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A Comprehensive Case Study of Climate Change Impacts on the Cooling Load in an Air-Conditioned Office Building in Malaysia

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Abstract

In an earlier paper [1], the authors had comprehensively reviewed the climate change impacts for commercial buildings and their technical services in the tropics, and it revealed that numerous studies have been conducted to assess the climate change impacts in terms of energy consumption of a building. However, only few studies were carried out in the tropical region. This study aims to project the future cooling load needed for the years of 2000, 2020, 2050 and 2080 in the tropics using the TRNSYS simulation. Based on the simulation results, the total cooling load increases as the temperature changes. The total maximum cooling loads required in the years of 2000, 2020, 2050 and 2080 are 297000 kJ/hr, 305000 kJ/hr, 321000 kJ/hr and 332000 kJ/hr, respectively. When compared with the year 2000, the maximum cooling load needed in the years of 2020, 2050 and 2080 increases by 2.96%, 8.08% and 11.7% respectively. Based on the simulation results, in the next 70 years, the efficiency and durability of the existing system is predicted to decrease.

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Keywords: Climate change impacts; Cooling load; TRNSYS; ACMV; Office building; Malaysia

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1. Introduction

A literature review by Yau and Hasbi [1] on climate change effects for large buildings and their technical services in the tropics was conducted. This review emphases on the buildings' contributions towards climate change and climate change effects on building structures, variations of energy consumption and peak demands, building load requirements, thermal comfort and emissions effects. In overall, buildings in regions with an estimated increase in temperature will require more cooling and less heating duties. Thus, building energy use and carbon emissions are anticipated to increase in its lifespan. In addition, the unpredictable weather trends will also affect the building effectiveness and sustainability, indoor air quality and thermal comfort. Even though the existing literature on this issue has increased substantially in recent years, there is still a need for further research in tropical climates as the climate change impacts vary with the different seasons, periods and regions.

The Fourth Assessment Report of the IPCC (AR4) predicted that building related carbon emissions to be around 8.6 million metric tons eqv in 2004 [2]. Note that Carbon emissions by definition is the carbon dioxide produced directly or indirectly caused by an activity. The major source of these emissions comes from combustion of fossil fuels for cooling, heating, lighting, and to power electrical appliances [3, 4]. Apart from this, the building industry is also responsible for a significant non- greenhouse gas emissions such as halocarbons, CFCs and HCFCs and hydrofluorocarbons (HFCs) due to their uses for cooling, refrigeration, and in the case of halocarbons, the insulation materials [2].

However, literature review reveals that research conducted on the investigation of the climate change impacts on the air-conditioning and mechanical ventilation (ACMV) systems in the office building in the tropics in terms of cooling loads is virtually none. For this purpose, the research must be conducted, and the aim is to examine the climate change impacts on the ACMV systems in the office building in the tropics in terms of cooling loads. For the present study, a small air-conditioned office in the Construction Research Institute of Malaysia (CREAM) building located in Kuala Lumpur, Malaysia, has been selected as a case study.

Nomenclature

ACMV	Air-Conditioning and Mechanical Ventilation
AR4	The Fourth Assessment Report of the IPCC
CLTD/CLF	Cooling Load Temperature Difference/Cooling Load Factor
CO2	Carbon dioxide
CREAM	Construction Research Institute of Malaysia
EMS	Energy Management System
HVAC&R	Heating, Ventilation, Air Conditioning and Refrigeration
IPCC	Intergovernmental Panel on Climate Change
SERG	Sustainable Energy Research Group
TMY2	Typical Meteorological Year
TRNSYS	Transient Systems Simulation Programme

2. Theory relevant to the current research

The climatic data details in the tropics will be described first in sub-section 2.1. The building descriptions will be discussed later in sub-section 2.2. The cooling load calculation and the weather profile due to the temperature change will be illustrated in sub-sections 2.3 and 2.4, respectively.

2.1. Climatic data

Kuala Lumpur, the capital of Malaysia is located in longitude 2˚30' N and longitude 112˚30' E with the total area of 329, 750 sq km. Malaysia's climate is categorised under the Koppen Climate Classification scheme as AF, Tropical Wet climate with some small areas of highland climates. The monsoon season sets in yearly from October