FORECASTING ANNUAL ELECTRICITY CONSUMPTION USING ARTIFICIAL NEURAL NETWORKS: THE CASE STUDY OF THE ANDEAN COMMUNITY

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Overview

Between 1973 and 2015, the world total electricity consumption increased from 5117 TWh to 20201 TWh, reflecting an average annual growth rate of approximately 3.4% [1]. This significant change in electricity consumption has been attributed to numerous factors, including high population growth, increased shares of access to electricity, rising incomes in developing countries and better energy productivity [2]. Over the next 20 to 25 years, the International Energy Agency (IEA) projects that electricity demand will rise by 60% and most of the growth, approximately 85%, will occur in developing countries [3]. Due to the rapid economic and structural transformation of developing countries, the modeling and prediction of long-term electricity consumption have become a key issue for policymakers, private investors, and related organizations. In the last two decades, the economic development of the member countries of the Andean Community of Nations, a trade bloc of four countries – Bolivia, Colombia, Ecuador, Peru, and the increase in electricity consumption have encouraged governments to invest in power capacity. Predicting long-term electricity consumption is by no means a trivial task as it is dependent on a number of uncertainties such as economic, technological and even political instability. Moreover, reliable electricity consumption forecasts are indispensable for an optimal long-term energy planning of a national power generation system.

Figure 1 - Member states of the Andean Community

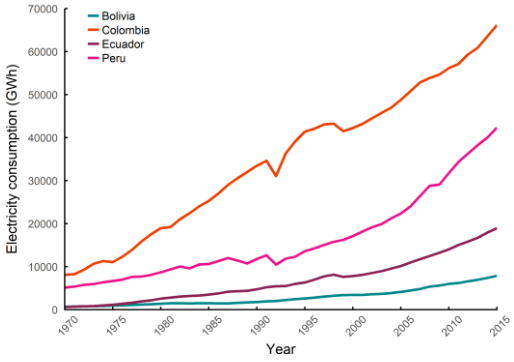

Figure 2 - Electricity consumption in the Andean Community (1970 – 2015)

A review of the literature shows that the vast majority of studies focus on developed economies and that most of those studies employ time series or econometric models. In recent years, Computational Intelligence (CI) methods used for the estimation and forecasting of energy demand and electricity consumption have drawn considerable attention due to their advantage (e.g. capturing the nonlinear relationships of complex data) over traditional forecasting techniques. Despite the extensive literature on forecasting electricity consumption, there is a lack of studies that explore the application of computational intelligence methods for the prediction of annual electricity consumption in Latin American countries, and in particular, on member states of the Andean Community (Colombia, Ecuador, Peru, Bolivia).

In this context, the main aim of this case study is to evaluate the predictive performance of time series and multilayer perceptron (MLP) artificial neural network (ANN) models. The time series ANNs were constructed to forecast future values of selected socio-economic indicators while the MLP ANN models were used to forecast the possible future annual electricity consumption for each member state of the Andean Community. The methodology implemented takes into account historical socio-economic data as well as other variables that could have an effect on electricity consumption. The paper is structured as follows: Section 1 presents a brief technical overview of artificial intelligence and in particular artificial neural networks. Section 2 describes the methodology applied in the development of the ANN model. Section 3 presents the computational results while section 5 presents a summary and conclusions.

Methods

In this study, we use an artificial neural network (ANN) method to forecast the annual electricity consumption. The ANN models are trained with previously observed socio-economic and energy statistical data. The data were obtained primarily from governmental and non-governmental reports, the Latin American Energy Organization (OLADE) and the World Bank. The predicted values of the ANN model were compared with historical data and official forecasts of these Latin American countries. Fig. 2 presents a simplified workflow of the electricity consumption forecasting method.

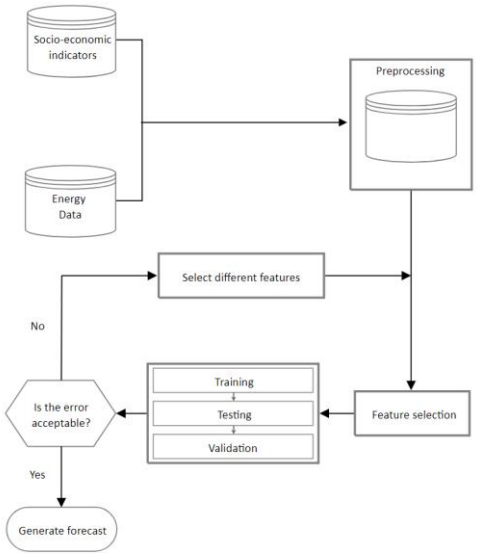

Figure 3 – Simplified workflow of the neural network forecasting method
Source: Own work

Each of the ANN models was computed under various configurations of hidden layers and number of hidden neurons. The predictive performance of each neural network model was investigated through well-known forecast error measures: the mean absolute percentage error (MAPE), root mean square error (RMSE), and the coefficient of determination R^2.

$$MAPE = \left(\frac{1}{N}\sum_{t=1}^{N}\left(\frac{|\hat{y}_t - y_t|}{y_t}\right)\right).100\% \quad (1)$$

$$RMSE = \sqrt{\frac{1}{N}\sum_{t=1}^{N}(\hat{y}_t - y_t)^2} \quad (2)$$

Results

The results presented in this paper show that two different architectures of neural networks, time series ANNs combined with MLP neural networks, are capable of predicting long-term electricity consumption. Furthermore, the prediction performance obtained for each model shows that the approach used in this study could be implemented as a possible mechanism for long-term energy planning of a national power generation system.

Conclusions

Until recently, the vast majority of studies focused on developed economies and most of those studies employ time series or econometric models. This paper aims to fill the gap in the literature on electricity consumption forecasting for countries that integrate the Andean community using a Computational Intelligence method.

References

[1] International Energy Agency, "Energy Statistics," p. 96, 2017.
[2] C. Wolfram, O. Shelef, and P. Gertler, "How Will Energy Demand Develop in the Developing World?," *J. Econ. Perspect.*, vol. 26, no. 1, pp. 119–138, 2012.
[3] IEA, "World Energy Outlook 2017," *Int. Energy Agency*, 2017.