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Electricity cost saving comparison due to tariff change and ice thermal storage (ITS) usage based on a hybrid centrifugal-ITS system for buildings: A university district cooling perspective

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ABSTRACT

In this paper, the case study of a district cooling system of a university located in a South East Asia region (lat: 01°29′; long: 110°20′E) is presented. In general, the university has high peak ambient temperature of around 32–35 °C coupled with high humidity of about 85% during afternoon period. The total electricity charge for the Universiti Malaysia Sarawak Campus is very high amounting to more than $314,911 per month. In this paper, a few district cooling schemes are investigated to provide "what-if analysis" and in order to minimize the overall electricity charges. Few scenarios designed for the application of centrifugal with and without ice-thermal storage (ITS) systems on the buildings were investigated. It was found that, due to the local tariff status, marginally saving can be achieved in the range of 0.08–3.13% if a new tariff is adopted; and a total of further saving of 1.26–2.43% if ITS is operated. This marginally saving is mainly due to the local tariff conditions and lower local temperature range (ΔT) which are less favorable as compared with those reported in the literature elsewhere.

1. Introduction

The building industry involves two kinds of energy applications, i.e., building construction application, and post-constructions (occupants) application. The latter consumes much of the energy use due to the energy consumption over a period of much longer time [1]. For modern buildings, one of the notable energy usages is due primarily to the electrical-driven air conditioning systems, either for heating or cooling. For bigger system such as district cooling systems (DCS) application, higher capacity of the cooling systems are necessary due to the higher cooling or heating demand which necessarily incur enormous electrical energy costs. The advantages of DCS systems in huge building areas compared with individual air-conditioning unit systems are many, among others:

- *Economical advantages*: The DCS have overall lower total capital cost compared to the split cooling that require their own cooling equipment(s) [2,3].
- *Space conservation*: The space required for cooling equipment(s) can become vacant for other purposes for a district cooling systems [2,3].
- *Noise reduction*: The noise that produced by the cooling machines can be avoided in the consumer buildings [2].
- *Flexibility*: The DCS systems also flexible to employ a wide range of inter-related thermal storage technologies such as co-generation, tri-generation, and thermal energy storage (TES) [2,3]. The present paper is primarily concerning with the TES storage technique.

In respect of energy usage, it was reported that thermal energy storage (TES) not only dramatically reduces the use of peak-period high cost energy; it can also reduce the total energy usage by as much as 13% [4,5]. The United State Department of Energy reported that many ice storage applications can result in lower first cost and/or with higher system efficiency as compared to non-storage system [6]. This is because ice-storage allows downsizing of the conventional chiller system [3,7], the resulting cost savings may substantially or entirely cover the added incremental cost of the storage system [7]. MacCracken [8] pointed out that since thermal

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