FORECASTING ELECTRICITY DEMAND OF CAGAYAN DE ORO CITY USING ARTIFICIAL NEURAL NETWORK (ANN) (A CASE STUDY)

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ABSTRACT: *As the size of the population increases, technological advancement and improved lifestyles accompany this growth as well, resulting in higher electricity consumption. There is a need to forecast the future demand for electricity in order to prepare electricity companies for their operations and provide sufficient energy for their consumers. In this paper, Multi-layered Neural Network (MLNN) and Feed-Forward Neural Network were utilized to formulate a prediction model of the monthly electricity demand of Cagayan de Oro City. The study builds a 108-months data collection from 2012-2020 as input and output data for the forecasting model. The training data set is from 2012-2019 and the testing data set is for the year 2020. The inputs for the models are gross domestic product, number of consumers, the effective rate of consumers, average monthly rainfall, and average monthly temperature. The results showed that FFNN has better performance for forecasting the monthly electric demand as indicated from the computed mean absolute percentage error. Cagayan Electric Power and Light Company, Inc. (CEPALCO) will benefit from this research by being able to supply enough power to its customers without worrying about running out.*

Keywords: monthly electricity demand, forecasting, artificial neural network

1. INTRODUCTION

Global demand for energy is rapidly increasing which arises from a growing population and economic growth. The total peak demand of the Philippines in 2019 was recorded at 15,581 MW which is 799 MW or 5.4% higher than the 14,782 MW in 2018 [1]. Electricity has been one of the most widely used forms of energy. With the passage of time, it has become essential for humankind to consider the explicit fact that almost everything depends on electricity [2]. A concept that has emerged as one of the most valuable human needs from the industrial revolution.

Electric energy consumption refers to the real energy demand placed on the present electricity supply. Today, electricity is a necessary input for all manufacturing systems and a requirement for all families. Electric demand in different areas has seen an increase locally and globally. Electricity use may result in not just a better way of life, but also worsened environmental repercussions owing to improper use. Overestimation or underestimation of power use results in excess idle capacity, resulting in lost financial resources or increased operating expenses for the energy supply, as well as the possibility of an energy outage. As a result, accurately estimating electricity use becomes critical in order to avoid costly mistakes and other unintended consequences.

Cagayan Electric Power and Light Company, Inc. (CEPALCO) is one of the largest electric companies in Cagayan de Oro City. It serves the power requirement in areas that are covered by the electricity company. As the size of the population increases, so does the demand for electricity. There is a need to forecast the future demand for electricity in order to prepare and help CEPALCO in its operations to provide sufficient electrical energy for its customers. Forecasting electric energy usage is an essential component of any energy management system. Traditional forecasting models are divided into two types: time series models and regression models. This study aims to develop a forecasting model to help model and predict the electric consumption of Cagayan de Oro City. The study's relevance lies in its ability to anticipate monthly electricity consumption (measured in kWh).

2. LITERATURE REVIEW

Forecasting the electricity demand helps the electric industries to provide the basis for decision-making in power system planning and operation. The following studies are related to forecasting electricity demand.

2.1 Studies Related to Forecasting Electricity Consumption

Cuarteros, K., and Cuarteros, N., "**Forecasting Electricity Consumption Using Auto-Regressive Integrated Moving Average",** forecasting electricity consumption is a crucial problem for electric industries [3]. The autoregressive integrated moving average (ARIMA) model is used to foresee future power usage of electricity. To evaluate the accuracy of the performance of the model, actual data was compared with the predicted values obtained in forecasting using mean absolute percentage error (MAPE). In carrying out predictions for electricity consumption, the method with the lowest MAPE is chosen as the most accurate and reliable method.

According to Aydin D. and Toros H., in their study, "**Prediction of Short-Term Electricity Consumption by ANN using Temperature Variables",** energy consumption is a key indicator of a country's level of development [4]. Because of its ease of use, ease of transportation, and clean energy, electricity is one of the most requested and utilized energy kinds. Lam. J. C. investigated the link between home electricity use in Hong Kong and economic and climatic conditions using regression and correlation analyses [5]. The study revealed that seasonal and yearly home electricity usage fluctuates depending on household income, household population, electricity price, and cooling degree days after analyzing 23 years of economic and energy data. Azadeh et al. used an artificial neural network approach to anticipate annual electric demand in Iran's high-energy-consuming industrial sector. Based on the results, the neural network model has a better performance than regression models [6].

2.2 Studies Related to Forecasting Electricity Consumption using ANN

A study conducted by K. Kandananond in his paper **"Forecasting electricity demand in Thailand with an artificial neural network approach"** different models for forecasting were used such as autoregressive integrated moving average (ARIMA), artificial neural network (ANN), and multiple linear regression (MLR) [7]. The study aims to compare the performance of these three models. The data used in this study was historical data about the electricity demand in Thailand from 1986 to 2010. Other data like population, gross domestic product: GDP, stock index, and revenue from exporting industrial products are also considered. Based on the results of their performance, the ANN model has the smallest mean absolute percentage error (MAPE) to 0.996%, while ARIMA and MLR have 2.80981% and 3.2604527%, respectively. Based on these error measures, the results showed that the ANN model is better than the ARIMA and MLR methods.

A study **"Energy Forecasting using Artificial Neural Networks",** by G. Tamizharasi et al, ANN was used for the long-term prediction of Greek energy consumption [8[. The actual input and output data absolutely affect the energy consumption used in the training, validation, and testing process. Predictions have been performed for the period 2005–2008, 2010, 2012, and 2015 using ANN with the results closer to the actual data, which is more accurate than the linear regression model and similar to those obtained by a support vector machine model.

Others studied the **"Electricity Consumption Forecasting in Thailand Using Artificial Neural Network and Multiple Linear Regression"** [9[. In this study, the authors forecast the electricity consumption using the regression model and ANN model. The inputs of both models are gross domestic product, the number of populations, maximum ambient temperature, and electric power demand to predict electricity consumption. Based on the results on the coefficient of determination, mean absolute percentage error and root mean square error, the ANN model gives a better performance than the regression model.

The study elsewhere revealed **"Forecasting a Monthly Electricity Consumption using Auto-Regressive Integrated Moving Average (ARIMA) and Artificial Neural Network (ANN) Model**, compares the Auto-Regressive Integrated Moving Average (ARIMA) model and Artificial Neural Networks (ANN) model which is useful in time series forecasting [10]. The models are: ARIMA (0,1,0), Feed-Forward Neural Network (FFNN), and Multi-Layer Neural Network (MLNN). The author used 108 data of monthly electricity consumption in Cagayan de Oro City from January 2012 and December 2020. Based on the results, the feed-forward neural network model has better performance in forecasting the monthly electricity consumption in Cagayan de Oro City.

3. METHODOLOGY

3.1 Collect data

The data for the monthly electric demand of Cagayan de Oro City will be gathered from CEPALCO. Monthly electric demand from January 2012 to December 2020 will be considered. Based on the Related Literature, Gross Domestic Product, number of consumers, maximum temperature, effective rate, rainfall, and electricity demand are used as inputs in the neural network, hence the data for these variables will be gathered as well.

3.3 Test for stationery

In testing for stationary, it assures that the data did not retain any trend. The test is also conducted because the study was focused on nonseasonal modeling

3.4 Model for forecasting

The input which is the independent variable for our neural network will be the number of customers (CO), gross domestic product (GDP), effective rate per type of consumers (ER), average monthly rainfall (R), and average monthly temperature(T). The output which is the dependent variable will be the monthly electricity demand. The data set will contain the monthly value of the input and output variables for the year January 2012 to December 2020. A total of 108 months of data will be used.

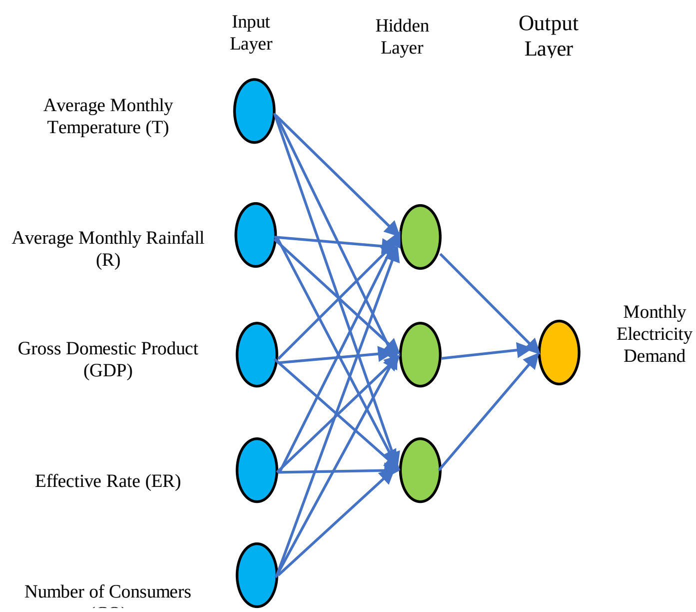

Figure 1: Neural Network Procedure

3.5 Validation of Results

The 2020 data will be used to validate the predicted value obtained in the forecasting process.

3.4 Forecast Monthly Electricity Demand of Cagayan de Oro City for the year 2021 - 2023

The best performing model will be used to predict the future electricity demand of Cagayan de Oro City

4. RESULTS AND FINDINGS

The results and discussions of the proposed model applied in this research are presented.

The monthly electric demand from January 2012 to December 2020 was taken from Cagayan Electric Power and Light Corporation's Inc. (CEPALCO) including the number of consumers, and the effective rate of the consumer. The monthly average rainfall and temperature are gathered from Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAG-ASA). And also, the gross domestic product of the city was taken from National Economic Development Authority (NEDA)

Table 1 Mean Absolute Percentage Error for best-fitted models

	Mean Absolute Percentage Error (MAPE)	
	MLNN	**FFNN**
Monthly Electricity Consumption (kWh)	**0.2678139**	**0.02191241**

Table 1 shows that the model feed-forward neural network has the least mean absolute percentage error, and it indicates that the feed-forward neural network is a suitable model for forecasting the monthly electricity demand in Cagayan de Oro City.

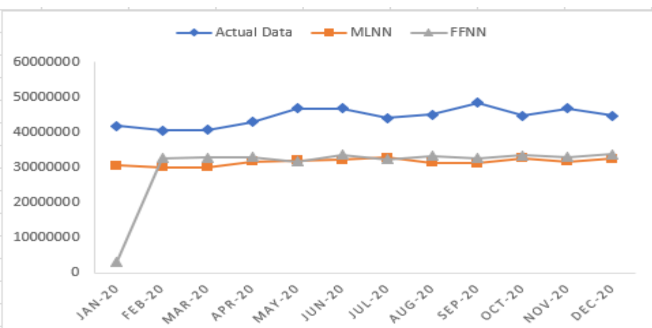

Figure 2: Actual and Forecast Monthly Electricity Demand for the year 2020 using MLNN and FFNN

Figure 2 shows the actual data and forecasting results of MLNN and FFNN models for the monthly electricity consumption. The blue line indicates the actual data. The grey line indicates the forecasted values using the multi-layered neural network (MLNN) from January 2020 to December 2020. The yellow line indicates the forecasted values using the feed-forward neural network (FFNN) with the same months.

Table 2 below shows the actual and forecasted values for electricity demand from January 2020 to December 2020. The mean absolute percentage error of the forecasted values using MLNN and FFNN are 0.2678139 and 0.02191241 which indicates that FFN is more accurate than MLNN.

Table 2: Actual and Forecast Monthly Electricity Demand for the year 2020 using MLNN and FFNN

Date	Actual	MLNN	FFNN
January 2020	41744701	30470716	3135751
February 2020	40444247	30104002	32578766
March 2020	40677144	29995096	32837040
April 2020	42978953	31668121	32993048
May 2020	46712070	31955541	31727706
June 2020	46720067	32159948	33608125
July 2020	44119958	32801619	32239462
August 2020	45035972	31407558	33355386
September 2020	48463106	31243304	32621171
October 2020	44726408	32683014	33497633
November 2020	46777800	31679670	32877519
December 2020	44699408	32484005	33723946
	MAPE	0.2678139	0.02191241

Table 3: Forecast Monthly Electricity Demand for the year 2020 using FFNN

Date	2021	2022	2023
January	32877519	34882273	32404351
February	33723946	34475667	33180931
March	33973634	35269287	35390871
April	33942154	35680494	35426235
May	32822289	35966863	36421351
June	33430082	34949844	35227574
July	34518945	35423022	35423996
August	33089264	35170120	37063303
September	33822681	35299578	36531351
October	34442507	33836538	37272717
November	34103479	34237373	36436842
December	35137564	34101128	37755250

Table 3 above shows the forecasted values of monthly electricity demand using a feed-forward neural network.

5. CONCLUSIONS & RECOMMENDATIONS

The purpose of this study is to forecast the monthly demand for electricity in Cagayan de Oro City using Artificial Neural Network (ANN) model. This study demonstrates the ANN model's efficiency and accuracy.

In this study, two artificial neural network models are utilized to forecast the monthly electricity demand of Cagayan de Oro City. The electric demand from the 2012 to 2019 period was used to train the models. The two artificial neural network models used were feed-forward neural network (FFNN) and multi-layered neural network (MLNN). Based on the results, FFNN has better performance than MLNN.

The researcher provides the following recommendations for further studies: (1) consider more independent variables to predict the electricity demand and (2) extend the scope of the historical data points that will help in the training set using neural network

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