UNIVERSITI TEKNOLOGI MARA

AUTOMATED CALIBRATION OF BASELINE MODEL FOR ENERGY CONSERVATION USING MULTI – OBJECTIVE EVOLUTIONARY PROGRAMMING (EP)

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ABSTRACT

This thesis presents multi-objective optimization approach in developing baseline energy using multi-objective Evolutionary Programming (EP). The co-simulation approach is proposed to obtain optimal solution of the thermal comfort–baseline energy configuration due to complexity in finding the trade-off between variables in reducing discrepancies between simulated energy consumption and measured data, furthermore leveraging automated computational calibration process. The proposed co-simulation process is developed by coupling building energy simulation (BES) software, EnergyPlus with multi-objective evolutionary programming (MOEP) algorithm which is implemented in Matlab using coupling software, BCVTB. The proposed optimization approach is applied to a single storey Green Energy Research Centre (GERC) office building located in UiTM Shah Alam with multiple characteristics of fully conditioned and partially conditioned buildings. The office consists of five different size rooms with different purposes. In this regard, three building parameters are taken as decision variables including occupancies, lightings and electrical equipment. Meanwhile, output from EnergyPlus i.e. hourly energy consumption and Predicted Percentage of Dissatisfied (PPD) are investigated as single and multi-objective optimization. The MOEP objective function is set to minimize the difference between simulated and measured energy consumption considering human thermal comfort in the building by using sum-weighted decision technique. To evaluate the accuracy of building energy model, hourly criteria for Normalized Mean Biased Error (NMBE) and Coefficient of Variance Root Mean Squared Error (CV(RMSE)) as proposed by the IPMVP are used. In the single objective approach, automated calibration method considering minimum baseline energy triumph over all other methods with NMBE and CV(RMSE) at 4.52 % and 10.8% respectively, hence meeting the acceptable range set by the IPMVP. The baseline energy is said calibrated and can be used for retrofit analysis. In multi-objectives approach, MOEP with fixed weight SWA technique is the best alternative to solve multi-objectives problem for baseline calibration with NMBE and CV(RMSE) of 3.02% and 4.64% respectively. This study is also extended to investigate potential saving from two ECMs, 20w LED lighting and 5kW PV panel using the best variables configuration obtain from previous stage.

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CHAPTER ONE
INTRODUCTION

1.1 Research Background

Malaysia is a developing country with energy intensity ratio over 1.0 in year 2010 [1]. Energy intensity ratio is a simple indicator that displays the level of energy efficiency in the country per Growth Demand Product (GDP). Energy intensity ratio is measured by the unit of energy use per unit of work done [2]. The ratio above 1.0 indicates that highly inefficient use of energy in Malaysia comparing to the increment of GDP per year. Figure 1.1 shows a comparison between primary energy supply (ktoe) (green – bar graph) and GDP at 2005 price (Blue - line) in Malaysia from year 1990 to 2012 [3]. It can be seen that for the last three years beginning 2010 to 2012, the intensity ratio is higher than 1.0. This means for every increment of GDP in Malaysia consumes a lot of energy. Meanwhile, Figure 1.2 shows the comparison between GDP (pink) and electricity usage (deep blue) from 1949 to 2004 for U.S Economy [4]. It can be seen that starting 1984, U.S Economy showed less dependent on electricity and for every goods and services offered consume less energy.

Energy Efficiency (EE) plan has been existed in government strategic planning since the oil crisis in 1970s. However, due to limited knowledge, technology, and non-existence responsible agencies, the plan was not effectively executed. As Malaysia's economic and population are growing, the EE agenda becomes more crucial. Government bodies such as Energy Commission (EC), Ministry of Energy, Green Technology, and Water (KeTTHA), Sustainable Energy Development Authority (SEDA), Malaysia Energy Centre (MCE) and Economic Planning Unit (EPU) have been established to strengthen energy development in Malaysia. Recently National Energy Efficiency Master Plan has been approved under KeTTHA to shape and colour EE activities. Under this plan, five actions and five key initiatives have been underlined to promote and develop EE.