recovery technologies offer the opportunities to reduce the energy consumption while maintaining the indoor air quality. The case study shows that a heat recovery wheel is a small investment (RM 38,000/ USD 11,436) for a medium-size biomedical facility with a 9000cfm (4.25 $m^3/s$) capacity in Malaysia. The energy saving is 70MWh, and the payback period is one year. Follow-ups with the building management and additional case studies are useful suggestions for future practices and discoveries.


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