Revista de Contabilidade e Organizações 17 (2013) 98-114

Revista de Contabilidade e Organizações
www.rco.usp.br

http://dx.doi.org/10.11606%2Frco.v7i17.56691

Journal of Accounting and Organizations
www.rco.usp.br

Corporate and environmental risk disclosure in the face of climate changes and global warming

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Article Info

Article history
Received: 29 November 2012
Accepted: 1 January 2013

Key words
Environmental disclosure
Hydroelectric generation
Climate changes
Corporate risks
Environmental vulnerability

Abstract

This paper is aimed at identifying economic and environmental evidence related to strategic risk caused by global climate change issues. To achieve this objective, descriptive and exploratory research was carried out, in the form of a case study, aiming to delimit the variables observed, the geographic area and the result of their possible interactions, in the context of a large company in the Brazilian hydroelectric energy industry. To characterize the importance of adapting its strategic planning in light of possible impacts from global climate changes, the Expert Panel, the Delphi Method and the SWOT Matrix were used as research techniques. The combined use of these three methods permitted further refinement of the research including the construction of long-term scenarios that could be inferred with regards to the research questions. The results obtained demonstrate that the reduction of water flow and reservoir levels, due to climate change, represent the main strategic environmental risks for the company being researched, which could threaten its corporate competitiveness and negatively compromise its operational, economic, and social performance until the year 2050.

1. INTRODUCTION

Currently, one of the most latent problems in discussions about the environment relates to concerns with the climate changes due to global warming, particularly those caused by pollutant gas emissions in the environment.

Although conscious of the severity of this situation, countries around the world have not yet reached a consensus about the common measures needed to reduce the impacts and the damage global warming can cause to society and ecosystems in general. Among the numerous losses caused by humanity, climate change and global warming mainly entail the loss of future human generations' rights to a healthier and more sustainable environment (Conejero, 2006).

The effort to reduce greenhouse gas (GHG) emissions, which are highly pollutant to the environment, is a concern that also affects corporate activities, as the impacts of created by global warming and climate change can also affect companies' external and internal economic-financial indicators, mainly in companies that depend on the use of natural inputs as their core resources.

Therefore, companies classified as "socially responsible" should incorporate management practices focused on the idea of socio-environmental responsibility into their organizational structures, thereby establishing corporate activities based on the concept of sustainability. This focus assumes that companies have a social function to play, outlined by the objective of protecting and preserving the environment, health, and occupational safety, in a broader sense (Cosenza, Andrade and Laurencel, 2009).

In this context, the main objective of this study is to discuss the issue of global climate change, called GCCs here, by (a) identifying how it could affect the internal and external indicators of hydroelectric energy producers and (b) analyzing how these companies could include in their strategic planning the answers to the possible risks the phenomenon could entail for their social, economic, and operational performance.

This research is justified by three fundamental questions: i) given that these companies need to disseminate the facts and risks associated with their activities in the reports provided to their stakeholders, the study contributes by encouraging the incorporation

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of environmental risks deriving from GCCs into hydroelectric energy companies' strategic planning; ii) the identification of how these companies perceive the risk of shortages could play a determinant role to anticipate proactive initiatives, aiming to guarantee the non-interruption of electric energy supplies in the country; and iii) reflections on the actions needed, involve adaptation measures and changes in these companies' strategic planning, seeking to guarantee their sustainability and, at the same time, reducing the vulnerabilities of the sector and the agents active in this segment.

It is also highlighted that a gap exists in research on the impacts of GCCs when they relate this phenomenon to economic issues, mainly regarding companies' decision making. Some studies address this issue peripherally, indicating which economic activities will be affected and what losses could be relevant, but they use a more social cost-focused approach. This paper contributes through aspects that had not been clarified yet in earlier studies on the consequences of GCCs for the economic-financial-operational balance of agents in the Brazilian electric energy market.

Thus, the research was delimited to Northeastern Brazil, which is considered the most vulnerable region in the country. The research was conducted at the *Companhia Hidrelétrica do São Francisco* (CHESF), the hydroelectric energy production and transmission company with the largest installed capacity in the country. In this context, although the prospective research methods employed in the study are not seemingly used in Applied Social Sciences, surveying and interpreting the effects of the GCCs using the private cost approach, which directly affects the company's performance, can be characterized as a relevant result and a research proposal in the area of Social and Environmental Accounting (SEA).

Therefore, the empirical study developed in this paper analyzes CHESF's behavior until the year 2050, in face of the threats caused by negative external environmental factors the GCCs provoke, conciliating theoretical aspects of the GCCs based on a concrete case, applied to the actual Brazilian context. The impacts of the GCCs on ecosystems and the life of the population represent severe problems, which are globally acknowledged and which should be solved by national and local governments. However, the economic agents that put in practice public policies in the Brazilian context are companies that do not always include the consequences of GCCs' impacts in their own operational and equity structures in their reports.

The paper is structured in five sections, including this introduction. The next section is a literature review about aspects related to hydroelectric energy production in the context of GCCs, addressing not only rising temperatures, but also water resources and other climate variables related to corporate risk and sustainability. The third section discusses the methodological aspects and research procedures applied to the case study, as well as its design. In section four, the main research results are summarized, describing the multidisciplinary approaches used to explain CHESF's future performance in the face of the effects of GCCs. Lastly, in section five, conclusions are presented and suggestions for future research are provided to articulate the research theme, followed by the bibliography.

2. THEORETICAL PLATFORM

The studies conducted by different researchers about the effects of climate change range from rising air temperatures to the vulnerability of populations, analyzing the effects on natural resources, among which studies water stands out. Water happens to be the main source of energy in Brazil. In this context, GCCs are discussed serving as a framework to analyze corporate sustainability and inherent risks.

2.1. Environment and Climate Change

Since the 21st century, industrialized countries have been developing fundamentally based on enhanced population growth and intensive fossil fuel use, which ends up causing severe environmental impacts.

Among these impacts, the results of global climate change stand out, due to global warming, the main consequence of GHG emissions. According to earlier studies (see Carvalho and Egler, 2003; Marengo, 2007 and 2008; Salati *et al*, 2007; Schaeffer *et al*, 2008; Oliveira, 2010; and Lucena, 2010), increased effects of climate change are expected as from 2040 and 2050. Andrade and Lacerda (2009) believe that global warming and its consequences, aggravated by the intense anthropization of land, will cause a series of situations that characterize vulnerabilities for mankind.

However, current knowledge on the effects of GCCs remains partially consolidated in scientific terms. Nevertheless, despite the lack of concrete scientific evidence, the possibility of a gradual air temperature increase is recognized as causing losses for economic activities. Among the areas susceptible to negative effects, Andrade (2012) cites coastal activities, including port activities, which could suffer the impacts of possible rises in ocean levels, as well as hydro-intensive activities, which could cause greater difficulties to access to water. In addition, changes in the rain regimen could cause more frequent floods. On the other hand, droughts and extreme climate events could become more intensive, including hurricanes and storms. Also, changes could occur in the direction and duration of the winds, besides other climate changes that could affect agriculture, navigation and other economic activities.

Installations in general could be compromised by the impacts of extreme climate events, which, associated with possibly significant variations in water flows, represent a great concern for Brazil's energy security (FMASE, 2010). Based on these considerations, it is presumed that some of these impacts will significantly interfere in company activities that use natural resources as their main input, as is the case of hydroelectric generation, the focus of this research paper.

Companies that produce energy based on water flow need to start perceiving that the environmental risks deriving from climate change can interfere in their future business, putting at risk their sustainability and competitiveness in the segment they are active in. Therefore, the possibility of hydroelectric energy shortage events is an important concern in the electric energy market, for companies as well as consumers, particularly in regions where water availability is limited. Hence, it seems evident that environmental risks entail economic consequences, which can disturb companies' performance in the years to come.

2.2. The Environment and Corporate Sustainability

The way in which hydroelectric generation companies perceive the risk of shortages can play a determinant role in the anticipation of proactive initiatives, aiming to guarantee the non-interruption of electric energy supplies in the country. These actions involve adaptation measures and changes in these companies' strategic planning, seeking to guarantee their sustainability and, at the same time, reduce the vulnerabilities of the sector and the agents working in this segment (Margulis, Dubeux and Marcovitch, 2010).

According to Tejada (1999), companies need to consider their relations with the environment as yet another factor for the competitiveness of their corporate strategies or will otherwise be putting their future success at risk. However, the strategic planning of most Brazilian companies active in hydroelectric generation and transmission activities, does not address the impacts linked to climate change. This is implicit in the annual reports of the largest companies in this segment, an evident sign that climate risks have not yet been fully incorporated as a strategic variable, capable of changing the course of business in the next decades. It seems that these companies are not yet clearly aware of the risks GCCs could bring for their economic-financial performance, in the current century, could affect their sustainability.

Nowadays, taking environmental issues into account is essential for the development of energy policies and for the energy sector's activities, whether in the search for more sustainability energy forms or in the expectation of improved environmental performance of operators (Hinrichs and Kleinbach, 2006). The risk of aggravating corporate vulnerability, if some preventive action is not introduced in a timely manner to guarantee the sustainability of the business, is an environmental problem that could provoke economic and financial impacts and compromise the developmental trajectory of corporate activities, mainly in companies that depend on results deriving from environmental assets.

According to Marengo (2008), vulnerability and sustainability are related concepts, considering that the term vulnerability indicates a limit at which a person or system can be affected and the point where sustainability could be compromised; while sustainability means a system's capacity to continue under certain conditions. From a corporate viewpoint, sustainability should assume a balance among the environmental, social and economic dimensions (Unerman, 2012). Corporate vulnerability results from negative impacts that can affect this balance and its ability to react and overcome possible obstacles. The following set of actions can no longer be postponed inside corporations: identifying the specific impacts that can affect each company, knowing and strengthening current conditions to face the impacts and programming future behavior to sustain business continuity.

2.3. The Environment and Corporate Risk

Analysis of companies' strategic behavior towards sustainability threats is impossible without a clear understanding of the variables and external and internal environmental factors that influence their decision making process. In the external context, the variables or factors are always complex and diversified, and normally comprise socioeconomic aspects like inflation, interest rates, gross domestic product, population, investments, credit, unemployment rate and income level, to name a few.

In addition, the guidelines indicated in economic, environmental, tax or social public policies gain great relevance in corporate strategic planning. Likewise, specific indicators from the companies' activity market are addressed, among which competition, logistics, consumers, prices, inputs, geographic area and workforce are highlighted. The energy issue, which all companies strongly depend on, is the cross-sectional highlight that touches upon all of these aspects.

In this sense, different types of risks inherent to corporate activities can be highlighted, as shown in Figure 1. In his study, Souza (2008) used a similar classification and emphasized that the function of risk management is to treat identifiable risk factors, presuppose their quantification and develop instruments to mitigate them. Therefore, companies need to incorporate administrative tools aiming to adapt to strategic risks that can threaten their business.

Table 1. Internal or external business risks

TYPES	MOTIVATIONS
Market Risks	Volume and demand estimates can under or oversize current contracts and investments, uncertainties in consumption and production;
Credit Risks	Client default, contract breach;
Planning Risks	Planning errors can provoke variations in operations, affecting revenues and results; understatement of hydrologic risks by system operator; insufficient investments;
Financial Risks	Choice of funding instruments incompatible with the structure of the activity market;
Legal Risks	Regulatory uncertainty, changes in function of current policy, fines and other penalties, legal gaps, court actions;
Operational Risks	Equipment, control, transmission, human or execution errors; technical losses; licensing deadline;
Economic Risks	Exchange, interest, inflation, price volatility, market liquidity, investments x return;
Environmental Risks	Licensing conditioners, hydrologic risks, climate risk;
Behavioral Risks	Alteration in behavior of clients, litigants, investors and corporations.

Source: Elaborated by the authors

According to Jay (2010), there is an urgent need to apply environmental assessment principles to the large changes that are ongoing in electric energy production.. Nevertheless, according to Ribeiro (2012), the value attribution process has been the main bottleneck to recognize companies' interaction with the environment, given the existence of intangible costs and benefits.

In this context, nowadays, aspects involved in corporate governance gain ground, an area that solidified through the detachment of property and asset management. As the separation between corporate property and control can result in agency conflicts, new monitoring and control mechanisms were also necessary, from a corporate governance perspective. Thus, most proprietors (stakeholders) do not administer their property (the company), but use governance tools to indicate the guidelines they want the actual administrators (managers and directors) to follow.

Motivated by the losses caused by industrial accidents, legal requirements and increasing social awareness about the environment, corporate governance has started to address some guidelines focused on the preservation and conservation of natural resources and corporate risk management. At the same time, greater concern with social problems emerged, especially problems identified in the region the company operates. In this sense, governance indicated corporate social and environmental guidelines, aiming view to understand the problem and contributing to its solution.

Thus, complex external factors were incorporated into companies' strategic planning, which now need to assess their characteristics and trends in conjunction internal factors, which include, among others, operating capacity, fixed capital, intellectual capital, clients, suppliers, management systems, cash and result management. In this context, where different internal and external variables relate and exert mutual influence, global warming was recently incorporated, provoked by the increased concentration of GHGs, which acts as an internal (emissions) and external (impacts) variable at the same time.

Fossil fuel use is appointed as one of the main causes of these gases, whose consequences include important climate change, which in turn tend to affect all economic activities, especially those that use natural resources as inputs, independently of whether they contribute or not to the volume of gas emissions launched into the atmosphere.

As social pressures have intensified towards the reduction of GHG emissions, on the supply side as well as on the demand side, some movements can be perceived as motivating the use of sustainable economic systems. Thus, new technologies emerged for the use of alternative, renewable and less polluting fuels, as well as increased product recycling and reuse programs. Private environmental management developed to follow national policies and global agreements were elaborated to reduce GHG emissions and stimulate actions to mitigate or adapt the resulting impacts.

Companies, mainly in the industrial segment, found themselves compelled to incorporate the environmental aspect into other business management components. The assumption of these new demands in companies implied the development of substantial literature about distinct alternative corporate report models, in the attempt to unify the effects of social and environmental variables on financial results, so as to constitute an integrated accounting system that incorporated these components into the management decision making process.

Normally, companies include the environmental risk dimension as an eventual, sudden and harmful factor in their strategy. In other words, this risk is characterized as an accident, which could cause harmful impacts to the environment and the local population. In this study, however, this approach is broadened to incorporate environmental risk as a gradual and diffuse event, with global causes and local consequences. In fact, GHG emissions can occur in one place, but their impacts disseminate and can be felt in distinct regions across the globe.

Despite the awareness about the undeniable importance of other external factors that affect companies' performance, in this study, the environmental factor assumes the greatest relevance, considering that, in the context of climate change, few studies exist about contemporary microeconomic aspects.

In this sense, investigating how these possible gradual environmental risks can guide corporate administration to cope with the consequences is an important and current problem in the modern world. In the specific case of hydroelectric energy production, these issues gain great importance, as their impacts could affect the sustainability of companies that use water as their basic input.

Despite uncertainties regarding the frequency and magnitude of these impacts, it is presumed that hydroelectricity companies should strategically enhance their capacity to adapt to the changes that are about to come. Therefore, analysis of how companies could direct their long-term strategic planning with guidelines focused on adaptation represents the central scope in this empirical study.

In the context of climate change, the term adaptation should be understood as a reaction aimed at managing the risks of an environmental problem, in the attempt to minimize potential damage and losses. The term mitigation defines actions put in practice to deal with the causes of the problem, that is, to avoid or reduce GHG emissions.

In view of evidence that global warming can change natural systems, then, companies should introduce adaptive actions to reduce their own vulnerabilities to climate risks and put into practice actions to mitigate their reduce their emissions of these gases.

Therefore, hydroelectricity generators would have to include responses to the possible risks posed to their economic, social and operational performance in their strategic planning, especially in terms of the environmental risks they are unable to control. The climate approach that permeates this study mainly considers actions to adapt to the impacts of GHGs, aiming to better understand how hydroelectricity companies could react to and overcome the adverse consequences

of GCCs forecasted for the regions where they carry out their activities.

3. RESEARCH CHARACTERISTICS

Based on the proposals listed in the research problem and the questions outlined as the study focus, an empirical analysis was developed. The research protocol to collect information was based on the survey of how a large player in the Brazilian electric sector responds to the threats of a negative environmental externality provoked by GHGs.

The main aspect that motivated the choice of this company was the fact that, besides being the largest and most important hydroelectric generator in the Northeast Subsystem of Brazil, the poorest region in the country, by economic and social terms, GCCs increase vulnerabilities and uncertainties in the electric energy administration and production process for the population in this region.

For data prospection purposes, information was collected by consulting reports published by ELETROBRAS (*Centrais Elétricas Brasileiras*), CHESF (*Companhia Hidrelétrica do São Francisco*), ANEEL (National Electric Energy Agency), ONS (National System Operator), ANA (National Water Agency), MCT (Brazilian Ministry of Science and Technology), MMA (Brazilian Ministry of the Environment) and CVM (Brazilian Securities Commission). In addition, expert opinions, a literature review and information published by research entities and Brazilian governmental agencies, were utilized

The issues discussed were not subject to any validation tests, as the study is descriptive, without any claim on extending the findings beyond the contextual horizon of the company under analysis. In other words, the study applies only to the concrete case of the company studied, although the ideas and assertions presented in the analysis can also be confronted with other market players.

Data was collected and treated across a six-month period. The analysis process started in March 2011 and was concluded in January 2012.

3.1. Research Method

Although countless classifications are found in the literature that define scientific research typologies, in this study, the appropriate type was selected based on the general procedure used to investigate complex business problems. According to this criterion, taxonomy can be established by distinguishing the research types as follows: bibliographic, experimental, descriptive and exploratory. The latter two techniques were used because they are appropriate for Applied Social Science research.

Exploratory research is fundamental to characterize and describe the nature of the variables one wants to know (Köche, 2007). Therefore, given that this research process in an area where little accumulated knowledge exists on the theme, this technique is justified to identify and point out the essential qualitative and quantitative characteristics involved in the corporate environmental risk deriving from GCCs. This will permit reaching in-depth knowledge about changes in a hydroelectric generator's internal and external variables, in Northeastern Brazil, in the long term. Surveying how these variables behave will provide additional information, which, once organized and clarified, complements earlier research that addressed this theme in a non-conclusive way.

This research also gains descriptive research characteristics, to the extent that it studies the relations between two or more variables in a given phenomenon without manipulating them. According to Köche (2007), in descriptive research, no *a priori* manipulation of the variables exists, while their manifestations are verified *a posteriori.* Given the essentially qualitative nature of the research problem, the study was developed in the form of a case study, as, according to Yin (2001), this permits the analysis of the study phenomenon in a more comprehensive way and the exploration of its details in their actual context.

3.2. Research Design

The fact that the case study permits limiting the variables observed, the geographic area and the results of their possible interactions justify the choice for this method.. In addition, this method appropriately responds to the proposed research question, although the results achieved should only be limited to the company under analysis. Thus, information was collected from a sole company and region in the country, so as to understand a complex problem in a concrete situation in the Brazilian electric sector, permitting a better understanding about the nature of these phenomena and their behavior on a long-term basis.

The Brazilian geographic area chosen as the research focus (Northeast) is not only considered vulnerable from an environmental perspective, continuously affected by intense droughts, but is also considered the poorest in socioeconomic terms and houses the company with the greatest installed electric energy production capacity in Brazil, CHESF, whose strategic planning does not seem to clearly incorporate the climate change approach, despite possible important changes in its main input, water, in this century..

According to Margulis *et al* (2010), the reduced water supply, mainly in the São Francisco River, will create the need for investments in the hydroelectric sector, whether in production through other sources, or in the transmission system to import energy from other regions. Nowadays, energy supplies to the northeastern population and for economic activities mainly come from the main hydroelectric generator in Brazil, CHESF, which, in view of its great dependence on water resources and the intensity and range of climate change effects, can suffer negative operational, economic and financial consequences in the long term.

CHESF believes that its future can only be guaranteed

through sustainable management. The Company (2011) considers sustainable management as the management form that drives the course of its activities along routes that value and recover all forms of capital (human, natural and financial), so as to create value for the stakeholders. From this perspective, it is presumed that this company elaborates a strategic planning that includes sustainable development dimensions, although reports on this planning have not been clearly disseminated.

In function of the relevant importance of CHESF for electric energy supplies, it is fundamental to analyze its capacity to cope with the risks deriving from the impacts of GCCs, forecasted for the coming years, particularly increased temperature, reduced rainfall and water flows in northeastern rivers, as the main environmental variables possibly affected by GHGs that can influence this company's long-term performance.

3.3. Methodological Procedures Applied to the Research

From a corporate viewpoint, sustainability also takes on environmental, social and economic dimensions. Corporate vulnerability results from the negative impacts that can affect CHESF's capacity to react to and overcome possible obstacles. Therefore, corporate sustainability demands social and environmental initiatives focused on exploring opportunities and minimizing risks, based on the mitigation or adaptation of company processes to solve these issues.

The relations among economic, social, environmental and operational variables are characterized based on knowledge about hydroelectric energy and analysis of companies and impacts of GCCs described in earlier studies, besides the application of the questionnaire. This permitted validating the survey conducted with the experts consulted.

To choose the variables and construct CHESF's SWOT (Strengths, Weaknesses, Opportunities, and Threats) Matrix and its respective contexts, two prospective methods were used: i) the Expert Panel; and ii) the Delphi method. Therefore, a model was constructed that demonstrates different perceptions of the causes and consequences of global warming in CHESF's future economic-financial situation.

Despite the eminently qualitative approach employed by the Expert Panel, Delphi Method and SWOT Matrix, some simple accounting and statistical techniques were also used for benchmarking and data treatment purposes.

3.3.3 Expert Panel

The use of the expert panel technique permitted selecting the main operational, economic, financial, social, and environmental aspects that should be addressed in CHESF's performance forecasts until the year 2050. To collect these opinions, the researchers met with a senior group of four Ph.D. graduates, chosen based on their experience in the development of finance, energy, economics and environmental studies. Besides the Ph.D. degree, another inclusion criterion to be part of the senior group was multidisciplinary research activities or publications on these themes; in other words, these experts should possess an advanced academic background, independence and considerable experience in scientific research. The interdisciplinary method adopted in the senior group's work sessions was also fundamental to guarantee scientific consistency as, according to Terrados, Almonacid and Hontoria (2007), new proposals and ideas were submitted to different scientific interpretations and/or techniques during interactive sessions or rounds.

In this first phase of the process, the senior group initially identified 24 variables, which were then grouped into twenty research variables and were inserted into a questionnaire. The questionnaire was validated through the use of the statistical test, Cronbach's Alpha. To prove the clarity and objectivity of the proposals, as well as the time needed to answer the entire questionnaire, it was previously given to a group of 30 students in the *Lato Sensu* executive graduate program MBP/COPPE at *Universidade Federal do Rio de Janeiro*. After applying Cronbach's Alpha[1] (see Cronbach, 1951, 1960 and 1975; Cronbach and Meelh, 1955; and Gliem and Gliem, 2003), the results justified the use of the questionnaire and corroborated its robustness and contribution to the achievement of the research objectives.

3.3.2. Delphi Method

The Delphi method is an acknowledged group interaction process that is frequently applied in social sciences (Graham, Regehr & Wright, 2003) and continues being used as a valuable instrument to make forecasts and support decision making (Landeta, 2006). The Delphi method is also used as an effective long-term planning method (Terrados, Almonacid & Hontoria, 2005), aimed at sustainable development (Shiftan, Kaplan & Hakkert, 2003; Popper & Dayal, 2002). In summary, the Delphi method serves to structure the group communication process and is very effective at assisting a group of experts to reach a group opinion when addressing a complex problem (Linstone & Turoff, 2002; Landeta, 2006).

According to Landeta (2002 and 2006), the Delphi method is aimed at achieving structured and reliable communication, based on a personality group technique, with its own applications, used in a group of experts. Cañibano and Sánchez (2002) consider that the method is particularly indicated for incipient matters, as it allows an expert panel to reach a consensus opinion about a certain theme on which no consolidated or mature knowledge is yet available.

The twenty variables identified in the expert panel were classified in the questionnaire, considering the economic, political, social and cultural factors that represent the influences of CHESF's internal and external environment, in terms of an analysis of strengths, weaknesses, opportunities and threats. This permitted

1. This coefficient is indicated to measure the internal consistency of the set of questions in the questionnaire, as well as the questions in the dimensions used in the SWOT analysis.

the development of the SWOT methodology, using the Delphi method to detect the expert group's perception about the importance of each of these variables to measure CHESF's performance.

In the questionnaire, the participating experts were asked to score the items on a five-point Likert scale, in order to determine each variable's level of importance, depending on how frequently each of them was performed, ranked from least to greatest importance.

To apply the Delphi method, with the objective of ranking the variables to construct the SWOT matrix, total of15 researchers agreed to participate in the expert group and answer the questionnaire, giving their opinions about the proposed themes. These experts were selected according to the following criteria: educational background and activity area. Two Ph.D.'s and thirteen M.Sc.'s were selected.

Their activity areas are: six in environment; two in energy; two in environment and energy; one in economics, finance and energy; three in economics, finance and environment; and one in fluid mechanics.

3.3.1. SWOT Matrix

Using the SWOT method, the internal and external variables, that could offer elements for CHESF's corporate decision making in response to GCCs, were determined. This type of analytic tool has generally been used to develop participatory budget models, although it was originally conceived for corporate and commercial strategic planning. According to Pickton and Wright (1998), this is a favorable method for elaborating diagnoses and achieving interdisciplinary coherence.

Special attention should be given, however, to the fact that the SWOT technique is a tool that, according to Terrados, Almonacid and Hontoria (2007), needs to be based on in-depth knowledge of the present situation and future trends.

In Table 1, the selected variables and their classification are displayed, according to the consensus opinion of the expert group that participated in the interactive sessions. The matrix was constructed based on group members' consolidated answers, which scored the twenty selected variables of high (level 4) and very high importance (level 5). In case of a tie, both were maintained. According to Markovska, Taseska and Pop-Jordanov (2009), the two main components of the SWOT method are internal situation indicators, described by existing strengths and weaknesses, and external environment indicators, described by existing opportunities and threats.

Table 2. Degree of Importance of Selected Variables

OPPORTUNITIES	Ranking	THREATS	Ranking
Invest in technology and innovation for adaptation	1st	Reduced flow	1st
Attend to growing demand	2nd	Public management constraints	2nd
Absence of competitors in the region	3rd	Inflation, interests, cost of financial resources	2nd
Increased flow	3rd	Unstable regulatory aspects	3rd
Increased reservoir level	4th	Entry of competitors in the region	4th
STRENGTHS	**Ranking**	**WEAKNESSES**	**Ranking**
Guaranteed revenues (sales contracts)	1st	Relevant indebtedness	1st
Investment in transmission/expanded production	2nd	Low return on invested capital	1st
Reservoir level	2nd	Stagnated hydroelectric generation	2nd
Market position	3rd	Modest liquidity	3rd
Dividend distribution to partners	4th	System errors and technical losses	3rd

Source: Research Data

As a product, the SWOT Matrix was elaborated, as shown in Table 3, which consists of the selection of the most

important consensus variables

Table 3. SWOT Matrix established for CHESF

MATRIZ CHESF		INTERNAL ENVIRONMENT					
		STRENGTHS			WEAKNESSES		
		Guaranteed Revenues	Investments in Production and Transmission	Reservoir Level	Indebtedness	Return on Capital	Stagnated Production
EXTERNAL ENVIRONMENT	OPPORTUNITIES	Scenario I – Development			Scenario II – Growth		
	Invest in Innovation for Adaptation to						
	Growing Demand						
	THREATS	Scenario III – Survival			Scenario IV – Decline		
	Reduced Flow						
	Public Management Constraints						
	Inflation, Interests and Cost of Financial Resources						

4. ANALYSIS OF RESEARCH RESULTS

The methods adopted permitted inferences of four distinct scenarios for CHESF until 2050: two related to extreme scenarios (I and IV) and two corresponded to intermediary scenarios (II and III). Each of these was analyzed based on regional and company characteristics, as well as economic-financial and operational indicators and the forecasted impacts of GCCs on hydroelectric generation.

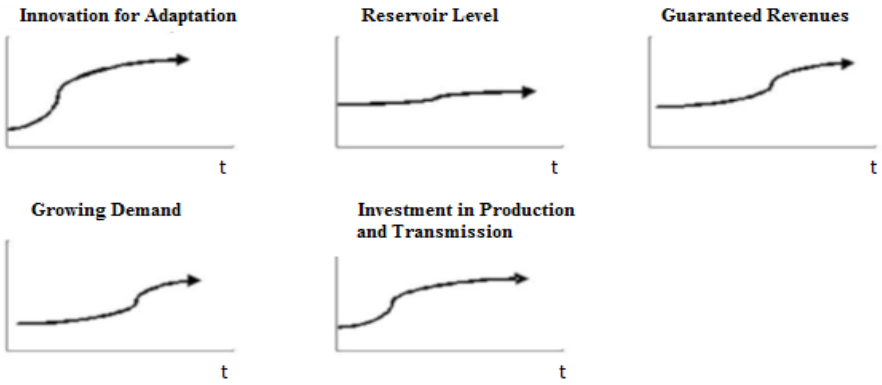
The variables in each of the scenarios were represented by curves and plotted in individual graphs, in which the horizontal axis "t" (abscissa) represents a timeline, while the vertical axis (ordinate) represents the quantity (value, volume, etc.) of each variable. In the curves representing trends, an inflection point exists that defines the moment when the trajectory will change, which can be more or less severe, depending on the context.

4.1. Scenario I: Development

The combination of strengths and opportunities resulted in Scenario I, in which CHESF's development in view of GCCs prevails. In this hypothesis, the company uses its operational strengths to make the best of future opportunities. It is the most optimistic scenario the SWOT matrix produced. In this scenario, it is considered that the GCCs will not affect CHESF, or that their consequences will be imperceptible, as adaptive actions will have been implemented in advance. Hence, this company's strengths will be preserved and are expected to develop without any great obstacles, putting the company in a comfortable and stable situation.

In this case, the reservoir level represents a safe energy stock and serves as a bolster for new long-term contracts, with guaranteed revenue. Relevant investments in energy production and transmission will allow CHESF to respond to the growing demand expected for the Northeast. Perceiving the opportunity to innovate and adapt to climate change would represent technological advances for alternative energies and new revenue sources.

Scenario I could be schematically represented as shown in Graph, as follows:



Graph 1. Scenario I – Development until 2050

Source: Research Data

In this scenario, the behavior of the selected variables favors CHESF's future situation. It is assumed that changes in this company's strategic planning take place at different times, as the trend inflections suggest, permitting the implementation of pro-active actions.

Despite the exhaustion of the São Francisco Basin's hydraulic potential, revenue is expected to increase due to the growing demand, pressured by the enhanced energy consumption in production sectors and in building refrigeration, provoked by the average temperature rise in the region.

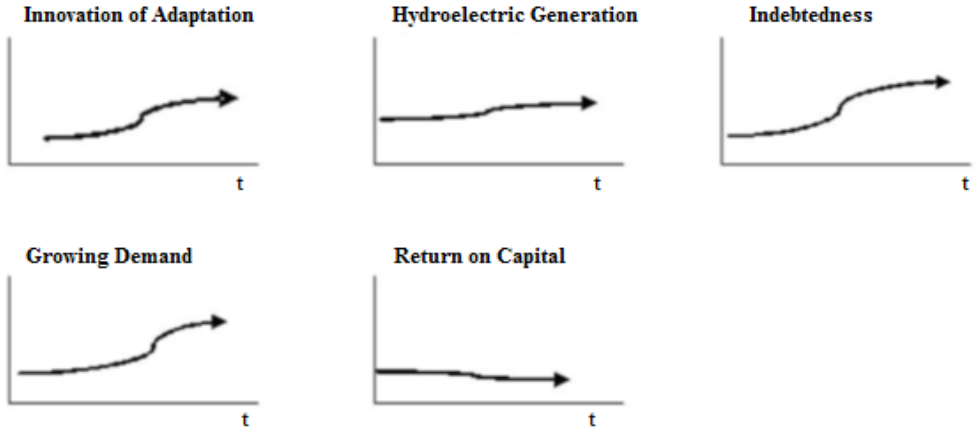
To respond to this increasing demand, the company needs to make important investments in technological innovations, in an attempt to set up wind, photovoltaic or biomass energy sources in its geographic activity region, and also expand its transmission network.

These innovations should comply with technical, environmental and economic feasibility criteria and not provoke any extraordinary increase in consumer fees. It is important to note that 86% of the experts considered the variable "investment in innovation for adaptation" as the most important..

4.2. Scenario II: Growth

In the hypothesis of Scenario II (opportunities versus weaknesses), called growth, CHESF would take advantage of opportunities, constrained by its economic-financial and operational weaknesses resulting from GCCs. It is one of the intermediary scenarios the SWOT method produced, in which it is considered that the GCCs will moderately affect the company, as adaptive actions will be implemented, but only when the impacts of climate changes would already be felt.

Scenario II can be graphically represented as shown in Graph 2, as follows:



Graph 2. Scenario II – Growth until 2050

Source: Research Data

In this scenario, CHESF will grow as a result of opportunities its external environment is projected to grant, more than as a result of its own management. The increased demand and innovation opportunity will not be very well leveraged, due to the company's operational and economic-financial weaknesses.

Hydroelectric generation would not be expanded, except for some Small Hydros, with low power levels. In this case, to meet demand, the company will purchase energy, so as not to breach contracts already signed and be subject to market price fluctuations variations.

CHESF would take advantage of the opportunity to meet the increased demand through new production sources during a late phase, as investments in innovation would be postponed and paid for with capital from third parties, subject to short and long-term interest. Its indebtedness would increase, putting a strain on its results and negatively affecting return on capital invested. In addition, the payment of the principal and interests could influence the cash flow and reduce the company's investment capacity.

In this growth scenario, the business would remain profitable, but the rate of return for investors would hardly be attractive in comparison to other Brazilian and international market opportunities. In short, the situation would not be comfortable, despite existing opportunities.

4.3 Scenario III: Survival

When the threats are confronted by the strengths, the result is Scenario III, survival. The most relevant threats pointed out by the SWOT method are: "Reduced flow", "Public management constraints" and "Inflation, interests, cost of financial resources," which will be confronted with the operational strengths the company has developed. In this case, the GCCs are expected to affect CHEST with moderate to strong intensity, influencing its development trajectory.

In this scenario, the company would not grow, but would merely survive, due to the threats its external environment is expected to present, which could be tackled with available strengths, aiming to maintain at

the least, a reasonable growth trajectory. It is a scenario of survival in which the "Reduced flow," provoked by GCCs, would affect the reservoir level and, consequently, the "Guaranteed revenue." Thus, the CHESF could lose contracts, as the auctions the Federal Government promotes require proven energy production capacity. Transmission revenue, however, could be preserved or increased, provided that investments were made in the network to increase its range and avoid system errors.

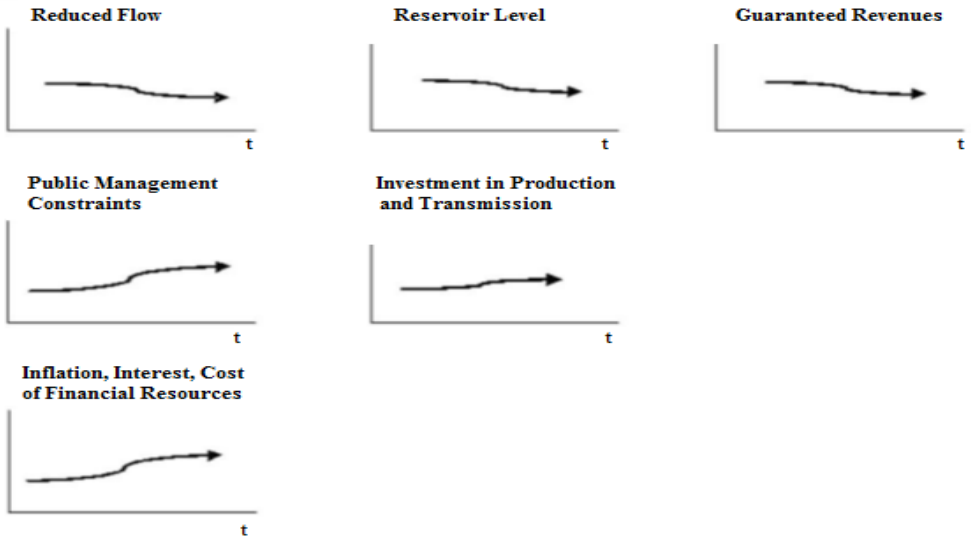
The lack of impetus, caused by reduced revenue, could slow down the investment rhythm and aggravate CHESF's situation even further. This could demand the use of short-term capital. These loans are remunerated at the highest interest rates in the world, due to the interest rates imposed in Brazil. Projections strongly indicate that the interest rate will continue to increase, in an attempt to reduce the rate of inflation, which is sensitive to the population's growing consumption.

The governance of CHESF is public, exercised by a holding (ELETROBRAS), which sets the general guidelines and coordinates the execution of the Federal Government's policies. In addition, this company is subject to the legal determinations and surveillance of the ONS (National Electric System Operator), ANA (National Water Agency), ANEEL (National Agency for Electric Energy) and CVM (Brazilian Securities Commission), among others. Hence, the different decision levels can complicate both the operational and the financial situation. Therefore, constraints on this multiple management are expected to increase, ranging from slow decision making at the highest levels to divergences among the different standards that need met.

On the other hand, public management can also entail positive aspects, as the company could receive resources from the holding, in the form of a capital increase, even if its profitability indicators are unsatisfactory, but this would not solve its situation on a permanent basis. In this scenario, CHESF should attempt to use its strengths to cope with its weaknesses, including those resulting from climate change, and all efforts should be focused on guaranteeing the company's survival in the face of variables beyond its control.

The fact that CHESF has an installed production plant can gain it competitiveness, permitting lower auction prices. This company can also use its business knowledge to enhance investments in energy transmission, which would become the activity with the highest growth level. Considering that the reservoir level is projected to be strongly affected by reduced flow and rains and rising temperatures will enhance the demand for refrigeration, as well as water evaporation, thereby limiting the possibility of maintaining revenue from hydroelectric generation even further, CHESF's investment should be directed toward alternative sources, seeking to guarantee its sustainability, even if that be at a level below the ideal.

In this survival scenario, the business would not be very profitable and the rate of return for investors would be very limited or null. In short, the situation would be very difficult, despite existing strengths. Scenario III could be graphically represented as shown in Graph 3:

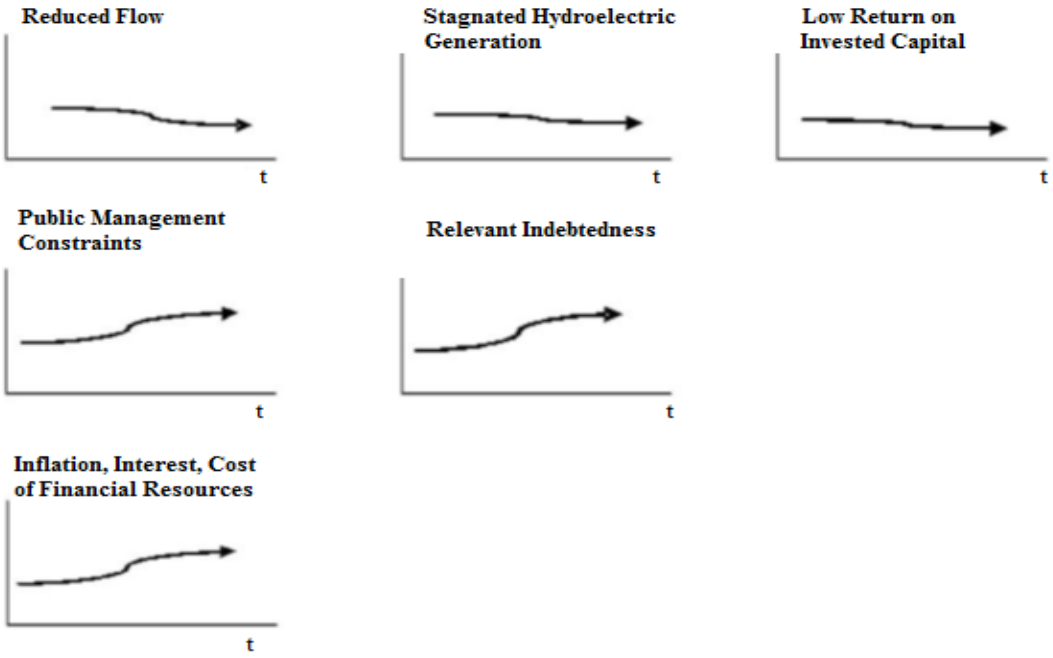


Graph 3. Scenario III – Survival until 2050

Source: Research Data

4.4. Scenario IV: Decline

The threats that appear in the SWOT Matrix could lead CHESF to an even more negative scenario, when its weaknesses are confronted with the GCCs. In this case, the company enters a downward course and could end up collapsing. In this Scenario IV, called decline, a dangerous combination of environmental, operational and financial problems exists, represented by the threats and weaknesses. It is the most pessimistic scenario the SWOT method produced, in which GCCs are expected to strongly affect CHESF, as adaptation actions would not be implemented and the company would depend on financial and operational aspects that are already performing negatively. Scenario IV could be graphically represented as shown in Graph 4:



Graph 4. Scenario IV – Decline until 2050

Source: Research Data

The relevance of the company's level of indebtedness would further weaken its liquidity and profitability indicators. The return on invested capital could degenerate and even turn negative. The effects of GCCs would be intense and the mitigation cost would surpass the cost of the adaptation that was not put in practice. As a result of growing interests and inflation rates, the company's situation would decline, also because, in these conditions, gaining market credit would become increasingly difficult.

Problems deriving from stagnated hydroelectric generation, due to the reduced flow and exhaustion of the hydroelectric potential in the region, could cause complications for the other submarkets of the SIN (National Interconnected System), who would be left in charge of providing the additional energy demanded in the Northeast. Investments would be needed to reduce the transmission system's errors and technical losses, as well as for its maintenance, in order to guarantee long-distance energy imports.

Without investments in innovative technologies, CHESF could lose its market position, default on its contractual obligations and suffer penalties imposed by the SIN control and surveillance entities.

With multiple decision levels, public management could react slowly to the impacts of external variable on internal variables, leading to the late implementation of response actions, lacking the efficiency and effectiveness highly complex problems demand.

In short, the worsening of the company's general situation could lead to decline without the possibility of immediate negotiations with decision makers, to convince them that postponing the inclusion of GCCs into their strategic planning could increase the risk of a deficit and reduce the reliability of the region's entire electric energy supply system.

4.5. Selection of the Most Probable Scenario

The four scenarios produced by the SWOT method all have the same possibility of occurring in the future. However, according to Godet (2000), possible scenarios are not equally probable. A rupture with the past could occur due to climate change, even if the knowledge accumulated thus far is inconclusive. It appears that these uncertainties justify the use of qualitative and behavioral methods for the elaboration of strategic planning to deal with these issues, which are unprecedented in the history of hydroelectric energy companies in Brazil, and, possibly, in the world.

In line with Godet (2000), no statistics about the future exist and, often, personal judgment represents the only piece of information available, demanding prognoses in the form of subjective probabilities. Subjective interpretation reflects the probability of a particular event, attributed by an individual and based on a set of available information.

Controversy exists in the world of statisticians about the use of personal (subjective) probability. Epistemic uncertainties are typically associated with extraordinary, non-repeatable events and, to express them in terms of probability, subjective probability would need to be used, which would represent someone's degree of belief in an uncertain proposition. The rejection of personal probability, as the basis for scientific reasoning, is one of the differences that distinguish most followers of classical statistics from and defenders of Bayesian statistics, as the latter generally adopt subjective probability in their methods (O'Hagan *et al*, 2006).

Despite this controversy regarding GCCs, no similar

events have happened in the past, therefore there are no repetitions to be observed, as traditional statistical analysis demands. At any rate, classical theorists also rest their conclusions on mathematical abstractions of the real world, as GCCs cannot be fully represented by any form in the current evolutionary level of science.

In the practical request for of specialized knowledge, however, this controversy is not an issue. In practice, the attention is always focused on variables for which at least one epistemic uncertainty component exists and, therefore, expert judgments are always personal probabilities. The objective of elicitation is to present expert knowledge and beliefs, precisely, in the form of a good probability distribution (O'Hagan *et al*, 2006).

Hence, in light of the multiple future aspects the four scenarios have indicated, all of which are equally possible, scenarios are identified that address the critical drivers in CHESF's internal and external environment, in order to select the most probable scenario in the long term. In this study, the critical drivers involve current environmental aspects that can be influenced by GCCs, which, consequently, could affect the company's future performance.

From this perspective, Scenario III (Survival) stands out among the others because it presents three drivers that are most vulnerable to GCCs: i) Flow; ii) Guaranteed revenue; and iii) Reservoir level.

Based on these evidence probabilities (P) were attributed to each of the scenarios resulting from the research, as shown in Table 4.

Table 4 . Scenarios and Expected Probabilities

Scenario	Probability (P)	Expected P
I – Development	Low	0.1-0.2
II – Growth	High	0.5-0.6
III – Survival	Very High	0.6-0.8
IV – Decline	Medium	0.3-0.4

Source: elaborated by the authors

It is highlighted that the probabilities, although numerically represented, should be considered as qualitative indicators, as a gradient of expectations, which contributes to reflections about complex problems in an uncertain context.

In fact, the lack of data about the future does not permit the precise establishment of any probability, but mere subjective *a priori* choices, aiming to represent possible future scenarios. According to Gusmão (2008), a subjective *a priori* represents the singular, direct and simple subjective of the researcher's referent to the parameter. Hence, the researcher's feeling is included in the *a priori* distribution, which in other words represents the researcher's previous knowledge, prior to observing the data (not yet available).

In this sense, the *a priori* information (not based on data) results from theoretical considerations by the researcher (Fonseca *et al*, 2006). Due to this additional information, the Bayesian method generally provides stronger conclusions than the traditional method for the same data set (Gusmão, 2008).

Thus, Scenario III reveals itself as the most probable, with a very high probability level (between 0.6 and 0.8), considering that CHESF's performance is more sensitive to variations in the critical environmental drivers it contains than to any other drivers, from a business viewpoint.

4.6. Critical Environmental Drivers

Water flow is fundamental for hydroelectric energy generation and 64% of the experts consulted during the application of the Delphi method considered its reduction to be the most important threat. In addition, in a study by Shaeffer *et al* (2008), it was estimated that the average annual flow (that is, the annual mean quantity of water flowing into the power plants) could drop by an average of 8.6% according to the IPCC's climate change scenario A2, versus 10.8% in scenario B2. Similarly, study results by Marengo (2007) indicated that temperatures could increase between 2ºC to 5ºC and rainfall could drop by up to 15% in the Northeast before the end of the 21st century. Both studies reinforce the trends indicated by Scenario III, as formulated in this paper.

In the same sense, the studies by Santos *et al* (2010), based on information between 1961 and 2007, produced two climate scenarios for the Brazilian Northeast and concluded that:

1. The Brazilian Northeast presents statistically significant upward trends in average air temperatures. The highest increase rates for this variable are found between the current climate situation and the scenario for 2050;
2. The evaporative demand, represented by potential evapotranspiration, also indicates growing tends across the region researched, for the current climate situation as well as for the two scenarios analyzed; and
3. The drought index indicates an increase and the humidity and hydric indices showed a reduction for the scenarios studied across the Brazilian Northeast, mainly in the semiarid region, indicating that it could become even more arid in the future.

Salati *et al* (2007) also conducted studies that indicated no water surplus in the Brazilian Northeast between 2011 and 2100. It is important to note that water flow is a function of the synergy between rain, temperature and evaporation, indicators GCCs will most strongly affect, according to the studies consulted.

Hence, based on this empirical evidence, a significant decrease is estimated in the water flow for hydroelectric energy generation, with a very high probability of occurrence, on the horizon up to 2050.

Another critical driver relates to guaranteed revenues, which 71% of the experts consulted considered to be the most important strength. This refers to the income that sustains the maintenance of company activities and investments to expand energy supplies. These revenues derive from a hydroelectric plant's operational

availability (probability that equipment will be operating or will be ready to operate at a given time) and firm power (average production). The vulnerability of this driver results from the probability that GCCs will reduce flow and, consequently, the company's production. Energy sales contracts are based on this capacity to supply stable power.

Hence, it is estimated that revenues from hydroelectricity (75% of total revenue) will decrease up until 2050. On the other hand, revenues from transmission, in light of investments made in this segment, present a tendency to grow for the same period, but are not expected to compensate for the reduced revenue from energy supplies. For CHESF to start producing from other energy sources, such as nuclear, wind or solar energy, in the years to come, considerable investments will be needed and the results would only be felt in the long term. In general, according to Lucena (2010), climate projections in IPCC scenarios A2 and B2 indicate a severe decrease of about 30% in the country's firm power and a decrease of 69% (A2) and 77% (B2) for the São Francisco River Basin, where the main CHESF plants are located.

Therefore, an significant reduction in revenue from hydroelectric energy generation can be estimated, with a high probability, on the horizon up to 2050.

Regarding CHESF's reservoirs (52 billion cubic meters in 2009), their level depends on variations in affluent natural flows which, in turn, depend on rainfall and temperature, that is, on variations that are vulnerable to the GCCs. According to Lucena (2010), the impacts on energy production are not proportional to the impacts on the water flow, due to the enormous water storage capacity in Brazilian plants' reservoirs. The reservoirs, however, which are true energy inventories, are useful for other purposes, like to control floods, provide water for human and animal consumption, irrigation and leisure. Some of these uses have priority over use for energy production.

The possible decrease in rainfall, increased temperature and evaporation are expected to reduce the affluent flow to the reservoir and, at the same time, increase water consumption for other uses, consequently resulting in a reduction in reservoir levels. Hence, reservoir levels, which 50% of the experts considered as a very important strength, will probably drop as a result of climate change. This reduction can be mitigated in compliance with one of the operating criteria of the SIN, which is the target level of the reservoirs. In this case, thermoelectric generation (in the Northeast and other regions) would be implemented to prevent the reservoirs from reaching very low levels.

Nevertheless, a considerable reduction in CHESF's reservoir levels can be estimated, with a high probability, on the horizon up to 2050.

4.7. Other Environmental Drivers

Scenario III (Survival) represents the situation in which CHESF could use its potential to cope with future problems. In this sense, critical drivers are those factors GCCs could directly affect, as previously mentioned. Other drivers in this scenario can also receive direct influence from public policies and market issues though, and indirect influence from GCCs. A summary of the other drivers' possible behavior is shown in Table 5

Table 5. Other Drivers in Scenario III

Driver	Behavior until 2050
Public management constraints	Public management is traditionally acknowledged as slow and bureaucratic. In the research for this paper, 43% of the experts attributed high or very high importance to this threat. But it seems that some flexibility is perceptible as, according to CHESF (2009), different generation and transmission projects are being executed in partnership with private enterprises. In these associations, CHESF holds a minority share in the share capital (12% to 49%). This financial configuration, under private control, is expected to grant more agility and freedom to administer these new businesses. But the company will continue under public governance, exercised by the holding and, in addition, by the Ministry of Mining and Energy. In addition, CHESF is subject to different public entities' legal determinations and surveillance, leading to multiple management. The consequences range from slowness in higher-level decision making to divergences between the different standards that need to be complied with. Public management can also entail positive aspects though, as this company could receive resources from the holding, such as a capital increase. Therefore, it is assumed that the probability of less public management constraints or greater flexibility by 2050 is low.
Inflation, interests and cost of financial resources	Giambiagi and Porto (2011) propose that the country adopts an inflation target reduction trajectory. The government would be responsible for a smooth transition, reducing the target to 4% in 2013 and 3.5% between 2016 and 2020, when it would drop to 3%. The target has remained stable at 4.5% for five years (up to 2012). This long-term inflation target could take the nominal interest rates to a level between 6% and 7%, with real interest rates bordering on 3% in 2020. The level would be close to the Long-Term Interest Rate applied to BNDES lines. The country would grow by 4.5% to 5% per year, with inflation reaching this target and a gradual reduction in the Selic rate to 2.5% per year in 2022. The PNE 2030 establishes an inflation target around 4% (scenario B1) or 8% (scenario B2) until 2016, dropping gradually until reaching 3% (B1) or 5% (B2) in 2030, which are the same levels observed in developed countries. However, reduced revenue and increasing investment needs can lead a company down a difficult road, of indebtedness in public and private banks, subjecting it to a real interest rate between 3% and 5%. The debt burden is expected to increase due to the volume captured. Hence, it is presumed that the probability of financial costs decreasing until 2050 is average.
Investments in Transmission and Expanded Generation	The company's investments are concentrated in maintaining its current installations and in businesses in other Brazilian regions. It is important to note that 60.6% of investments in 2009 were aimed at the transmission system and only 8.3% at energy production. Between 2005 and 2009, the Compound Annual Growth Rate (CAGR) of investments corresponded to 8.18%. Transmission errors imply lack of availability of the asset and, for this reason, CHESF can be fined by ANEEL. Energy sales contracts also assume penalties in the event supplies are interrupted. The company's efforts have been directed towards the reducing interruptions, but some operational indicators still do not reflect the results of investments made for this purpose. It can be highlighted that, if the resource volume is insufficient to guarantee system expansion and maintenance, company revenue may decrease and the company may be obligated to pay fines due to non-compliance with legal determinations and eventual contract breaches. In the research for this paper, 50% of the experts considered this driver important or very important. It is presumed that the probability of increased investments within the study horizon, even if in a late phase, is average.

One important strategy CHESF can adopt for the future, when threats will have to be faced, would be diversifying its production matrix, incorporating other energy generation sources, aiming to guarantee the maintenance of its strong points. Wind and biomass sources are important options, but it is highlighted that the use of gas is also expected to increase. The company would use its important position in the market and in Brazilian accounts to strongly advance in this sense, imposing a development trajectory that would privilege its corporate sustainability.

In that sense, CHESF should also focus on overcoming the weaknesses diagnosed in this study. These include: i) Improving its economic-financial and operational indicators, which point out negative trends, appears to be a pressing matter; ii) Investing in a new energy source matrix would help to overcome the stagnation in its power generation system; iii) withholding a significant part of profits to invest in expansion could improve indebtedness and liquidity levels.

During the expansion phase, a more limited dividend distribution is assumed, but this can be easily compensated when new plants are operating. Nevertheless, growth targets should be set for the ROE (Return on Equity) and profit available for distribution.

5. CONCLUSIONS

The qualitative approach in this research produced evidence that GCCs can affect different internal and external factors in hydroelectric power generators, which support the forecast that the operational aspect and, consequently, CHESF's revenue and income could be negatively affected by the impacts of GCCs on water resources, temperature, rainfall, and evaporation levels expected for this century.

The company's operational, financial, economic, social, and environmental indicators are sensitive to these impacts, which could put CHESF in a difficult position if adaptation and mitigation actions are not put into place for the sake of prevention.

CHESF, whose main revenue source is hydroelectricity, highly depends on climate issues to sustain the development of its economic activities. In the different scenarios estimated for its performance until the year 2050, the need for the company to invest in innovative technologies remained implicit. This investment would allow CHESF to adapt to the negative impacts the GCCs are expected to provoke in water resources.

To reduce its exposure to the impacts of GCCs, due to its great dependence on electric power generation, CHESF has worked to expand its business structure with a focus on sustainability. The implementation of wind parks in 2010, both individually and through partnerships, reflects the company's first initiatives in the field of alternative energy sources.

One possible adaptation would be using the power of the sun and ocean waves or tides, as these natural resources are abundant in Northeastern Brazil. Biomass power generation, from garbage and other residues, such as sugar cane bagasse, for example, should not be ruled out. The implementation of small wave and tidal power plants to harness the energetic potential of the ocean, with low-fall turbines and capacity to produce power in both water outlet directions, could be an interesting option. The potential power of winds in the region could be leveraged and could complement hydroelectric generation during the dry season of the rivers.

Given that the region receives a high degree of sunlight during the year, the implementation of solar energy plants could also be a good option. The feasibility of technologies to produce and store this energy depends on their cost behavior. Long-term technological development could reduce the area occupied by solar power plants and their installation and maintenance costs. Efficiency also needs to improve and the use of solar energy concentrators is highly promising in that sense.

The use of electric power generation potential from biomass should combine the availability of residues with transportation costs. This option could contribute to solve the urban solid waste disposal problems that ail local governments..

The introduction of plants that use alternative energy sources seems to be a pressing matter for the electric sector. Setting up these plants in the Northeast depends on private investment stimulation policies and public investment programs, committed to renewable power generation, especially from power sources that are least dependent on water.

To guarantee its position in the market, CHESF could lead this transition process between the current electric power matrix and a matrix that consists of renewable and alternative energy sources, a matrix that is solid and more independent from water cycles.

One of the reasons for underinvestment in the upcoming years seems to be the maximization of returns for stockholders, which competes with the resources that would be kept inside the company, in order to expand its generation and transmission capacity. This situation is due to the fact that ELETROBRAS (holding of important companies in the electric sector), is obligated to contribute to the Federal Government's primary surplus and Eletrobras thus uses its subsidiaries' profits to reach its annual targets.

Budgetary constraints exist for CHESF, due to the competition between investments and stockholder remuneration. Environmental constraints also exist, which delay or impede investments due to difficulties to gain environmental licenses, as well as legal constraints, making company management slower and foster uncertainties as to its future.

The climate risks indicted by Scenario III, which are expected to stimulate investments in adaptation and technological innovations, have not yet been appropriately incorporated into the company's strategic planning. It is estimated that these obstacles will be faced at a later stage, making CHESF's survival even more difficult.

Concerning Brazilian policies, the structure of the Brazilian electricity sector, put in practice through the reform implemented in 2004, is not expected to

suffer relevant changes in the coming years. Possible adjustments in the current model are not expected to reduce the competitiveness auctions have enhanced, which is one of its fundamental principles. But some proposals can be formulated to improve the sector's performance, including:

i) Stimuli for energy efficiency and energy conservation on the demand side;

ii) Gradual and forceful reduction in interest rates and keeping of inflation at reasonable levels;

iii) Increased flexibility of management laws for public companies; iv) Stimuli for actions to adapt to GCCs; v) Increasing, timely and relevant public investments in renewable and alternative energy, which are less susceptible to GCCs;

vi) Review of primary surplus accumulation criteria, aiming to keep profits inside the companies; vii) Modernization of environmental legislation to expe

dite licenses; and

viii) Inclusion of GCCs' impacts in sectorial planning.

The SWOT matrix was used to analyze the effects of climate change in the context of CHESF, contributing to shift the focus from the global level (policies) to the corporate level (management). Based on the analysis of the most probable scenario (Scenario III - Survival), it can be concluded that corporate vulnerability can significantly compromise the energy market's performance and, consequently, the Federal Government's strategic policy, which prioritizes energy supply and control on the supply side, without also considering other important aspects, such as those mentioned in this study, which could affect sectorial performance in the long term.

In future studies, the present research results could be improved by expanding the database, the number of experts, companies, and regions considered. Also, long-term information of different kinds could be employed in appropriate computer models to this same end. This would permit the development of a useful qualitative-quantitative method to analyze corporate risks deriving from GCCs.

Lastly, for the sake of reflection, environmental history experts call attention to the fact that Sciences and Humanities need to move forward hand in hand, in order to adjust the economy, consumption, pollution, money, and wellbeing.

The capitalist view cannot be the absolute manner to view economics, considering that it leads to the notion that natural resources are endless and also created an economic model that results in climate change. According to Donald Worster, one of the creators of environmental historiography, society needs to discover new energy forms and utilize the scientific and technological knowledge gained over time to create a new type of culture that is compatible with the environment (O Globo, 2013). From abundance to vulnerability, frontiers exist for a new world. This paper aimed at contributing to this form of viewing the world, that is, that we have actually reached the frontier of the new world, which involves understanding nature and its influence on the survival of people and organizations.

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