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Prediction of Hourly Cooling Energy Consumption of Educational Buildings Using Artificial Neural Network

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Abstract— Predicating the required building energy when it is in the design stage and before being constructed considers a crucial step for in charge people. Hence, the main aim of this research is to accurately forecast the needed building cooling energy per hour for educational buildings at University of Technology in Iraq. For this purpose, the feed forward artificial neural network (ANN) has been selected as an efficient technique to develop such a predication system. Firstly, the main building parameters have been investigated and then only the most important ones were chosen to be used as inputs to the ANN model. However, due to the long time period that is required to collect actual consumed building energy in order to be employed for ANN model training, the hourly analysis program (HAP), which is a building simulation software, has been utilized to produce a database covering the summer months in Iraq. Different training algorithms and range of learning rate values have been investigated, and the Bayesian regularization backpropagation training algorithm and 0.05 learning rate were found very suitable for precise cooling energy prediction. To evaluate the performance of the optimized ANN model, mean square error (MSE) and correlation coefficient (R) have been adopted. The MSE and R indices for the predication results proved that the optimized ANN model is having a high predication accuracy with $5.99*10^{-6}$ and 0.9994, respectively.

Keywords— cooling energy; artificial neural network; HAP software; energy management.

I. INTRODUCTION

Rapid growth in population and industrial production have increased the energy demand in recent decades. The continued high energy consumption worldwide has led to a large number of environmental problems, including air and water pollution. Building sector, however, represents the leading energy consumer by consuming one-fifth of the world's total energy and severely accounts one-third of the global greenhouse gas (GHG) emissions [1]. Among all the required energy in typical buildings the HVAC (heating ,ventilating, and air conditioning) systems consume the most significant amount of electricity in residential buildings [2]. Thus, buildings have become the focus for the decision makers when they try to design and implement policies to effectively reduce energy consumption in buildings. Thus, it is important to develop energy consumption forecasting methods to reduce energy consumption and thereby reduce cost and environmental pollution.

In this regard, many researchers have developed different algorithms based on artificial intelligence techniques for energy prediction since 1990s. For example, Javeed Nizami and Al-Garni [3] deigned an artificial neural network model to relate the electrical energy consumption in Saudi Arabia to population and different weather parameters, such as temperature, humidity, and solar radiation. Six years of data from August 1987 to July 1992 were used for training the model and one year from August 1992 to July 1993 were used for validation purposes. The mean square error (MSE) and determination coefficient (R^2) were 0.001 and 0.002, respectively. For performance evaluation the neural network model was compared with the regression model using data that was not used in the training process. The comparison result showed that the neural network model has better predication performance than the regression model with MSE reach to 0.001 for the former and 0.011 for the latter. In another research a number of heating load cases acquired for various buildings, that were ranging from small to large, were used to train a suitable network for heating load forecast [4]. The aim was to produce a network to be able to handle unusual cases with minimum number of inputs, which were type of windows and walls, and areas of windows, walls, partitions and floors. Chaves [5] designed ANN models that were able to predict energy consumption and evolution with an accuracy of up to 99%. Campinas city in Brazil was taken as a case study, the input data were temperature, wind speed, time, day and month. Number of hidden layers and learning rate were changed in order to evaluate their influence on the training result. The specific