Measure Of Energy consumption

Phase 4 project :

Abstract: In the present era, due to technological advances, the problem of energy consumption has become one of the most important problems for its en-vironmental and economic impact. Educational buildings are one of the highest energy consuming institutions. Therefore, one has to direct the individual and society to reach the ideal usage of energy. One of the possible methods to do that is to prediction energy consumption. This study proposes an energy consumption prediction model using deep learning algorithm. To evaluate its performance, College of Computer (CoC) at Qassim University was selected to analyze the elements in the college that affect high energy consumption and data were col-lected from the Saudi Electricity Company of daily for 13 years. This research applied Long short-term memory (LSTM) technique for medium-term prediction of energy consumption. The performance of the proposed model has been meas-ured by evaluation metrics and achieved low Root mean square error (RMSE) which means higher accuracy of the model compared to relative studies. Conse-quently, this research provides a recommendation for educational organizations to reach optimal energy consumption.

Keywords:

- Energy consumption
- Educational building
- Deep Learning
- LSTM
- Prediction

Introduction:

At present people face an issue of energy consumption and increasing demand for electricity. Given Saudi Arabia economic and population growth, especially in the ex-treme weather conditions experienced by it.

The demand for electricity in Saudi Arabia growing at an annual rate of nearly 8% [1]. In 2030, energy consumption will be double by reach 360 TWh [2], and the demand for electricity will increase to about 120 GW per year [1]. This is why consumers need to be aware of the optimal use of electricity. In Saudi Arabia, power plants rely on oil and natural gas [1]. Meeting the demand for electricity in the future is expected to consume 3 barrels of oil per day, caused a signif-icant impact on the state economy by reducing the country's income from oil exports [1]. In Saudi Arabia, extreme weather is a major problem faced by society.

Artificial Intelligence (AI) a branch of the computer that consists of observation and learning. Machine learning is a subset of AI that makes the system learn from itself without the need for human intervention. All Machine Learning comes under AI but not all AI is Machine Learning [4]. Some of the machine learning techniques that have been used redundantly for prediction purposes: Artificial neural

network (ANN), ex-treme learning machine (ELM), adaptive neuro-fuzzy inference system (ANFIS) and support vector machines (SVM) [5].

In this study, to reduce energy consumption and to improve the efficiency of electri-cal appliances, the best way is to predict energy consumption based on specific factors affecting energy consumption in Saudi Arabia. Furthermore, to improve the social and economic benefits of buildings

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2 Analyzing the Problem

In recent years, energy consumption has become one of the major problems because of its impact on the economic, financial spheres. In Saudi Arabia, there are many factors that cause increasing energy consumption in non-residential buildings.

In the CoC, there are many problems that cause increased consumption. Extreme weather is one of the main problems, causing summer temperature increases to increase energy consumption through repeated use of air conditioning. In winter, the heat causes increased energy consumption through repeated use of the heater [8], depending on the type, size, operation time and wattage consumed per hour.

The number of devices has a large load on energy in general, the increase in the number will inevitably increase the consumption of energy [9]. In the CoC, there are many devices and servers. The growing number means increasing energy consumption. If we consider the workday, there are many lectures which mean there is excessive consumption of energy compared to the weekend. The quality of the devices affects the consumption of energy where the lower quality the greater consumption.

Problems Impact Recommendation :

1- Extreme weather :

Impact: Large windows and glass facades were used to allow sunlight to enter. In summer, sun-light causes a significant increase in temperature. This affects the heat inside the building and therefore leads to a negative impact on energy consumption.

Recommendation: The use of shading devices in the building of the College of Computer to help reduce energy consumption.

2- Other devices :

Impact : the types of devices used and their number has a clear and significant impact on the consumption of energy.

Recommendation : Reducing the number of devices used at the same time in order to help reduce loads and thus reduce consumption.

3-Quality of devices :

Impact : Old devices of a low quality are one of the main reasons for the excessive consumption of energy.

Recommendation : It is better to use new devices that have been manufactured in recent years because of the new features and technologies that al-low them to save energy while using them.

4-type of servers :

Impact : The physical server leads to high energy consumption.

Recommendation : Replacing the physical server with the Cloud Server that leads to less energy consumption.

Literature Review:

So far, many studies have been done to build energy consumption prediction models using various machine learning techniques and algorithms.

Analytical work

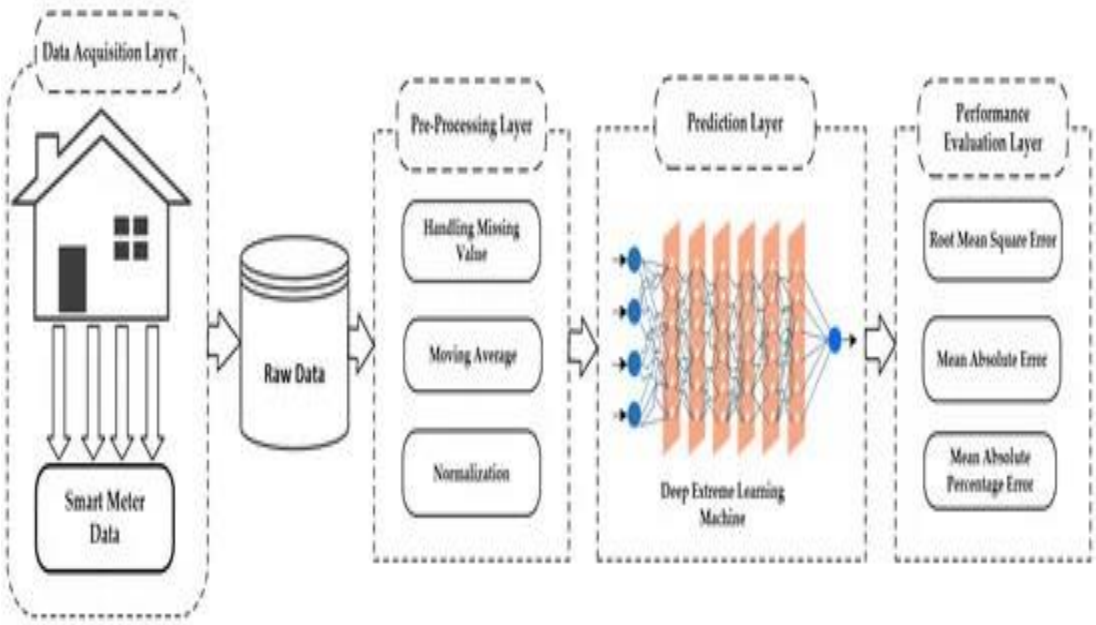
Al-Mofeez (2007) [10] compared the past days to today, as the modern lifestyle has changed and developed the new buildings that need more equipment and thus increase consumption. The paperdiscussed energy saving and rehabilitation work for a one-story house in Dhahran. The data were compared based on the results before and after retrofitting. Data extraction techniques were used for the analytical process, and the International Performance Measurement and Verification Protocol IPMVP were used to measure the performance. The end result was a 34% reduction in peak consumption.

Predictive work

In their study, J. Moon et al. (2017) [15] presented the problem of energy consump-tion on campus. Based on machine learning, Artificial neural network (ANN) and Sup-port vector regression (SVR) algorithms were used in the prediction process. Root mean square error (RMSE) and Mean absolute error (MAE) were used to assess prediction accuracy. The study was applied to the campus in Seoul, capital of Korea, and the data were collected for 15 minutes for one year. The performance was evaluated in the al-gorithms used, resulting in a prediction model based on the ANN algorithm that per-formed better than the SVR-based model. The research is consistent with the previous research in that the studies were in a non- residential area and in an educational building.The authors in (2018) [16] argued that due to population growth and economic de-velopment, energy consumption has furthermore increased in China and that increased usage of energy has led to severe problems.

The Proposed Methodology

In this research, energy consumption prediction will be applied in non-residential buildings and LSTM technique will be used because of the advantages of deep learning. CoC at Qassim university selected for this research and focused on four inputs the temperature C, workday (On or Off), number of devices andhistorical energy consumption by 13 years. The output will be medium-term prediction of energy consumption (kWh) and will apply a trial and error method to determine the optimal neural network struc-ture. Based on this prediction a recommendation will be provide to the organization



. Fig. 1. The proposed methodology

The energy consumption prediction model was Implement using Python with Keras library that using the TensorFlow backend. The dataset in the CSV file contains 5 fea-tures: date, temperature, number of devices, working days and daily energy consump-tion for 13 years and it has 4595 rows. The algorithm is a set of instructions to properly and effectively resolve a particular problem. Energy consumption data were collected from the Saudi Electricity Company. Weather data collected from open source, data of working days and number of devices were collected from the Computer college.

Algorithm:

Algorithm of energy consumption prediction :

```
1: D — Data
2: Read D
3: Preparation D
4: Normalize D
5: Separate D to training and test
6: For index in length of D do
7:     Setup reshape of D to X_train and X_test
8: End loop
9: Start
10: Build LSTM model
11: Compile LSTM model
12: Executing LSTM model
13: Stop
14: Diagnose overfitting and underfitting
15: Actual — y_test , Predict — predict(x_test)
16: For index in length of y_test do
17:     Difference = Absolute( Actual - Predict )
18: End loop
19: Calculate performance evaluation matrices
20: Make prediction
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Fig. 2. The proposed model algorithm steps

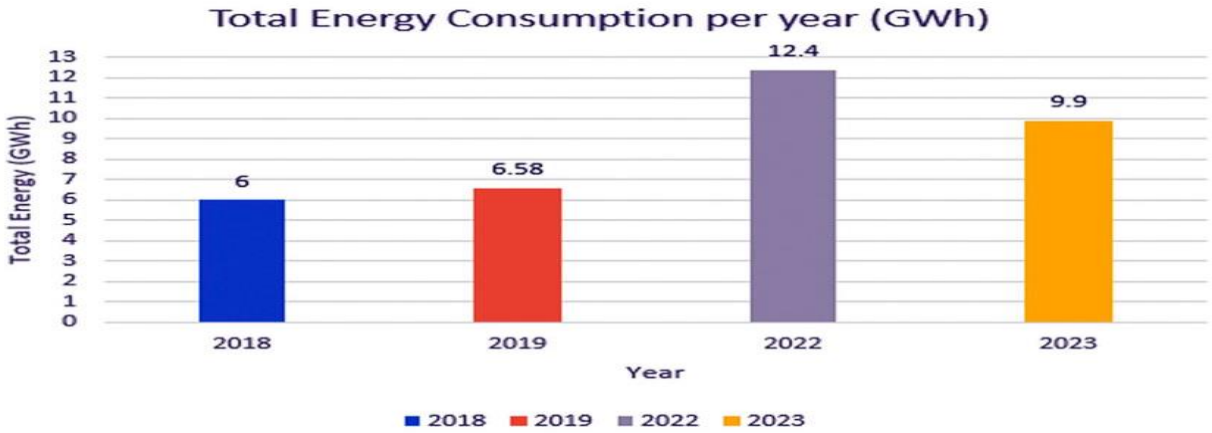
The main reasons for increasing energy consumption in educational buildings were identified. Full analysis of CoC building in terms of all the factors triggering high en-ergy consumption. Model to predict

Result Analysis:

energy consumption using LSTM and got high accuracy by 94.31%. Offering a useful recommendation based on full analysis. the analysis of both factors and the current technologies and achieved better result.

Discussion and Recommendation:

In this work, deep learning has been used to predict energy consumption in a non-residential building and shows good results. This means that deep learning has shown its efficiency in prediction. The dataset contains 13 years on a daily basis and this is a historical and time series. Therefore, LSTM has proven its worth in prediction in time series.



Conclusion :

In this research, a predictive model of energy consumption has been developed in the building of the CoC, Qassim University using deep learning. This research devel-oped an analysis of the building and identified the most important factors affectizzxng energy consumption and provided tips to reduce their impact. The model is designed using inputs that may affect the energy consumption in the building such as tempera-ture, number of devices, working days and energy consumption. In this study, LSTM has been used for the development of the model for medium prediction of energy con-sumption with a large window size up to 35 which achieved a high accuracy by 94.31%. It was evaluated by RMSE and achieved 0.045. Consequently, a recommendation has been made to help reduce energy consumption in non-residential buildings.