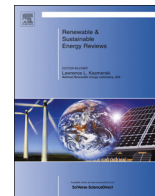




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Prospects for the Brazilian electricity sector in the 2030s: Scenarios and guidelines for its transformation

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ABSTRACT

The long-term study of the electricity sector needs to consider a number of variables beyond the changes in population or economic activity, and include the availability of resources, the development of technology standards, environmental management and cultural habits. Thus, quantitative predictions may prove fragile and a consistent alternative lies in developing qualitative scenarios. In this article, we examine the characteristics of the Brazilian electricity sector to the 2030s, evaluating the uncertainties inherent in energy use patterns, the expectation of expanding the supply of electricity, the rate of development, the spread of smart grids, the insertion electric vehicles, commercial and regulatory trends as well as the future structure of the business environment. The goal is to present in summary form the constructed scenarios and guidelines formulated for the Brazilian electricity sector of the 2030s, through the different topics previously mentioned. In this study, we consider society's behavior as the central variable distinguishing the baseline scenario and the scenario "Energy in Future City". In short, the scenario "Energy in Future City" is expected that consumers will have a more active behavior and grant more importance to the quality and sustainability in the baseline scenario. Thus, while the power supply expansion reference scenario occurs primarily from the operation of conventional sources and advances in smart grids and electric mobility are limited, in the scenario "Energy in the City of the Future", there the emergence of new technologies associated with the diffusion of new business models and a regulatory framework less interventionist.

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1. Introduction

The prospects for the electricity sector on a 20-year time horizon need to consider not only population size and level of

economic activity, but also the structure of this economy, the technological standards, the availability of resources, the constraints imposed by the environment, and cultural habits [1].

The difficulty of analysis is therefore noticeable, since each of these dimensions possesses a reasonable level of uncertainty. Moreover, the uncertainties that are present here are the type that cannot be quantified and, as a result, they do not permit the assignment of a probability distribution [2,3].

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In cases like this, the fragile nature of making forecasts by extrapolating historical data from statistical tools [4]. Thus, the alternative is an essentially qualitative approach that describes the possible paths to be traveled by the variables within the context in which they are included, i.e., the construction and analysis of scenarios [5].

It is thus relevant to use scenario planning to examine the Brazilian electricity sector in the 2030s, especially considering the prospect that the increased dissemination of information and the increasing need to minimize environmental impacts will cause consumers to tend to place more emphasis on the quality and sustainability of goods and services.

Nevertheless, it is necessary to propose regulatory guidelines, public policies, and business strategies, which enable the effective transformation of the Brazilian electricity sector.

This paper's objective is to present a summary of the scenarios developed and the guidelines formulated. The paper is divided into four sections. First, the adopted methodology is described. Then, the developed scenarios are presented, followed by the guidelines necessary to make the alternative scenario possible.

2. Adopted methodology

In addition to being an important analytical tool for governmental decision-making (as a result of explaining the risks involved in decisions), scenario planning is very important in the development of business strategies, especially those relating to investment [6].

In short, scenarios can be taken as narratives of the behavioral trajectories of systems that have interdependent variables with uncertainty. As such, the development of scenarios requires the proper delimitation of the problem, the initial state of the variables, and the definition of consistent hypotheses in order to obtain plausible and relevant scenarios that allow a real understanding of the possible behaviors of the system in question over time [7].

In the scope of the study, the object is to examine what characteristics the Brazilian electricity sector will have in the 2030s, considering that there are uncertainties inherent to: energy use patterns, how the expansion will occur in the electricity supply, the pace of developing and disseminating smart grids and inserting electric vehicles, the commercial and regulatory trends, as well as how the new business environment will be structured.

The presence of many uncertain variables is a feature characteristic of the dynamics of complex systems. However, the relevance of the scenario-building technique requires an effort to construct the smallest possible number of trajectories for the problem being analyzed. As a result, since the number of scenarios grows according to the number of variables considered to be uncertain, there is a clear need to adopt well-established criteria.

Thus, while recognizing the importance of relative variables to the dynamics of technological development, per-capita income level, and the relative prices of energy inputs, the hypothesis has been adopted that these variables are predetermined.

The variable considered to be capable of distinguishing the reference scenarios and the "Energy in the City of the Future" of the Brazilian electricity sector in the 2030s will be the behavior of society, since this impacts the regulatory, political, and business guidelines to be implemented and, therefore, interferes with the development and dissemination of new technologies. In short, the assumption is that, in the "Energy in the City of the Future" scenario, consumers will have a more active behavior and accord more importance to quality and sustainability, especially given the need to mitigate climate change.

Besides the development of the "Energy in the City of the Future" scenario, this paper presents proposals for public, regulatory and business strategy policies that are intended to encourage its implementation. In short, it presents guidelines that, upon being adopted, would induce the achievement of this scenario in the 2030s, at the expense of the reference scenario.

However, as already reported, the consistency of the scenarios is directly linked to the reasonableness of the assumptions adopted. Since the definition of hypotheses shows some level of discretion, care should be taken to ensure that the developed scenarios are not biased, especially when it comes to the "Energy in the City of the Futures" scenario, since it can be seen as the "desirable" one, and this concept involves some degree of subjectivity.

In order to minimize this risk, in addition to thorough technical and academic literary research, the process of developing scenarios and defining guidelines involves a tremendous interaction with experts and representatives from the main institutional agencies in the electricity sector. This paper thus sought to construct a Vision 2030 that would consider the position of business, the regulator, the planner, and civil society.

3. The reference scenario

In the 2030s, many technologies that are currently in the developmental stage should be available. Among the technological advances, the automation of daily activities in conjunction with information and communication technologies will impact the dynamics of social and economic activities [8]. However, these technologies will be restricted to large urban centers and/or concentrated in those social segments with higher income.

With regard to the behavior of society, there will be greater interaction between individuals, and this will provide a greater exchange of information and a valuation of knowledge about the present day [9]. However, civil society will continue to have an essentially passive role in governmental decisions and the definition of business strategies. Accordingly, it is worth noting that, despite consumers attaching importance to an increase in the quality and sustainability of goods and services, the cost variable will remain predominant.

Given the magnitude of the challenge of mitigating climate change and considering the predominance of developing countries in current emissions, climate agreements should include emission reduction targets for developing countries, especially China, India, and Brazil [10]. However, establishing a comprehensive and relevant agreement on emission reduction targets will likely not be compatible with the attempt to stabilize the concentration of greenhouse gases in order to limit global warming to 2 °C.

In any case, the issue of sustainability will be part of the Brazilian national agenda, especially in light of the growing realization of the need to mitigate climate change. However, it will not be a high-priority policy guideline in Brazil. Thus, although there is a trend towards a more efficient use of energy resources, this will largely occur as a trend and will not be induced as a result of specific policies and regulations.

Globally, the decarbonization of the economy will be associated with a more efficient use of energy resources will be associated with a greater use of electricity, because different energy demands will be met by electric energy. In other words, there will be a tendency towards the electrification of the energy system, since electricity is the most "distinguished" type of energy. Therefore, when this trend is combined with the realization that the need to meet different social demands requires a greater use of electricity, it is easy to understand why there is a worldwide expectation that the worldwide demand for electricity will grow at more significant rates than the demand for energy over the next 20 years [11].

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