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Long term electricity consumption forecast in Brazil: A fuzzy logic approach

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ABSTRACT

The energy companies are always facing the challenge of producing more accurate load forecasts. A fuzzy logic methodology is proposed in order to extract rules from the input variables and provide Brazil's long-term annual electricity demand forecasts. In recent literature, the formulation of these types of models has been limited to treating the explanatory variables in the univariate form, or involving only the GDP. This study proposes an extension of this model, starting with population and the GDP additional value. The proposed model is compared with the official projections. The obtained results are quite promising.

1. Introduction

The energy consumption in Brazil has become a widely discussed variable over the past years. With the two last decades presenting a sequence of crisis in the energy sector, the government and the energy companies are looking for accurate models with the ability to reflect the best predictions of energy consumption in an unstable economy scenario.

The investment on infrastructure and operation tends to produce better results when they are based on solids scenarios. To cope with the uncertainties on demand and mitigate the risks of economic and financial losses, the decision making is based on long-term demand forecasts [24].

In addition to the better utilization on infrastructure investments, one can also mention the long-term electricity demand forecasting as an important tool for the tariff regulation and energy trading. Taking the Brazilian electricity market as an example, the long-term forecast horizon requires, at least, a five-years ahead horizon, a time span between the energy trading auctions and the energy selling [3].

The electricity distribution tariffs are regulated by the price cap scheme in which at each period of four years the Brazilian Electricity Regulatory Agency (ANEEL, in Portuguese) conducts periodic tariff review in order to achieve gains on efficiency in the electricity distribution sector. For that, this tariff review heavily depends on the demand forecasts [14].

In Brazil, these demand forecasts are produced by the Energy Research Company (EPE, in Portuguese), which is responsible for the generation and transmission expansion planning studies. In this paper, these predictions, provided by the most recent planning study available, i.e., the Ten Year Plan for Energy Expansion in 2023 [7] are used for comparison purposes. Due to the complexity of generation, production and distribution of the Brazilian electrical energy sector, the system is composed of utilities from four subsystems: South, Southeast/Midwest, Northeast and North.

This study aims to propose new load predictions procedures starting with the energy consumption modeling based on a Fuzzy Logic approach. This kind of technique provides elements to treat imprecise data, making the reasoning based on imprecise propositions [17]. Through the rules extractions of the input variables, and the statistical modeling for the lags structure identification, it is produced annual predictions generated by independent models for each consumption sector and region.

In the recent literature, the formulation of these types of models has been limited to treating the explanatory variables in the univariate form, or involving only the GDP [12]. However, some recent studies have shown the importance of economic variables on the

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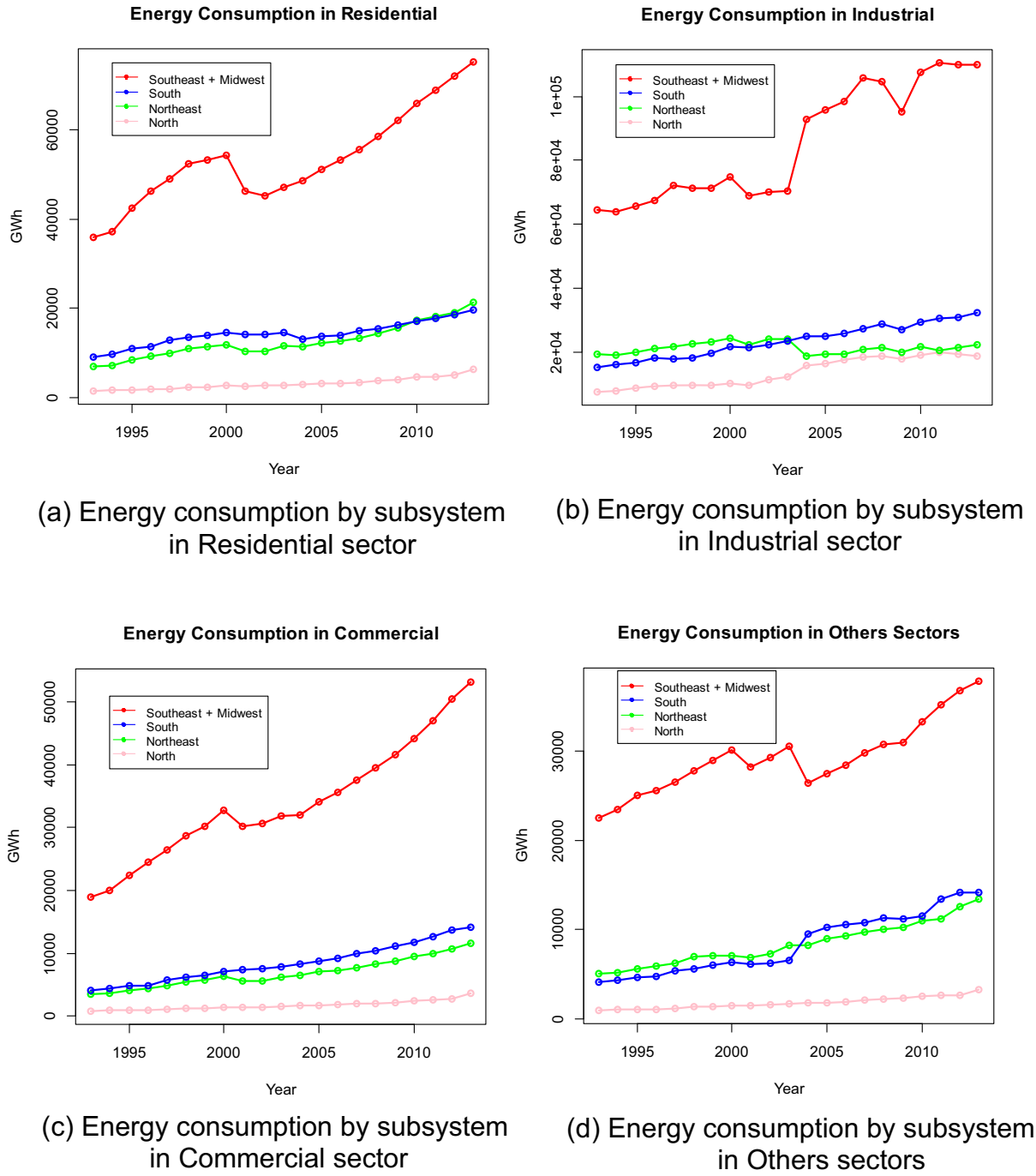

Fig. 1. Energy consumptions by sectors and subsystems.

electricity demand forecast, such as residential population and socioeconomics indicators [2]. This study proposes an extension of this model, by the inclusion of Brazilian population and the additional value of the state GDP, by sectors with its variations. The forecasts produced by the proposed model are compared with the official projections for the sector, provided by EPE.

This paper is organized as follows: Section 2 presents a brief description of the Brazilian energy sector focusing on the energy consumption growth over the past years until today. In Section 3, the description of the Fuzzy Logic methodology, including the Time Series forecast algorithm is discussed. The applications and the results of the proposed models are displayed in Section 4. Finally, the final remarks and some suggestions for further studies are shown on the final section.

2. The past and present of the Brazilian energy sector

The main Brazilian electricity supply crisis took place in 2001, when the Brazilian population was forced to change their consumption habits drastically to attend the decree of energy consumption constraints. The government determined a 20% reduction in consumption to all domestic clients, whose average monthly