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Public Energy Management and Decision-Making Model: A Proposal based on Energy Sustainability Indicators

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Abstract

The objective of this study is to develop a decision-making model for the Brazilian electricity sector, based on sectoral indicators of energy sustainability. The methodology of this investigation constructed sectorial indicators of energy sustainability, from linear correlations verified between variables of the energy input and development variables, whose results fed a decision-making structure supported by technology, norms and rules and in the decision style. The place of study was the State of Pará and the time span between 2010 and 2019. The investigation concluded the need to re-read the decision-making process in the Brazilian electricity sector, through the essential use of a sectorial system of indicators, which demonstrates strategic respect for the specificities the economic sectors and to guide, through a decision-making model, how electricity can be translated into development based on the productive processes of these sectors.

Index terms— electric energy. investments. economic sectors.

1 Introduction

lectricity public management and decision-making aspects in the electricity sector have always been prominent in the social debate. Modern society uses increasing amounts of electricity (Narayan, Doytch, 2017). Electric energy has always been a fundamental bias in the development process of societies (Collaco et al., 2019). According to Schultz (2016) and Pereira (2018), public management encompasses intricacies linked to the territory and the needs of populations, in order to also involve connections between economic, social and political powers, through decision-making.

The electricity sector is a social organization formed by systemic relationships that involve the process of transforming primary energy to its finais use by type of consumer. These relationships are established between the components of the electricity sector, such as: generation, transmission and distribution of electricity. Electric energy is a secondary energy that can be acquired through primary energy sources transformed from converters; however, depending on the nature of these converters, the generation of electricity can direct economic, social, technological and environmental impacts, to a greater or lesser extent, from all sectors of economic activity (Reis, Fadigas, Carvalho, 2012). The quantitative and qualitative profile of the availability of the energy input establishes bases for the conditions of the populations to guarantee a certain quality of life through. It is in this sense that the construction of electricity sustainability indicators represents relevant tools in view of the possibility of unraveling the existing intricacies between electricity and quality of life.

According to Borges (2012), in public electricity management, indicators favor the decision-making process through guidelines, which tend to articulate with greater precision the strategic mission of energy with the development of regions and countries. In each economic segment, electricity reflects in order to generate jobs, levels of income concentration, consumption flow, volumes of polluting gases emitted, from different quantities. (Amaral, 2017). In this perspective, this study asks: how could decision-making in the electricity sector in Brazil be supported by sectorial indicators of energy sustainability? The purpose of this investigation is to build a

decision model for the electric energy sector in the country, supported by sectorial indicators of electric energy sustainability.

2 II.

3 Theoretical Framework

The discussion environment about public management has raised numerous relevant aspects for examining the capacity of public managers to achieve efficient goals in dealing with public resources invested in regions or countries; among these aspects, it is cited the interference of the ideological field of people who influence more decisively with the decision-making power, through relations in segments, such as electricity among them, the influence of ideologies of groups that interfere with more power of decision, through correlations of forces along various branches, such as energy (Schultz, 2016).

The public energy management environment is developed through public policies in the electricity sector, which generally aim to demonstrate that investments aim at economic growth and improving the population's living conditions. In this process, strategic aspects are verified, from the choice of electricity generation sources to the effects of the use of this energy in the different sectors of a country's economy (Bermann, 2003;Borges 2012;Cornescu, Adam, 2014).

As for decision-making in the public environment, according to Silva (2013), there are three elements that make up a decision-making process within public management. They are: technology; rules and norms; and decision-making style. With regard to technology, it is observed that the administrative and organizational structure must be improved from instruments relevant to information technology to support decision-making, as a way of reducing risks, that is, without using aspects of a subjective nature; as for the rules and norms, it is highlighted that the obedience to these norms and rules makes it possible to achieve optimization in decision making; and finally, with regard to the decision-making style, it is highlighted that it refers to the common standards that decision makers tend to use when facing a decision-making panorama (Silva, 2013).

In this perspective of discussion, attention is drawn to the mission of electricity sustainability indicators in line with the intricacies of the decisionmaking process. Indicators must be interpreted based on the definition of sustainable development. Sustainable development seeks sustainability and the difficulties in conceptualizing the terminology sustainability demonstrates the difficult task of reflecting concepts in practical terms (Sachs, 2009; **??**osta, Teodósio, 2011;Prado, 2015). According to Costa and Teodósio (2011), sustainability comprises the ability to maintain bases of an economic, social and environmental nature that generate the possibility of contemplating the demands of populations in a harmonious way and the organized possibility of examining sustainability is in line with the elaboration of sustainability indicators.

The effort to improve energy analysis tools along with the development process has translated since the 1990s into three important contributions

4 Methodological Strategy

The study site was the State of Pará. Pará comprises a geographical area of 1,247,689.515 km² and an estimated population of 8,690,745 inhabitants, which gives it a density of 6.96 inhabitants/km² (Ibge, 2020). The public electricity distribution service in the State is a concession of Centrais Elétricas do Pará -Celpa, while the share in the generation market is the domain of Centrais Elétricas do Norte -Eletronorte.

The correlation sought as a result a coefficient that quantified the degree of correlation Pearson's coefficient (p) (Chen, Popovic, 2002).

Where: x1, x2, ..., xn and y1, y2, ..., yn comprise the measured values of both variables. And the following equations are the arithmetic means of these variables: e The linear correlations verified in each dimension, through the sectors, were described and analyzed regarding their importance, representativeness and used measurement unit. Later, the variables were organized according to the dimensions: economic, social, environmental and political, which built the energy sustainability indicators, and from each sector of activity, which made up the energy sustainability indices. In calculating the indicators, we proceeded from a weighted average composed of the result of the calculation of the composite variables. In calculating the composite variables, the calculation adopted two variables: the first referring to development, and the other referring to the energy environment.

Table 1 shows the construction structure of the index and the electricity sustainability indicators for the agricultural sector in Pará.

Volume XXI Issue III Version I Table 2 shows the construction structure of the electricity sustainability index and indicators for the industrial sector in Pará. Table 3 shows the construction structure of the electricity sustainability index and indicators for the industrial sector in Pará. In addition to 0,60% High From 0,60% a 0,4% 3 Good From 0,3% to 0,2% Medium Untiul0,1% Low Variation in duration of interruptions per unit. consumer/variation of the tariff charged for electricity

In addition to 0,40% High From 0,40% to 0,21% Good From 0,20% to 0,2% Medium

5 Until0,1% Low

Source: Prepared by the authors (2021).

In the methodological strategy of this study, each sector of economic activity was assessed based on the components of the decision structure proposed by Silva (2013), in order to favor a decision model based on the results of the indicators (Figure 1). In the agricultural sector, the highlight was the social and environmental dimensions, with positive results, predominantly registering indicators with levels between Good and Medium.

6 Source: Prepared by the authors (2021)

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7 B

Next, the results and discussions relevant to the calculation of energy sustainability indicators and the provision of subsidies to the decision-making process in the electricity sector will be presented, Which considers the intricacies of technology, rules and IV.

8 Results and Discussions

This section will be composed, firstly, by the presentation of the results of the sectorial indicators of electric energy sustainability and their analysis, in the scope of each economic activity sector. Then, a decision-orientation model will be presented, which considers the intricacies of technology, rules and standards, and decision-making style, fed by the results of the sector sustainability indicators measured for the State of Pará, between 2010 and 2019.

Below, in Tables 4 and 5, the results of the investigation on energy sustainability indicators in the agricultural sector of the State of Pará are presented. In the agricultural sector, the highlight was the social and environmental dimensions, with positive results, predominantly registering indicators with levels between Good and Medium. In the years 2018 and 2019, the panorama changed as there were records of Low level indicators in the economic, environmental and political dimensions in the sector. The environmental dimension is a concern regarding sustainability and the possibility of measurement in this study is in line with the reality portrayed that ways to measure sustainable development are being structured and tested in various parts of the world (Lira, 2008). The political dimension was the one with the most weaknesses in the period studied. These weaknesses reveal the inadequate energy supply of a large portion of Pará society, which influences public management with lesser decisionmaking power. Thus, part of society ends up benefiting at the expense of others, demonstrating the influence of different ideologies of groups that interfere with more decision-making power in public management (Schultz, 2016).

Below, in Tables 6 and 7, the results of the investigation on energy sustainability indicators in the industrial sector of the State of Pará are presented. In the industrial sector, the positive highlight was the economic dimension, also with a predominance of Medium and Good levels. The political dimension was the one with the most weaknesses in the sector during the period analyzed. The indicators measured reveal an important responsibility to the framework of environmental unsustainability insofar as they point to a profile endowed with large proportions of consumption, added to the relatively low energy yields verified in the analyzed period. The encouragement of mechanisms that strategically redirect the industrial profile of Pará to the condition of contributing to income deconcentration could be operated by increasing the state tax burden for exports of heavy industry products from Pará. The change in the industrial profile would occur through the absence of tax incentives for the segments identified by the study: ferroalloy, aluminum, steel, pulp and paper and chemical products, and the provision of these incentives to the food and beverage, textile and cement industries. The industrial profile of Pará signals the absence of priority aspects to the development process, particularly in relation to the variables that affect the sustainability of the sector, which is in line with the considerations of several authors on the association between energy use and development **??** Below, in Tables 8 and 9, the results of the investigation on energy sustainability indicators in the commercial sector of the State of Pará are presented. In the commercial sector, positive attention was given to the economic and social dimensions, registering indicators of Medium and Good levels. The political dimension, like other sectors, was the one that presented the most difficulties. Source: Prepared by the authors (2021). The decentralization of energy planning, through the creation of the State Energy Policy Council (CEPE), would ensure that the guidelines and strategies designed for the electricity sector in Pará were conducted not only in accordance with the federal government's global interests, but also in a manner to ensure compliance with the demands of society in the state supplying this electricity. What meets the concerns of managers to achieve qualitative results in public management with regard to financial resources applied in the territory (Mafra; **??**ilva, 2004).

In Table 10, below, a structure for decisionmaking guidance based on the results of the sectorial indicators of sustainability of electricity in Pará, measured in the period from 2010 to 2019, is presented. Suggestions for alternative actions within each of the sectors of economic activity and that considers the economic, social, environmental and political 3. The quality could beverified through the number of interruptions in the supply of electricity and the duration of these interruptions.

The actions based on the results of the sectorial indicators of electricity sustainability for the State of Pará were divided into three stages: short, medium and long term. In the short term, the study recommends: a) decentralization of energy planning through the creation of the State Energy Policy Council (CEPE); b)

establishment of a local integrated strategic planning model that uses as an instrument the methodological framework for the construction of energy sustainability indicators and indices, proposed in this article; c) maintain the flow of investments in electricity to maintain Gross Domestic Product -GDP expansion in all sectors; and d) regulation of tariffs based on the quality of supply.

In the medium term, the following are indicated: a) the implementation of social sustainability programs with the energy environment of the agricultural sector, including production chains, and of the industrial sector, reducing the workload in energy-intensive industries; b) incorporation of compensatory devices for environmental costs in the industrial sectors.

In the long term, it is recommended: a) the encouragement of mechanisms that strategically direct the industrial profile of Pará, promoting changes in the composition of heavy industry exports (from the increase in the state tax burden for exports of heavy industry products from Pará) and changing the industrial profile, in order to withdraw tax incentives to the segments identified by the study: ferroalloy, aluminum, steel, pulp and paper and chemical products, and the provision of these incentives to the food and beverage, textile and cement industries, sectors these indicated by the results of the analyzes carried out); and b) increase in the energy efficiency of electricity through credit lines to agricultural enterprises that intend to exchange equipment with high electricity consumption.

V.

9 Final Considerations

The study elaborated an original decision planning model based on sectorial indicators of electricity sustainability in the state of Pará, capable of contributing to the planning of public actions for sustainable development in Pará, according to the results of these indicators measured by sector of economic activity.

The indicators calculated in this investigation revealed a particular reality in each sector of economic activity in the State of Pará. In the agricultural sector, the highlight was the social and environmental dimensions, with positive results, registering levels between Good and Medium. In the industrial sector, the positive highlight was the economic dimension, also with a predominance of Medium and Good levels. In the commercial sector, the positive highlight was the economic and social dimensions, recording, in the same way, Medium and Good levels. The political dimension was the one that showed the most weaknesses in the period surveyed, in all sectors of economic activity in Pará.

The study also presented a decision-making model that suggested actions linked to increasing energy autonomy in Pará, redirecting the industrial profile, including compensatory devices for environmental costs, directing investments to increase GDP in the reality of each sector of economic activity, among other recommendations. The article contributed through: an originality of analysis that reveals the strategic usefulness of knowing the energy specificities of each economic sector and how electricity reflects on the productive processes of each sector; a reinterpretation of the Brazilian energy plan from a decision analysis dynamic that considers the regional specificities for the strategic use of the energy input; and the possibility of using a decision-making model in the electricity sector applicable to any state in Brazil.

New investigations can follow the methodological dynamics presented in this study and the residential sector would be the one that would most add to the deepening of the understanding of this theme. The residential sector comprises a relevant environment for examining the reality of meeting basic energy needs, as it identifies the socioeconomic profile of households in a given population and their conditions of access to energy input.

$$r = \frac{\sum_{i=1}^{n}(x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum_{i=1}^{n}(x_i - \bar{x})^2} \cdot \sqrt{\sum_{i=1}^{n}(y_i - \bar{y})^2}},$$

Figure 1:

$$\bar{x} = \frac{1}{n} \cdot \sum_{i=1}^{n} x_i$$

1

Figure 2: Figure 1 :

1 2

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[2]Public Energy Management and Decision-Making Model: A Proposal based on EnergySustainability Indicators

$$\bar{y} = \frac{1}{n} \cdot \sum_{i=1}^{n} y_i$$

Figure 3:

1

AGRICULTURAL SECTOR ECONOMIC INDICATOR

Figure 4: Table 1 :

2

ECONOMIC INDICATOR FOR THE INDUSTRIAL SECTOR

[Note: Source: Prepared by the authors (2021).]

Figure 5: Table 2 :

3

COMMERCIAL SECTOR ECONOMIC INDICATOR

Figure 6: Table 3 :

4

Figure 7: Table 4 :

5

INDICADOR	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Economic	Good	Good	Good	Good	High	Good	Good	Medium	Low	Low
Social	Medium	Medium	Medium	Good	Good	Good	Good	Medium	Medium	Me
Environmental	Good	Good	High	Good	Medium	Medium	Medium	Medium	Medium	Low
Political	Low	Low	Medium	Good	High	Good	Medium	Medium	Low	Low

Source: Prepared by the authors (2021)

Figure 8: Table 5 :

6

8 (Volume XXI Issue III Version I)	Economical	VARIABLE Variation in electricity GDP/Quantity of KW consumed Quantity of GW consumed/ amount invested in electricity tariff/amount invested in electricity from Balance of formal jobs/amount invested in	2010	2011	2012	2013	2014	2015	3	3	2	3	3
			4		4	2	2	1	4				
	Social	electricity income/Quantity of GW consumed Variation in energy efficiency in the sector/Quantity of GW consumed	Average	1		2	2	2	1	1			
				2		3	1	1	4	1			
	Environmental	Variation in the polluting gases derived from emission of electricity generation /		2		3	4	2	1	1			

Figure 9: Table 6 :

7

INDICATOR	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Economic	Good	Good	Good	Good	Good	Good	Good	Medium	Medium	Me
Social	Medium	Good	Medium	Medium	Low	Medium	Medium	Medium	Good	Low
Environmental	Medium	Good	Medium	Low	Medium	Low	Medium	Low	Good	Mediu
Políitical	Low	Low	High	High	Low	Low	Medium	Good	High	Good

[Note: Source: Prepared by the authors (2021).]

Figure 10: Table 7 :

8

	VARIABLE		2010	2011	2012	2013	2014				
Economic	GDP/Quantity of KW consumed		1		1	2	2	2	3	3	3	4
	Quantity of GW consumed/ amount invested in electricity	Variation in	3		4	3	3	3	2	2	1	1
	electricity	tariff/	3		3	1	4	4	3	2	2	1

[Note: Source: Prepared by the authors (2021). Legend: 4= High Level; 3= Good Level; 2= Medium Level; 1= Low Level.]

Figure 11: Table 8 :

9

INDICADOR	2010	2011	2012	2013	2014	2015	2016	2017	2018	2
Economic	Good	Medium	Medium	Good	Good	Good	Medium	Medium	Medium	
Social	Medium	Medium	Medium	Medium	Medium	Good	Medium	Medium	Good	G
Environmental	Medium	Good	Medium	High	Medium	Medium	Medium	Medium	Medium	I
Político	Low	Low	Medium	High	Low	Medium	Medium	Medium	Low	I

Figure 12: Table 9 :

10

SETOR	DIMENSION

Figure 13: Table 10 :

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