# SECTORAL FORECAST AND IMPACTS IN THE ELECTRICAL ENERGY CONSUMPTION IN BRAZIL: AN INTEGRATED APPROACH (ECONOMETRIC + INPUT-OUTPUT) FOR 2009 - 2014.

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*This study proposes a new approach for studying the Brazilian electricity sector, based on the integration of econometric (EC) and input-output (IO) models. Such integration is undertaken through the household consumption. The first step estimates this component of final demand disaggregated by 5 economic sectors. The second step uses such estimation to examine the effects of a variation of the household consumption upon the IO Structure by 12 sectors. This, enable us to have sectoral estimates of this macroeconomic aggregate on an yearly basis from 2009 to 2014 and under three different scenarios. As a result we verify that household consumption do not pressure the sectors regarding the electricity consumption. The study also presents a comprehensive discussion on the Brazilian electricity sector, as well as the electricity consumption among the sectors analyzed in this study.*

# 1. INTRODUCTION

The supply of electricity is a restraining factor to the industrialization process and the economic growth, so that availability and access to this energy resource are of major importance. In other words, the energy topic is a core one for every nation (BRAZILIAN ATLAS ELECTRICITY, 2005).

The Brazilian economic growth from 2004 to 2008 and the perspective of its maintenance for 2009 to 2014 (2.5% annually on average according to the International Monetary Fund, 2008) stress the importance and the concern regard to the country's electricity consumption in the next years, given the relationship between economic performance and increasing use of electrical energy.

In addition, studying the electricity sector is prominent because (a) there exists many challenges in policy development for the sector; (b) imports of electricity depends on the existence of transmission networks; and (c), as consequence of (b), the shortage of electricity may imply in consumption contention programs (e.g., as the one introduced in Brazil in 2001), which would prevent the economic growth.

Thus, the expected market growth and the investments needed to guarantee the fulfillment of agents' demands of electricity may take place under inappropriate conditions; that is to say, it is necessary to reduce the uncertainty with regard to the sector's perspectives, what implies in the adoption of methods capable of capturing the complexity of the electrical energy industry (Caio et al, 1998).

The energy indicators play a fundamental role as they constitute a tool of analysis enabling the economic policy maker to evaluate the sector (for instance, issues related to electrical energy consumption), and in turn to trace proper policies in the field.

In this context, the goal of this paper is to propose a new approach to analyze the behavior of the Brazilian electricity sector as a whole using an integration of models. The first step is to estimate the household consumption by sector[1] (e.g., food and beverages) for 2009 to 2014 (econometric module (EC)), and the second is to interconnect those estimates to the input-output matrix and verify the electricity consumption (measured in GWH) also by sector[2] (input-output module) for three different scenarios (optimistic, moderate, and pessimistic) generated using the limits (“lower” and “upper”) of the EC module interval forecasts.

In other words, an integrated (econometric and input–output) model have two advantage: (a) allows gains of forecasting power due to the econometric model, and (b) take advantages from the inter-sectoral features presented in the IO model.

To accomplish that, it will be used the results of household consumption for the years 1974 to 2004 provided by the Brazilian Institute of Geography and Statistics (BIGS, 2008) to build the econometric model. Yet, for the IO module, it will be used the input–output matrix for 2005 developed by the same Institute.

The major contribution of this work is to assessing how much, given three distinct scenarios (optimistic, moderate, and optimistic), a growth of household consumption in a particular sector (e.g., agriculture) will impact the electricity consumption of this and the other sectors of the economy.

Besides, it is important to highlight the period chosen for forecasts, say, the years 2009 to 2014, once, according to the Brazilian Lights Institute (2008), in 2010 the risk of a rationing program in the country will be of 8%, with the maximum acceptable limit for the National Agency of Electrical Energy (NAEE) as well as for the National Operator of the System (NOS) is of 5%. In 2011, the indicator will increase to 14%, say, almost three times

[1] The sectors considered in the EC module are: agriculture; iron & steel products and other metal products; food and beverage; other industries, and transportation.
[2] The sectors considered in the IO module are: [1] agriculture; [2] mining; [3] food and beverage; [4] textiles and clothing; [5] paper and rubber products; [6] chemicals; [7] Non metal ores; [8] Iron & Steel products and other metal products; [9] other industries; [10] trade plus services, [11] Transportation e [12] Utilities.

the maximum admissible risk. For this reason, the deadline for analysis in this paper was extended to 2014 as the risk is expected to increase.

In addition to this introduction, this paper is organized as follows. Section 2 discusses the major reasons leading to the 2001 crises with emphasis on the regulatory models for the electrical sector implemented by the Brazilian federal government, along with the features of supply and demand that are typical to electricity. Section 3 discusses the results obtained with the EC model and the integrated EC+IO model. Section presents conclusions and some directions for future studies.

## 2. BRAZILIAN ELECTRICITY SECTOR

### *2.1. Causes leading to the 2001 crisis of the electrical sector and the regulatory models*

According to Pires et al (2002), in general, the crisis of electricity supply in Brazil has four major causes: (a) the breakdown of the state driven model, which was responsible for the sector expansion since the 1960s; (b) management failures in the transition from the state to the private model; (c) regulatory and contractual problems; and (d) lack of coordination among federal agencies.

As to the breakdown of the state model, it happened for two reasons. First, the state's fiscal crisis, with the end of the government's capacity to invest the necessary amount of resources to expand the system (enterprises were overwhelmingly state owned). Second, an inadequate regulatory regime that did not foster the search for efficiency and the low cost of generation (tariffs were regulated in the segments of generation, distribution, and transmission of electricity).

Regarding the state's fiscal crisis, which started in the 1980s, it is important to highlight that other factors had contributed to aggravate this problem. First, the increase of the sector's marginal cost of expansion, given that the new hydro electrical basins are located far distant from the consuming centers.

Second, the spoil of tariffs' real values whose price level began to not reflect the increase in sectoral costs. In addition to being equalized throughout the country (as there were no competition), the tariffs were often used as instruments of inflation control. This process led to capital losses and the consequent bankruptcy of many agents of the sector. Third, with the consolidation of democracy and monetary stability, social demands imposed to governments the need of more precise criteria in the application of funding resources (Pires et al, 2002).

From the regulatory point of view, the absence of incentives to the search of productive efficiency led the enterprises to not strive for cost reductions. According to Scheffer et al (2003) in the 1970s, for instance, tariffs were made uniform in all country in order to stimulate energy development of certain regions, making enterprises bearing surplus to compensate with enterprises bearing deficits, by means of transfers, losses and gains from the individual efforts of each one of them.

As for the problems in the transition from state to private model, at the moment the privatizations were launched in the middle of 1995 and contrary to what was expected, private enterprises did not invest in the expansion of the generation apparatus, taking as priority the payment of dividends to the new asset controllers. Thus, the major effects of the privatizations, according to Fernandes et al (2005), was a fast recovery of tariff levels (outdated until then) in order to turn the sector more attractive to private enterprises.

In 1995, with the so called "Law of Concessions" the process of privatization and reform of the sector started up. According to Pêgo and Campos Neto (2008), in addition to creating conditions for a larger participation of private capital, the new Law introduced competition in the development of new projects, formerly allowed to state and federal utilities only.

The reform toward the free market model (1995 to 2003) kept progressing with the inclusion of the Eletrobraz System in the National Program of Privatization (NPP) and with directions to privatizations in the segments of generation and distribution. Yet, according to the same authors, the restructuring process was reinforced with the Law that settled the legal basis for large consumers to be able to buy energy freely (free consumers) and the ruling of the independent producer of energy,  a key feature of the system, in addition to authorizing the auto–producer to sell its surplus production.

Letting the reform to proceed further, in 1996 the Project for Restructuring the Brazilian Electrical Sector, with the purpose of promoting the de-verticalization of electrical energy utilities, say, to split them into segments of generation, transmission, and distribution; to foster competition in the segments of generation and trading while at the same time keeping under state regulation the sectors of distribution and transmission of electricity, regarded as natural monopolies. (BOARD OF TRADE OF ENERGY ELECTRIC, 2008).

It was also observed the necessity of creating a new agency to regulate and supervise all relation in the sector (National Agency of Electrical Energy - NAEE), of an operator of the country's electrical system, and which started its operations in august 1998 (National Operator of the System - NOS) and of an environment for transactions of purchases and sells of electrical energy (Wholesale Electric Energy Market – WEEM), which started to working with many restrains in 2000.

Goldenberg and Prado (2003) highlight that the failure of the reform (free market model) was due not only to the lack of foreign resources or to the political resistances faced within the government proper, but fundamentally to the failures of strategic management, coordination, and planning of the electrical system which were induced by the adoption of a reform based on experiences of other countries that was not fitted to Brazilian features and to an overwhelmingly hydroelectric system.

In 2001, because of the failure of the reform, as noted by Joskow (2008), and of problems associated to short frequencies of rains, the electrical system underwent a severe crisis of supply that induced a National Plan for Electrical Energy Rationing, in which all consumer categories (residential, industrial, trade, rural, public office, public lightning, civil service, and own consumption) were impacted. According to Pêgo and Campos Neto (2008), as the crisis was perceived too late the measures of immediate results were the ones of consumption control. As to the government, it placed focus on projects for building new term electrical units and improved the budget for investments of state owned enterprises.

In 2003, a new regulatory model for the electricity sector was designed, with the legacy of correcting the flaws which produced the crisis, with major focus placed on questions of low–priced tariffs, access universalization and the resume of energy planning.

In institutional terms, the new model present to create a company responsible for the planning of the electricity sector in the long term, the Energy Research Company (ERC). An institution with the task of continuously assessing the security of supply of electricity (Monitoring Committee of the Electricity Sector - MCES) and Board of Trade of Energy Electric (BTEE), responsible for marketing the electric power grid in National Interconnected System (NIS) and aggregating the activities of WEEM, ended in May 2004.

The new model of the energy sector provided a set of measures to be observed by agents, such as the requirement for recruitment of all the demand from distributors and free consumers, contracting of thermoelectric and hydroelectric plants in proportions that ensure better balance between security and cost of supply, and the permanent monitoring of the continuity and security of supply, to detect cyclical imbalances between supply and consumption. It is observed in panel 1, a summary of the main changes between the pre-existing models and the current model

Summarizing, to ALVEAL (1999), the new model is characterized by a redefinition of economic and institutional functions of the state, especially for the Brazilian energy sector. That is, there was a process of transition of the Entrepreneur for the State Regulator.

[Insert Panel 1]

### *2.2. The Supply of electricity in Brazil*

The system for generating electrical energy in Brazil, with approximately 96,634 MW installed, it basically hydropower. The sector share was approximately 73,000 MW in 2006, representing almost 76% of generation. Meanwhile, the thermoelectric sector and the sector thermonuclear have 22% and 2% of generation capacity, respectively.

However, the sharing percentage for hydropower has decreased over the years. This is because the reduction of negative[3] environmental impacts and, particularly, the decline of hydrological risk in the supply of electricity in the country. Those points are goals that justify policies to diversify the energy matrix of the country. Accordingly, it is, for example, the Incentive to Alternative Sources of Energy Program, which has as main goal to be achieved until 2022, the attendance of ten percent of annual consumption of electricity in the country by alternative sources (wind, small hydroelectric plants and biomass).

As the development of the capacity of the national electricity sector, regardless of energy source, is observed in chart 1 that it is increasing every year since 1974. However, the proportion increase from one year to another does not follow the same pattern, because in the

[3] It is important to note that, in general, thermoelectric plants cause more damage to the environment that the hydroelectric plants, however, wind power, biomass and small hydroelectric plants tend to be less harmful. Furthermore, the thermoelectric power plants reduce the hydrological risk (BRAZILIAN ATLAS ELECTRICITY, 2005).

period 1996 to 2006, the annual average increase of installed capacity was 5% p.a, but when considering the years 2005 and 2006, the average gain decrease to 3% p.a.

[Insert chart 1]

This fact reinforces the importance of providing for the consumption of medium and long-term of electricity, because whether the increased consumption of energy will press the country's installed capacity in the coming years becomes prominent.

### *2.2.1. Peculiarities of the Electric Energy Supply in Brazil and the National Interconnected System (SIN)*

According to Pires (2000), the Brazilian electric sector has characteristics that differ it from any other in the international context (for example, hydroelectric plants in Brazil account for 75% of the domestic supply of energy, in the world this percentage is only 16 %). In Brazil, as mentioned, the basic generator is eminently hydraulic. Thermal generation works as a backup system that is used when occurs a peak in system and/or risks in time of rainfall.

Such as hydroelectric dams are built in areas where they can best exploit the gaps and the influx of rivers, usually located in places far from the consumer centers. It became necessary to develop the country's extensive system of transmission. This distance, coupled with the large territory and the climate and hydrological changes in the country, tend to cause excess or shortage of hydropower production in certain regions and periods of the year. The interconnection enables the exchange of energy among regions, thus allowing it to obtain the benefits of the diversity of the river basin.

It is important to emphasize that in addition to the system linking the country as a whole for the distribution of power, we have to consider the operative interdependence of the system. In other words, since most of the installed capacity consists of hydroelectric plants, which is spread over 8 different basins[4]. The interdependence operative recovery is caused by all the hydroelectric resources through the construction and operation of power plants and reservoirs located in sequence in several river basins. Thus, the operation of a plant depends on the flow released by others.(NATIONAL OPERATOR OF THE SYSTEM, 2008).

Because of these two factors (transmission systems and operational interdependence), the Electric System is composed of the National Interconnected System (NIS), and the isolated systems, located mainly in the north of the country (only 3.4% of production capacity). The NIS consists of companies from the South, Southeast, Midwest, Northeast and the North. The size and characteristics have to be considered so unique in the world.

Its function is the integration between the systems of production and transmission. The NIS is important to supply the consumer market, link almost all the national territory, and to meet possible deficits of energy in states or regions with production below its consumption. Therefore, as emphasized by Benjamin et al (2004), the idea of operating each plant separately and decide individually by the completion of a new investment is meaningless in the Brazilian electrical system.

Thus, according to Marreco (2007), both the technical and economic aspects should be highlighted. This is because the energy sector has characteristics that should be highlighted in relation to other sectors, such as that of natural monopoly (electricity sector as a whole) and industry network (e.g. segments of transmission and distribution).

Moreover, the structure of network generates economies of scope, of scale and requires the coordination and operation of centralized services. The economy of scale in the sector stems from the possibility of dilution of fixed costs of enterprises with high capacity. As the economies of scope, they occur because of the possibility of selling different services using the same basis as active.

[4] These basins are: Bacia do Rio Amazonas, Bacia do Rio Tocantins, Bacia do Atlântico Norte/Nordeste, Bacia do Rio São Francisco, Bacia do Atlântico Leste, Bacia do Rio Paraná, Bacia do Rio Uruguai, Bacia do Atlântico Sudeste. (National Agency of Electrical Energy, 2008).

According to Cima (2006), in the case of the electrical activity of a sub-function of production and specificity of active transport, competitive pressures make it inefficient to increase the number of agents. This is because, in natural monopoly, regulation of quality and price of energy services that matter. Especially in network industries, where costs are reduced when increasing the number of consumers connected to the network, in others words, the marginal costs of long term tend to be decreasing.

### *2.3. The Consumption of Electricity*

The consumption of electric power sector shows that, with the exception of 2001 due to the rationing of electricity, the same have been growing over the last 5 years in a level of 5%, reaching in 2006 a consumption of approximately 150,000 GWH of electricity. This amount represents 40% of electric power consumption in Brazil.

Given the importance of consumption of electric power sector as a whole, it is also prominent verify the behavior of consumption in each sector. As seen in chart 2, the sector that consumed more energy in 2006, was the Iron & Steel and other metal products (61,485 GWH). Still, it appears that despite a drop in consumption in 2001 of approximately 9% compared to 2000, the industry picked up 31% and increased its consumption in the period 2002 to 2006.

About the sector Other Industries, its behavior is somewhat different, because in 2001 the consumption sector fell only 1.75% and for the period 2002 to 2006, consumption increases 31% in the same sector Iron & Steel and other metal products. This fact, makes the consumption of this sector reached the level of approximately 41,000 GWH.

[Insert Chart 2]

Industry Food and Beverages presented the second highest growth in the consumption of electricity in the period 2002 to 2006, about 35%. Moreover, in 2001, consumption of the sector had a decrease of only 1.64%. This fact has enabled the industry, moving from a consumption of approximately 15,000 GWH in 2001 to almost 22,000 GWH in 2006. In Agriculture, monitoring the performance of the sector in the country, the consumption of electricity increased by 32% between 2002 and 2006 and reached a level of 16,000 GWH in 2006. Finally, with respect to the Transportation sector, we observe that it consumes a small amount of electricity (1,462 GWH in 2006). The sector, after sharp fall in consumption in 2001 and 2002, about 25%, recover in the coming years and surpass the level of consumption in 2001.

Thus we can conclude that the sectors influence the consumption of electricity in the country, and that all sectors, on average, had positive changes with respect to the consumption of electricity exceeding 30% for the period 2002 to 2006, thus, it is clear the relevance of this study.

## 3. DATA AND METHODOLOGY

### *3.1. DATA*

The database used for the EC module was taken from the National Accounts and Statistics of the XXI Century, both provided by the Brazilian Institute of Geography and Statistics (BIGS, 2008). The selected period was the years 1974 to 2003, because there is no sector data available outside the time period for the household consumption. The data were updated for 2003, where, for this, took up the implicit deflator of GDP. This choice was based on the fact that deflator takes into account sectors of the economy, since it measures the inflation of the economy as a whole.

In order to do a job that allows for a more current discussion of the Brazilian economy, using the matrix estimated by the Brazilian Institute of Geography and Statistics (BIGS, 2008), information obtained from the National Accounts of Brazil, to incorporate this to an econometric model.

The IO matrix for the Brazilian economy is constructed as a commodity by sector matrix and the values are measured at basic prices. This structure allows that a commodity be produced by more than one sector and also that each sector produce more than one commodity. We have two matrices: a) a production matrix and; b) a use matrix. Both are 110 commodities by 55 sectors. However, in order to reach the aim of this paper we leave to implement an aggregation in the former matrix. We use the idea of a make matrix to have a sector by sector matrix (55 x 55).

We implement a reconciliation between two sources of data (sector by sector IO matrix) and National Energy Balance Report, 2005.

Moreover, to obtain the result of consumption of electric energy in physical values, we used data from use of energy in tep (ton of oil equivalent), available for 2005 in the National Energy Balance Report (BEN, 2007) and converted to gigawatts-hours (GWh)

## *3.2. METHODOLOGY*

### *3.2.1. Input-output Module*

According to Miller and Blair (1985, p.6), the mathematical structure of an input-output system is formed by a set of n linear equations with n unknowns. In this set, the demand of a specific sector j by inputs from other sectors is related with the amount of goods produced by the sector j and with the final demand.

Thus, taking into consideration that the economy is divided in n sectors, we have that:

$$X_i = z_{i1} + z_{i2} + ....... + z_{in} + C_i + I_i + G_i + E_i \tag{1}$$

Considering that each sector will have a similar equation, it is possible to write:

$$\sum_{j=1}^{n} z_{ij} + C_i + G_i + I_i + E_i \equiv X_i \tag{2}$$

The input-output method assumes that the interindustry flows from sector i to sector j are based on a ratio called technical coefficient $a_{ij}$ denoted by:

$$a_{ij} = {}^{z_{ij}}\!/_{X_j} \tag{3}$$

The technical coefficients are fixed measures of a sector and its inputs. In other words, we do not take into consideration the idea of scale economies in the production process. We consider the hypothesis of constant returns.

Substituting (3) in (1) and assuming that $Y = C + I + G + E$ we have the opened Leontief system. In other words, the final demand is considered exogenous.

$$X_1 = a_{11}X_1 + a_{12}X_2 + \cdots + a_{1i}X_i + \cdots + a_{in}X_n + Y_1 \tag{4}$$

The equation (4) can be written in the metrical form as:

$$AX + Y = X \tag{5}$$

Where A is the direct input coefficients matrix (n x n); X and Y are the column vectors (n x 1).

Solving the equation (5) is possible to have the total production that is necessary to satisfy the final demand. Thus:

$$X = (I - A)^{-1}Y \tag{6}$$

where $(I – A)^{-1}$ – the direct and indirect coefficient matrix. The Leontief inverse.

### *3.2.2. Econometric Module*

The Exponential Smoothing and ARIMA present well fitted characteristics for the purpose of this paper, as: (i) a good forecast capacity (mainly of short and medium run); (ii) range forecasts, where the limits can be understand as scenarios “optimistic” and “pessimistic”; and (iii) we can calculate disaggregates forecast.

Before we discuss the econometric methods used we have to understand the idea behind the methodology used in this paper. In other terms, first of all we estimate the household consumption by sector comparing the statistics test results; second of all, basing on the “best fit” of the statistics tests outside the sample (error minimization) we determine the model that will be used for the forecast (Exponential Smoothing or Box & Jenkins). In the end, the data were forecast.

It is important to highlight the statistics used to evaluate the behavior of the forecast model, this is, the Regression Coefficient ($R^2$), the Bayesian Information Criterion (BIC), the Mean Absolute Percent Error (MAPE) and the Geometric Mean Relative Absolute Error (GMRAE)[5]. Those measures are used to evaluate the behavior of the estimated model in sample and out of sample rolling evaluation[6] of data used in the paper.

In order to elaborate the scenarios we use a statistic criterion because the forecast is probabilistic. We adopt a significance level of 5%. The probability of the result be located between the lower limit and upper limit is 95%.

The expected value calculated by the forecast equation was used as moderate scenario. The lower limit of the probability distribution was taken as pessimistic scenario and the optimistic one take the upper limit of the distribution.

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[5] See Greene (2003) for more information.

[6] In order to evaluate the behavior out of sample we use data from the last three years.

The idea behind the use of this criterion to construct the scenarios is avoid the ad hoc construction. In other words the scenarios are based on specific statistical measures.

### *3.2.2.1.* Exponential Smoothing *Methodology*[7]

Suppose that a set of observations $Z_1$, $Z_2$, ....., $Z_T$ formed a time series of order T and also that this series represent the household consumption of a specific sector. The series present a level variation during the period of analysis. A more adequate model is the one represented by the equation (7):

$$Z_T = (a_1(T) + a_2(T) * t) + \varepsilon_t \tag{7}$$

Where $a_1(T)$ is the level parameter in the instant T; $a_2(T)$ is the trend parameter in the instant T; t is the time variable (t=1,2,…,T) being T the amount of data disposable and $\varepsilon_t$ is the forecast error.

This model is called as Holt-2parameters model. The actualization of the parameters can be made according to (8) and (9).

$$\hat{a}(T) = \alpha * Z_T + (1-\alpha) * \left[ \hat{a}_1(T-1) + \hat{a}_2(T-1) \right] \tag{8}$$

$$\hat{a}(T) = \beta * \left[ \hat{a}_1(T) - \hat{a}_1(T-1) \right] + (1-\beta) * \left[ \hat{a}_2(T-1) \right] \tag{9}$$

The equations (8) and (9) show the idea of weighted “present” and “past” for the actualization of the parameters. However, we use two smoothing constants ($\alpha$ e $\beta$), one for the level parameter ($a_1$) and the other for the trend parameter ($a_2$).

In the equation (8), the actualization of the level parameter is made given a weight $\alpha$ □ for the more recent real data and a weight (1-$\alpha$) for the last estimative made for the level that is formed by $\hat{a}_1(T-1)$, the estimative made for the level in the previous instant (T-1), plus

[7] More details see: Montgomery e Johnson (1990).

$\hat{a}_2(T\text{-}1)$, that is the estimative done for the trend also for the previous instant (T-1). Thus, level plus trend (growth ratio) enables us to calculate the estimative of a new level. The (T-1) term indicate that the calculus was made for the previous instant.

In the equation (9) the actualization of the trend parameter we observe that a weight $\beta$ is used for the difference between the new levels estimative (calculated in the equation 8) and the last level estimative (made in the previous instant T-1). The level variation is exactly the term that characterizes the trend component or the growth rate. If a weight $\beta$ is given for a present estimative for the trend parameter, a (1-$\beta$) weight is given for the last trend estimative done for the previous tendency (T-1).

#### *3.2.2.2. Box & Jenkins Method*

Differing from the regression models in which $Y_t$ is explained by k variables $X_1, X_2, X_3 \cdots X_k$, the Box and Jenkins models enables that $Y_t$ be explained by past values, or lagged values of Y and also of the stochastic errors.[8]

The first step on this methodology consists on identify, if it is necessary, the degree of homogeneity "d". In other words we have to identify the number of integration of original series in order to be a stationary series. This procedure can be made through the observation of the graphic of the series or of the autocorrelation function (FAC).

The next step is the identification of the model, which means the order (identification of p and q). We use the autocorrelation function and the partial autocorrelation (FACP) where in order to indentify the order we observe the behavior of both.

[8] For more details see: BOX, G. E. P., JENKINS, G. M. *Time Series Analysis, Forecasting and Control*; e, Grenne (2003, p. 609 – 645).

In general terms, in order to identify the order p, the model AR(p), for example, we observe if the FAC is decreasing and the FACP has a cut. If this happens, the lag where the cut occurs give us the order p (p = cut lag).

On the other hand, for a model MA(q) the FAC and FACP present an inverse behavior when compared to a pure auto-regressive model. This means that, for a MA model, the FACP decrease and FAC present a cut. In the same way, the lag where the cut occurs shows the order q of the MA model.

After the identification of the model order, is necessary to obtain the parameter estimative of the model. The method used for those estimative is the maximum likelihood.

The last part consists on the fitted tests to verify the final consistence of the model: residual tests and upper fixation tests.

### *3.2.3. Econometric model integrated to an Input-output model*

According to Rey (1998) the advantages in the use of an integrated model (EC + IO) are many because both methods used separately have limitations. But, when those models are integrated some limitations are minimized. Furthermore we avoid the criticism of using the final demand as determined ad hoc.

Rey (2000) shows three motivations in the utilization of EC+IO models. They are: (a) improve the forecast results; (b) the forecast analysis became more complete and (c) there is an increase in the worries about the measure errors (hypothesis tests and level of confidence)[9].

According to Rey (1999) we have three ways to integrate the EC+IO model: (i) Linking- Kort e Cartwright (1981); (ii) Embedding and (iii) Coupling. In the linking strategy

[9] There is uncertainty in relation to error and parameters both in the EC module and IO module. For more information see Rey, West e Janikas (2004).

the modules (EC or IO) are exogenous one to the other. Thus the integration between then is recursive. For the other strategies the modules present simultaneous retro alimentation.

According to Rey and Dev (1997), the more complete way to integrate is the coupling, in which the integration between the IO model and EC model is simultaneous and present two ways of feedback (West, 1994; Conway, 1990).

The EC + IO module used in this paper was integrated using the linking strategy (EC model join the IO model). We use as source Rey (1999), Rey, West e Janikas (2004) e Mattos et al. (2008).

In this way, in order to construct the EC+IO model we define the main macroeconomic identity and the IO equations that will be used to form the EC+IO model.

$$\Delta Y_{i,t} = \Delta C_{i,t} + \overline{G} + \overline{I} + \overline{E} - \overline{M} \tag{10}$$

$$X_{i,t} = AX_{i,t} + Y_{i,t} \tag{11}$$

$$EE_{i,t} = PX_{i,t} \tag{12}$$

where Y is the gross domestic income by sector and C is the household consumption by sector. G is the government consumption, I is the private investment, E are the exports and M are the imports, both exogenous to the model. EE is a nx1 vector of electric energy sectoral consumption measured in GWH. P is a nxn diagonal matrix that have in the main diagonal the sectoral electric energy use coefficients measured by the ration between GWH and GDP, both sectorals.

In order to better understand the equations (10), (11) and (12) we have to observe that sectoral variations in the consumption, will impact the product (Y) and based on the linking strategy will vary the IO module. Thus it will be possible to observe how much of electric energy the other sector will consume.

The linking between the EC and IO models are made using the basic identity of IO model.

$$\Delta X_j = (I - A)_j^{-1} \Delta Y \tag{13}$$

Where, $(I - A)_j^{-1}$ is the Leontief inverse, $\Delta X_j$ is the change in the total product in the industry j due to a change in the final demand (Y). This modification comes from the auto forecast models. It is important to highlight, however, that there is not a linking from equation (13) to the auto forecast model, which means that there is not a retro alimentation process.

## 4. SOME EXPERIMENTS

### *4.1. Econometric Model*

As can be observed in table 1, the Agriculture sector, Food and Beverages and Iron & Steel products and other metal products present an ARIMA result for a parametric structure. Thus, we can compare both models, contrary to the other sectors.

For the Agriculture, we observe in the in sample analysis that both the $R^2$ and BIC and MAPE indicates that the best fit is for the Box & Jenkins. However, when the adjustment is analyzed out of sample the Exponential Smoothing is classified as the best one. And for this reason it will be adopted for this sector.

For the Food and Beverages sector, as observed in table 1, the analysis became more trivial because the Box and Jenkings shows the best statistical results both for in and out of sample. The Iron & steel products and other metals products sector present statistical results very similar for both methods. However, the Exponential Smoothing will be used because show best results for the forecasts.

The sector Other Industries and Transports present good results for the Exponential Smoothing both for in and out of sample. Those sectors tend to present good forecasts for the household consumption (table 1).

In this way, after we define the method with the best fit for each sector we put in the sample the data that were taken from the sample, calculate the parameters and made the forecasts.

[Insert Table 1]

*4.2. Econometric plus Input-output model*

Before we analyze the results is important to highlight the importance of household consumption for the Brazilian economy. In 2007 this component of the final demand was responsible for 48% of the GDP. Thus, the detailed study of this component is significant for all the sectors in the economy because some variation in this component will impact directly the production of this sector and as a consequence the electric energy consumption.

It is also relevant the analysis of the sector mentioned in this section[10], because, in 2006, the total consumption of this sectors was about 150.000 GWH. By other side, when we forecast the household consumption we observe that the consumption forecast, in 2009, in the moderate scenario, will be around 27 000 GWH. This means that the household are consuming only 18% of the electric energy used by these sectors. Thus we can observe that the household consumption is not a final demand component that consumes a great amount of electric energy in relation to those sectors.

*4.2.1. Agriculture*

As we can observe the chart 3, a variation in the household consumption of the agriculture sector will occasioned a aggregate electric energy consumption of 2000 GWH in

[10] Sectors of the EC module: Agriculture, Food and Beverages, Iron & Steel products and other metal products, Other Industries and transportation.

the 2009 and 2010 years for a moderate scenario. This consumption can reach 3000 GWH in 2014 due to the increase in the household consumption in this sector.

It is important to observe that in volume terms of the electric energy consumption this result represents only a small fraction of the sector consumption[11], once the forecast is made only in the household consumption of the agriculture sector.

[Insert Chart 3]

An analysis of the pattern[12] of electric energy consumption (the amount consumed by each sector in relation to the total consumption) (table 2), given a forecast in the household consumption of the agriculture sector, we verify that the sectors that will consume more energy are, the agriculture sector (48% of the total), the Chemical (24.1%), the food and beverages (11.7%).

The low consumption of electric energy in this sector can be explained by three factors. First of all by the fact that the sector is demanded by the other sectors and also demand a small amount as the IO matrix can show. In other words it not consumes a big amount of electricity from the other sectors. Second of all, it is an exporter sector and third the sector presents a small ratio between the electric energy consumption and GDP.

[Insert Table 2]

### *4.2.2. Food and Beverages*

Observing the change in household consumption in the sector of food and beverage, we can affirm that the household consumption of electricity is changing little over the years. In

[11] In 2006, the sector consumption was 16.400 GWH.

[12] It is important to note that the profile of the electric power consumption will be repeated when the industry is the same and for different scenarios and years, independent of projection. This can be explained by a limitation of the array of IO that are fixed coefficients of input-output, as explained in this work.

2009, the minimum consumption of 9,900 GWH could be and could reach up to 16,000 GWH (chart 4). It is interesting to observe how the consumption of electricity in this sector is greater than in the agricultural sector, this fact can be explained by three reasons, first because the area of Food and Beverages represents a higher percentage of household consumption, hence the amount of energy spent will be greater. Secondly, the Food and Beverage sector is more intensive in energy, and therefore consumes more input of this kind. And third, this is a sector, as noted in Table 3, which requires much of the other sectors to produce their final product, which increases the consumption of household electricity.

Other important characteristic of this segment is the share of household consumption, in other words, comparing the moderate forecast in 2009 with the results of 2006, household consumption is responsible for 65% of electricity consumed by industry. Note that only the transport sector is so closely linked to household consumption among all sectors analyzed.

[Insert Chart 4]

As the amount of power split, it is observed that the Food and Beverage sector is the most consumed (approximately 9,000 GWH in 2009, with participation of 68.4% of total). In addition, we can emphasize the results for agricultural sector (about 1,400 GWH and participation of 10.0% of total) and for the chemical industry (7.9% stake) (Table 3).

Observing the change in consumption of these three sectors it is possible to verify that the expenditure on electricity can vary around 70% in 5 years (2009 to 2014). That is, the consumption may vary from about 1,000 GWH in 2009 to 1,682 GWH in 2014, in the agricultural sector. In the sector of food and beverages it varies between 6,800 and 11,500 GWH, and the chemical industry may vary between 780 and 1,400 GWH.

[Insert Table 3]

### *4.2.3. Iron & Steel products and other metal products*

We can observe that despite being an intensive electricity sector, a change in household consumption does not provide a substantial increase in electric power consumption (chart 5). This is explained by the fact that this sector is not very representative for the household consumption[13].

[Insert Chart 5]

As can be seen in table 4, this is a sector where the electric power consumption occurs almost entirely in itself. In other words, about 90% of electric power consumption is the same. However, it is important to check the possibility of a variation of about 160% in the consumption of the sector between the years 2009 to 2014. This indicates that the amount of electricity can vary between 420 and 1,100 GWH.

[Insert Table 4]

### *4.2.4. Other Industries[14]*

In respect to the aggregated forecasting consumption of electricity, after a change in household consumption in the Other Industries, we find that in 2014 the consumption could reach a level of approximately 16,000 GWH (chart 6). A fact that can be credited mainly to the consumption of the sector itself (about 7350 GWH) and to the industry of Iron & Steel products and other metal products (about 5,400 GWH) (table 5).

---

[13] Compared with consumption of the sector in 2006, the expenditure of energy after a change in household consumption represents only 2%

[14] Other industries are included in the following sectors: a) Machinery and equipment, including maintenance and repairs, b) Appliances, c) office machines and computer equipment, d) Machinery, electrical appliances and materials, e) electronic material and communications equipment, f) devices / medical instruments and hospital, and optical measurement, g) Cars, vans and utilities, h) Trucks and buses, i) Parts and accessories for motor vehicles j) Other transport equipment, l) Furniture and products of various industries, m) Construction, n) Cement.

It is important to note that this is a sector that spends a significant amount of electricity due to household consumption, because, by observing the consumption of the sector in 2006 (section 2.3) and comparing with a probable consumption in 2009, after a change in household consumption, it appears that the expenditure that comes from households represents approximately 25% of the electricity of this sector.

[Insert Chart 6]

As seen in table 5 the sectors that consume more energy are the own sector (45.8% of total) and the sector of Iron and Steel, metals and other non-ferrous metallurgy (33.5% of total). It is important to note that this relationship is consistent with the intra-sectoral economic relations. This is, the other industries sector is intensive in raw materials sector of Iron & Steel products and other metal products.

[Insert Table 5]

### *4.2.5. Transports*

Regarding the transport sector, we noted that this is not a sector that is intensive in the consumption of energy. Moreover, we realized that it is a sector where the use of this input does not vary much over time. This finding was revealed in the forecast, because, to vary the consumption of households in the transport sector, the demand for electricity will vary at most between 600 GWH (pessimistic scenario) in 2009 and 820 GWH (optimistic scenario) in 2014 . (Chart 7)

[Insert Chart 7]

As can be seen in table 6, the Transport sector, unlike other sectors, is not the one that consumes more electricity after a change in it. This is, given a moderate scenario, while the sector consumed 54 GWH in 2009 (8.0% of electricity), the chemical industry consumed 285 GWH (41.8% of energy). Iron & Steel products and other metal products, Other Industries and Trade plus Services sector consumed about 80, 66 and 56 GWH respectively, of total electricity demand by the transport sector.

[Insert Table 6]

## 5. CONCLUSION

It is important to highlight the unique characteristic of this work for the Brazilian economy, since, as far as we know, it is the first research to deal with the an integration of a econometric method to an input-output matrix in which the components of the econometric module were estimated sector by sector, and they were also impacted in the Brazilian input-output matrix for 2005. This approach generates sectoral results in GWH for three different scenarios for the years 2009 to 2014.

This work enabled a new way to view and analyze the electrical sector in the country. The estimation and the analysis of each component of final demand, in this case, household consumption, is a useful exercise for medium and long-term forecast for the electric energy sector.

It is important to emphasize that the methodology employed in this work can be used to estimate the consumption of other energy products (e.g. gasoline), however, the electricity was the theme chosen, mainly, because is one of the sectors that require more synchronization between the pressures of consumption and conditions of supply, especially in Brazil, where the system is eminently hydropower.

We can affirm that there is a range of possibilities for future work. First, the choice of component of final demand (household consumption) could be extended to other components.

Secondly, the update of the components of final demand could be for the year 2005 (year of the matrix). Third, future work may use different econometric models in an attempt to "establish" other results and make a comparison between methodologies. Another interesting research agenda would be the estimation of all sectors and implementing all forecasts, without a criterion to estimate the sectors with the "best fit".

A fifth point is the integration method (linking). As noted there are at least two other possibilities to join the econometric model with IO matrix (embedding and coupling). Another possibility would be to increase the breakdown of IO matrix to observe the consumption of electric energy in a more disaggregated.

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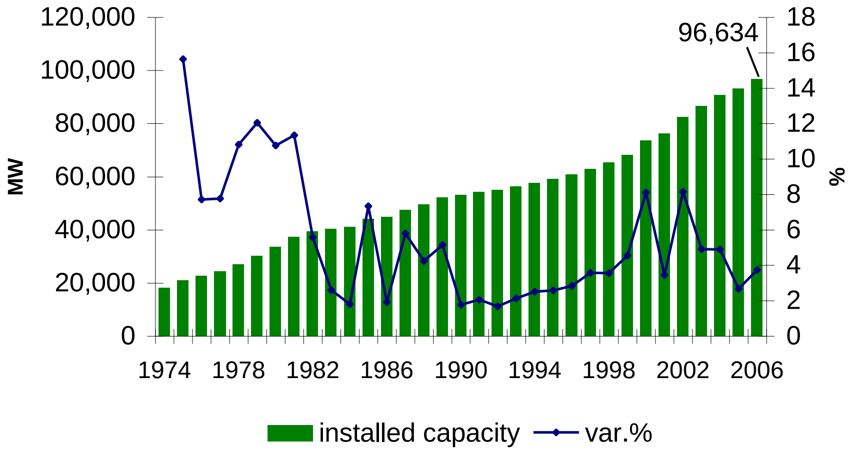
Panel 1 – Comparison between the energy model

| **Former Model (until 1995)** | **Free Market Model (1995 until 2003)** | **New Model (2004)** |
|---|---|---|
| Financing through public resources | Financing through public and private resources | Financing through public and private resources |
| Business verticalized | Companies divided by activity: generation, transmission, distribution and marketing | Companies divided by activity: generation, transmission, distribution, marketing, import and export. |
| Companies predominantly state | Openness and emphasis on privatization of enterprises | Coexistence between State and Private Companies |
| Monopolies - no Competition | Competition in generation and marketing | Competition in generation and marketing |
| Captive Consumers | Free and captive consumers | Free and captive consumers |
| Regulated tariffs in all segments | Prices freely negotiated in the generation and marketing | In free environment: Prices freely traded in the generation and marketing. In regulated environment: the auction and bidding lower rate |
| Regulated Market | Free Market | Coexistence between Free and Regulated Markets |
| Planning determined - Group Coordinator of Planning of Electrical Systems (GCPES) | Indicative Planning by Council for the National Energy Policy | Planning for the Energy Research Company (ERC) |
| Recruitment: 100% of Market | Recruitment: 85% of the market (until August/2003) and 95% market (until dez./2004) | Recruitment: 100% of the market + reserve |

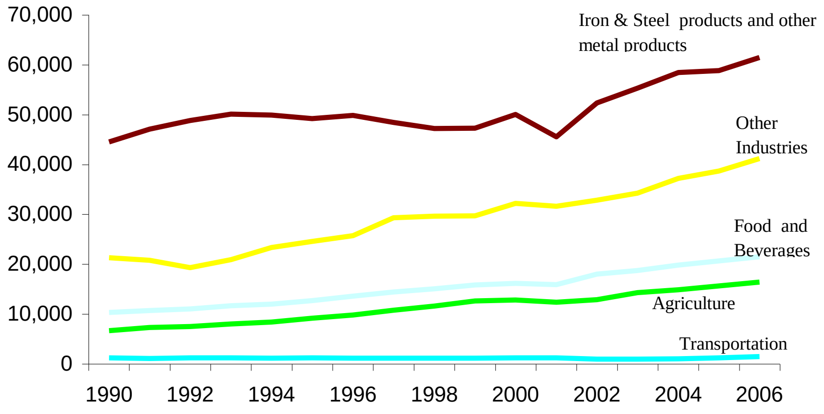
Source: BOARD OF TRADE OF ENERGY ELECTRIC (2008)

Chart 1 - Growth of Installed Capacity of Electricity and Change Percent




Source: BRAZILIAN ENERGY BALANCE (2007)

Chart 2 - Changes in Real Consumption of Electricity (in GWH)



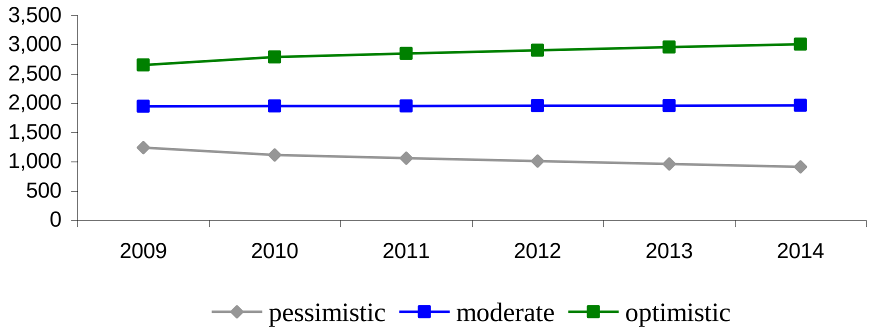

Source: BRAZILIAN ENERGY BALANCE (2007)

Table 1 - Results of the test statistics for Exponential Smoothing Model (ESM) and Box & Jenkins (BJ)

| | | in the sample | | | out of sample | | | |
|---|---|---|---|---|---|---|---|---|
| | | 1974 a 2003 | | | 1974 a 2000 | | | |
| Sectors | Metrics | $R^{2*}$ | BIC | MAPE* | MAPE * (H=1,N=3) | MAPE* (CUM) | GMRAE (H=1, N=3) | GMRAE (CUM) |
| Agriculture | ESM | 57.0 | 4.8E+07 | 6.30 | 3.80 | 3.30 | 1.04 | 0.93 |
| | BJ | 68.0 | 4.2E+07 | 5.30 | 4.90 | 3.60 | 1.40 | 0.99 |
| Iron & Steel products and other metal products | ESM | 64.0 | 1.5E+08 | 5.00 | 3.10 | 4.10 | 1.06 | 0.86 |
| | BJ | 68.0 | 1.4E+08 | 4.90 | 2.90 | 3.80 | 0.91 | 0.93 |
| Food and Beverage | ESM | 58.0 | 4.7E+06 | 5.60 | 6.70 | 8.00 | 0.96 | 0.99 |
| | BJ | 63.0 | 4.1E+06 | 5.30 | 7.00 | 9.00 | 1.01 | 0.83 |
| Other Industries | ESM | 73.0 | 1.5E+08 | 6.90 | 5.30 | 6.40 | 1.14 | 0.93 |
| | BJ | ARIMA(0,1,0) | | | | | | |
| Transportation | ESM | 74.0 | 2.4E+07 | 6.40 | 4.70 | 5.40 | 0.71 | 1.22 |
| | BJ | ARIMA(0,1,0) | | | | | | |

(*) values expressed in percentage terms
Notes: H: horizon; N: number of forecasts; cum: cumulative
Source: authors own elaboration based on the Program Forecast Pro 3.

Chart 3 - Forecast aggregated consumption of Electricity (in GWH) after change in household consumption in the Agriculture sector




Source: authors own elaboration

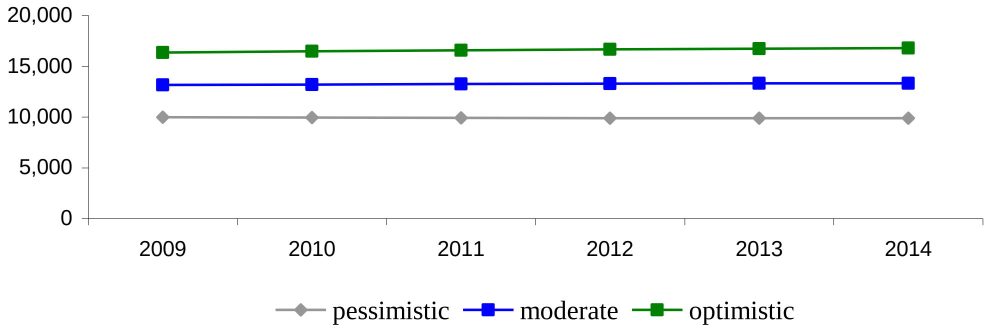
Table 2 - Disaggregated[15] Electricity expenditures (in GWH) after change in household consumption of Agriculture sector

| Sectors | 2009 | | | 2014 | | |
|---|---|---|---|---|---|---|
| | Pessimistic | Moderate | Optimistic | Pessimistic | Moderate | Optimistic |
| 1 | 595.6 | 934.8 | 1,273.9 | 438.9 | 941.7 | 1,444.5 |
| 2 | 40.4 | 63.4 | 86.4 | 29.8 | 63.9 | 98.0 |
| 3 | 145.0 | 227.6 | 310.2 | 106.9 | 229.3 | 351.7 |
| 4 | 4.6 | 7.2 | 9.8 | 3.4 | 7.3 | 11.1 |
| 5 | 25.5 | 39.9 | 54.4 | 18.8 | 40.2 | 61.7 |
| 6 | 299.4 | 469.8 | 640.3 | 220.6 | 473.3 | 726.1 |
| 7 | 4.2 | 6.6 | 9.1 | 3.1 | 6.7 | 10.3 |
| 8 | 69.5 | 109.1 | 148.7 | 51.2 | 109.9 | 168.6 |
| 9 | 14.1 | 22.2 | 30.2 | 10.4 | 22.3 | 34.3 |
| 10 | 31.8 | 49.9 | 68.0 | 23.4 | 50.3 | 77.1 |
| 11 | 2.3 | 3.6 | 4.9 | 1.7 | 3.6 | 5.5 |
| 12 | 8.4 | 13.2 | 18.0 | 6.2 | 13.3 | 20.4 |
| SUM | 1,240.9 | 1,947.4 | 2,653.9 | 914.4 | 1,961.9 | 3,009.4 |

Source: authors own elaboration

[15] Numbers represented: [1] agriculture; [2] mining; [3] food and beverage; [4] textiles and clothing; [5] paper and rubber products; [6] chemicals; [7] Non metal ores; [8] Iron & Steel products and other metal products; [9] other industries; [10] trade plus services, [11] Transportation e [12] Utilities.

Chart 4 - Forecast aggregated consumption of Electricity (in GWH) after change in household consumption of Food and Beverage sector



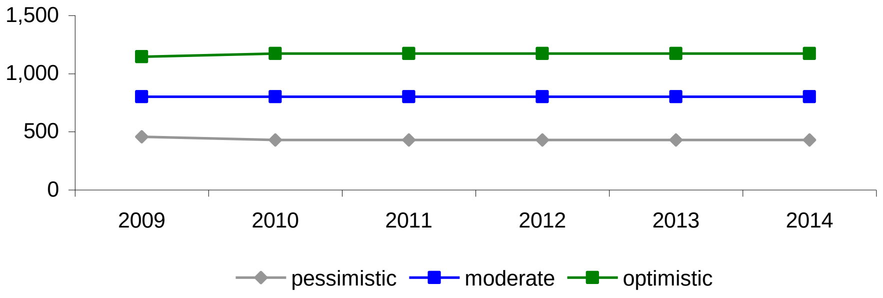

Source: authors own elaboration

Table 3 - Disaggregated Electricity expenditures (in GWH) after change in household consumption of Food and Beverage sector

| **Sectors** | **2009** | | | **2014** | | |
|---|---|---|---|---|---|---|
| | Pessimistic | Moderate | Optimistic | Pessimistic | Moderate | Optimistic |
| 1 | 1,001.6 | 1,319.9 | 1,638.2 | 991.0 | 1,336.9 | 1,682.8 |
| 2 | 108.6 | 143.1 | 177.6 | 107.4 | 144.9 | 182.4 |
| 3 | 6,828.4 | 8,998.0 | 11,167.6 | 6,755.6 | 9,113.7 | 11,471.8 |
| 4 | 25.8 | 34.0 | 42.3 | 25.6 | 34.5 | 43.4 |
| 5 | 252.5 | 332.8 | 413.0 | 249.8 | 337.0 | 424.3 |
| 6 | 785.6 | 1,035.2 | 1,284.8 | 777.2 | 1,048.5 | 1,319.8 |
| 7 | 30.3 | 40.0 | 49.6 | 30.0 | 40.5 | 51.0 |
| 8 | 547.1 | 720.9 | 894.7 | 541.2 | 730.2 | 919.1 |
| 9 | 103.5 | 136.4 | 169.3 | 102.4 | 138.2 | 173.9 |
| 10 | 215.4 | 283.8 | 352.3 | 213.1 | 287.5 | 361.8 |
| 11 | 17.1 | 22.5 | 28.0 | 16.9 | 22.8 | 28.7 |
| 12 | 66.2 | 87.2 | 108.2 | 65.5 | 88.3 | 111.2 |
| SUM | 9,982.1 | 13,153.8 | 16,325.5 | 9,875.7 | 13,322.9 | 16,770.1 |

Source: authors own elaboration

Chart 5 – Forecast aggregated consumption of Electricity (in GWH) after change in household consumption of Iron & Steel products and other metal products sector



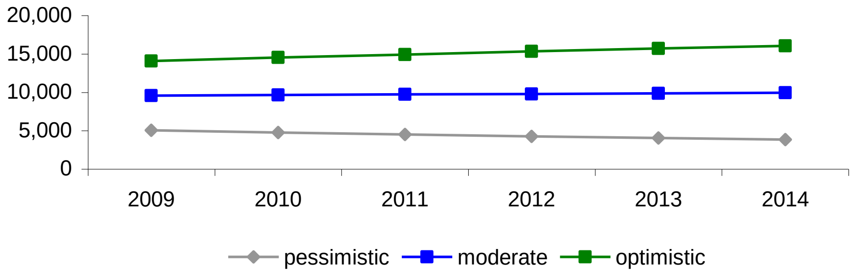

Source: authors own elaboration

Table 4 - Disaggregated Electricity expenditures (in GWH) after change in household consumption of Iron & Steel products and other metal products sector

| **Sectors** | **2009** | | | **2014** | | |
|---|---|---|---|---|---|---|
| | Pessimistic | Moderate | Optimistic | Pessimistic | Moderate | Optimistic |
| 1 | 0.4 | 0.7 | 1.0 | 0.4 | 0.7 | 1.1 |
| 2 | 5.7 | 10.0 | 14.3 | 5.4 | 10.0 | 14.7 |
| 3 | 1.0 | 1.8 | 2.6 | 1.0 | 1.8 | 2.6 |
| 4 | 0.3 | 0.4 | 0.6 | 0.2 | 0.4 | 0.6 |
| 5 | 4.1 | 7.2 | 10.3 | 3.8 | 7.2 | 10.5 |
| 6 | 12.3 | 21.6 | 30.9 | 11.6 | 21.6 | 31.7 |
| 7 | 1.1 | 1.9 | 2.7 | 1.0 | 1.9 | 2.8 |
| 8 | 420.9 | 739.7 | 1,058.4 | 395.9 | 739.7 | 1,083.5 |
| 9 | 3.5 | 6.1 | 8.8 | 3.3 | 6.1 | 9.0 |
| 10 | 3.7 | 6.5 | 9.3 | 3.5 | 6.5 | 9.6 |
| 11 | 0.3 | 0.6 | 0.8 | 0.3 | 0.6 | 0.8 |
| 12 | 2.5 | 4.4 | 6.3 | 2.4 | 4.4 | 6.4 |
| SUM | 455.8 | 800.9 | 1,146.1 | 428.6 | 800.9 | 1,173.2 |

Source: authors own elaboration

Chart 6 – Forecast aggregated consumption of Electricity (in GWH) after change in household consumption of Other Industries sector



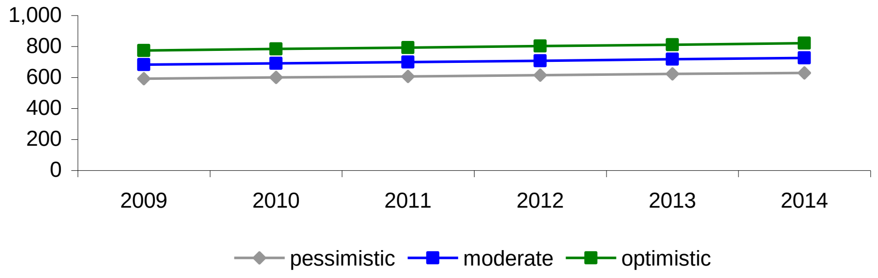

Source: authors own elaboration

Table 5 - Disaggregated Electricity expenditures (in GWH) after change in household consumption of Other Industries sector

| **Sectors** | **2009** | | | **2014** | | |
|---|---|---|---|---|---|---|
| | Pessimistic | Moderate | Optimistic | Pessimistic | Moderate | Optimistic |
| 1 | 15.7 | 29.7 | 43.7 | 11.9 | 30.9 | 49.9 |
| 2 | 69.8 | 132.1 | 194.4 | 52.8 | 137.3 | 221.7 |
| 3 | 34.2 | 64.8 | 95.3 | 25.9 | 67.3 | 108.7 |
| 4 | 16.5 | 31.3 | 46.0 | 12.5 | 32.5 | 52.5 |
| 5 | 247.3 | 468.1 | 688.9 | 187.1 | 486.3 | 785.6 |
| 6 | 333.1 | 630.5 | 927.9 | 252.0 | 655.1 | 1,058.1 |
| 7 | 149.6 | 283.1 | 416.6 | 113.1 | 294.1 | 475.1 |
| 8 | 1,694.8 | 3,208.1 | 4,721.4 | 1,282.2 | 3,333.1 | 5,384.0 |
| 9 | 2,314.3 | 4,380.8 | 6,447.3 | 1,750.9 | 4,551.5 | 7,352.0 |
| 10 | 131.1 | 248.2 | 365.3 | 99.2 | 257.9 | 416.5 |
| 11 | 6.7 | 12.7 | 18.7 | 5.1 | 13.2 | 21.3 |
| 12 | 39.0 | 73.7 | 108.5 | 29.5 | 76.6 | 123.7 |
| SUM | 5,052.1 | 9,563.1 | 14,074.1 | 3,822.2 | 9,935.7 | 16,049.1 |

Source: authors own elaboration

Chart 7 – Forecast aggregated consumption of Electricity (in GWH) after change in household consumption of Transportation sector




Source: authors own elaboration

Table 6 - Disaggregated Electricity expenditures (in GWH) after change in household consumption of Transportation sector

| Sectors | 2009 | | | 2014 | | |
|---|---|---|---|---|---|---|
| | Pessimistic | Moderate | Optimistic | Pessimistic | Moderate | Optimistic |
| 1 | 5.9 | 6.8 | 7.7 | 6.3 | 7.2 | 8.2 |
| 2 | 30.2 | 34.8 | 39.4 | 32.0 | 36.9 | 41.8 |
| 3 | 15.7 | 18.1 | 20.4 | 16.6 | 19.1 | 21.7 |
| 4 | 7.2 | 8.3 | 9.4 | 7.6 | 8.8 | 9.9 |
| 5 | 46.4 | 53.5 | 60.6 | 49.3 | 56.8 | 64.3 |
| 6 | 247.6 | 285.5 | 323.4 | 262.8 | 302.8 | 342.7 |
| 7 | 5.4 | 6.2 | 7.0 | 5.7 | 6.5 | 7.4 |
| 8 | 69.4 | 80.0 | 90.7 | 73.7 | 84.9 | 96.1 |
| 9 | 57.6 | 66.5 | 75.3 | 61.2 | 70.5 | 79.8 |
| 10 | 48.5 | 56.0 | 63.4 | 51.5 | 59.3 | 67.2 |
| 11 | 47.1 | 54.3 | 61.6 | 50.0 | 57.6 | 65.2 |
| 12 | 11.7 | 13.5 | 15.3 | 12.4 | 14.3 | 16.2 |
| SUM | 592.7 | 683.4 | 774.2 | 629.1 | 724.8 | 820.5 |

Source: authors own elaboration